4thInternationalConference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

ASSESSMENT OF SEDIMENT OXYGEN DEMAND (SOD) OF HEAVILY POLLUTED TONGI KHAL (CANAL)

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ABSTRACT
In any surface water body, sediments are the ultimate sink of many of the pollutants. Contaminated sediments can act as a secondary source of pollution for the overlying water, releasing pollutants by different physiochemical or biological processes. Anthropogenic activity like dredging can accelerate release of pollutants from sediment, thereby quickly deteriorating water quality. This study investigates potential sediment oxygen demand (pSOD) of Tongi khal, a heavily polluted peripheral river/canal of Dhaka City. The objective was to estimate possible contribution of sediment in depleting oxygen level in upper water layer during a major disturbance in sediment layer, such as dredging. For this purpose, sediment samples were collected during dry season (Pre-monsoon and winter) from four specific locations of Tongi khal and pSOD was determined using ex-situ laboratory methods. The sediments of Tongi khal have been found to have very high oxygen demand. Potential sediment oxygen demand of pre-monsoon samples (collected in March and April of 2017) ranged between 6.02 to 16.38 mg O_2/g Sediment/day; that for the samples collected during winter (December 2017 and January 2018) ranged between 10.02 to 18.87 mg O_2/g Sediment/day. Employing specific gravity measurements, the potential sediment oxygen demand was found to vary between 13,485 to 35,380 g O_2/m^3 Sediment/day for samples collected during pre-monsoon period, and 17,208 to 37,191 g O_2/m^3 Sediment/day for samples collected during winter. The very high sediment oxygen demand of Tongi khal sediments shows high level of organic pollution of this peripheral canal of Dhaka city. Bangladesh government is planning restoration of the peripheral rivers of Dhaka city involving dredging of these water bodies. Findings of this research will help planning the dredging operation and assessment of its impact on aquatic environment during the dredging operation.

Keywords: Dredging; Sediment Oxygen Demand; Sediment Quality; Tongi khal

INTRODUCTION
Dhaka, the capital of Bangladesh, is surrounded by rivers all around. These rivers include Buriganga, Balu, Sitalakhya, Turag, and Tongi khal. The ecosystem of these peripheral rivers is continuously being strained by the unregulated industrialization, overpopulation and unplanned urbanization from its early days. Over the last few decades the situation has worsened. Although studies frequently report the degraded conditions of the peripheral surface water bodies, but few studies focus on sediment quality assessment. In aquatic system sediment is usually the ultimate sink for all sort of pollution which can often act as a major source of pollution for the overlying water (Spellman, 2016). The sediments of the peripheral river of Dhaka have turned into a sink of diverse range of pollutants including domestic and industrial effluent as well as solid wastes (UNDP, 2010). However, limited data is available on sediment quality and its impact on water quality.
Sediment quality of any aquatic system can be assessed by its physical, chemical, biochemical parameters. One of the most crucial biochemical parameter is sediment oxygen demand (SOD), which

indicates the total oxygen utilized (i.e. taken up) by all biological (biological respiration) and chemical (chemical oxidation) processes in the sediment (Sabit and Ali, 2015; Sommaruga, 1991; Hargrave, 1969). SOD acts as a critical and dominant sink of DO, and therefore it has a significant influence on oxygen budget of a river system (Liu and Chen, 2012; Matlock et al. 2003). Controlling factors affecting SOD rate are many, such as sediment age, surface area, temperature, water velocity, and differences in chemical and biological (e.g. organic content, microbial concentrations etc.) components between sediment and water layer (Chen et al. 2012). This variable (i.e., SOD) includes oxygen demand from two separate processes: a) biological respiration, where dissolved oxygen is removed to satisfy the respiratory requirements of all living organisms in the sediment, and b) chemical oxidation, where oxygen is consumed due to abiotic oxidation of reduced ions and substances present in the sediment (Hargrave, 1969; Bowman & Delfino, 1980). Sediment Oxygen Demand (SOD) for a river typically has two states - diffusion limited SOD (SOD) and potential SOD (pSOD) (Matlock et al. 2003). Of those two states the pSOD usually represents the oxygen demand during disturbance events like dredging. Although this parameter is widely assessed across the globe (Collins et al. 2017; Akomeah and Lindenschmidt 2017; Rong et al. 2016; Liu and Chen, 2012; Truax et al.1995; Hall and Berkas 1988; Bowman and Delfino, 1980 etc.), only limited data is available on SOD of polluted water bodies in Bangladesh; a few studies (e.g., Sabit and Ali, 2015; Khan, 2008) reported pSOD values of contaminated sediments from lakes. As government has plans to restore the peripheral water bodies of Dhaka city involving major dredging operations, it is important to assess the sediment oxygen demand of contaminated sediments of these peripheral rivers. This study focuses on assessment of sediment oxygen demand of, Tongi khal, one of the peripheral rivers of Dhaka city that receive significant pollution load from both domestic and industrial sources.

METHODOLOGY

In this study, sediment samples were collected from several distinct points along the Tongi khal during pre-monsoon and winter seasons (low flow period) for measurement of sediment oxygen demand.

Study site

The river system in and around Dhaka includes the river Buriganga in the south, the Balu and Shitalakhya rivers in the east, the Tongi khal in the north and Turag river in the west. (Siddiqui et al., 2004). These rivers form the two major surface water systems around the capital Dhaka city. Turag-Tongi-Balu river system is one of the most polluted water systems (Whitehead et al., 2018). This canal is a manmade surface water body which connects the Turag river with Balu river (Fig. 1). This canal lies near one of the largest industrial hub named "Tongi". This canal receives semi-treated and untreated liquid wastes from this industrial hub.

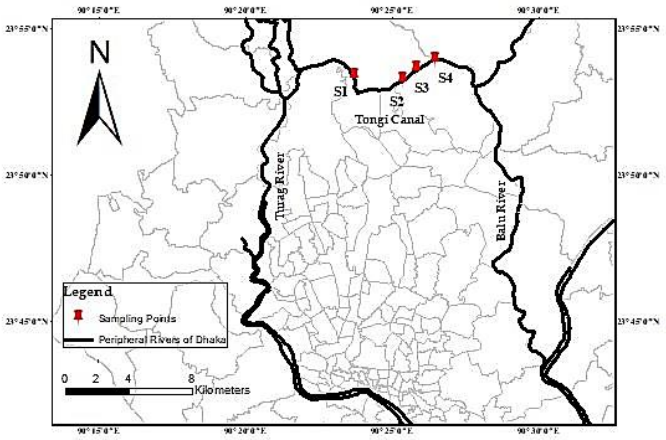

Figure 1. Study area and sampling locations.

Collection of sediment samples

Sediment samples were collected from four distinct points along the Tongi khal during pre-monsoon season (March'17 & April'17) and winter season (December'17 & January'18). Figure 1 shows the

sediment sample collection points (S_1, S_2, S_3, S_4). All sediment samples were collected using an Eckman grab sampler. Only top 20 cm layer was chosen for sediment collection, which is the most biochemically active layer that have considerable influence on overlying surface water layer. Sediment samples were collected in plastic jars and transported to the laboratory in airtight condition for analysis.

SOD measurement of the sediment samples by Ex Situ approach

Sediment oxygen demand can be measured through both in-situ and ex-situ methods. This study measured sediment oxygen demand using a standard ex-situ method as described by Matlock et al., 2003. For each set of experiment, 5 grams and 10 grams of sediment samples were introduced into each of the two BOD bottles (300 mL volume). Then the BOD bottles were filled with aerated deionized water. A magnetic stirrer was placed in each of the BOD bottles. The probe (LDO probe) of a dissolved oxygen (DO) meter was put into the bottle and the bottle was sealed (as shown in Fig. 2). After recording concentration of initial dissolved oxygen (DO), the contents of the bottles were stirred using a magnetic stirrer and the change in dissolved oxygen concentration in the system was monitored and recorded with a HACH HQ 40d multi-meter. Dissolved oxygen level reading was taken in one-minute increments for the first 30 minutes and then in two-minute increment until the dissolved oxygen level came down below the detection limit.

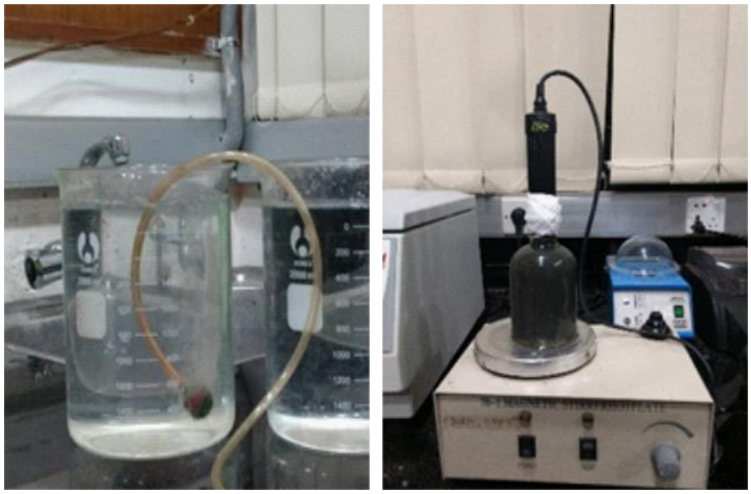

Figure 1.SOD measurement in laboratory.

RESULTS AND DISCUSSION

Figure 3 (a-d) show the changes in dissolved oxygen (DO) concentration as a function of time in the experimental suspensions containing different quantities of sediment samples (5 gm and 10 gm) collected during pre-monsoon and winter season. Figure 3 shows that, in general, the rate of depletion of dissolved oxygen was very high initially; with time the depletion rate decreased. As expected, the systems/suspensions with more sediment t (i.e., 10gms) reached the anoxia more rapidly. Figure 3 also shows that the systems/suspensions with winter sediment reached anoxia more quickly compared to the systems/suspensions with pre-monsoon sediment.

For a particular sediment sample, potential sediment oxygen demand (pSOD) was calculated in mg O_2/g Sediment/day from the result of oxygen consumption of the experiment. Specific gravity of the collected sediment samples was measured using ASTM D854 standard method. Employing this specific gravity, the potential sediment oxygen demand was finally expressed in mg O_2/m^3sediment/day.

The details of the sediment oxygen demand for pre-monsoon and winter sediment samples are presented in Table 1 and Table 2. During both seasons, the measured SOD values were very high compared to other measurements reported in different SOD measurements in throughout the world (Collins et al., 2017; Sabit and Ali, 2015; Khan 2008; Matlock et al., 2003 etc.). For pre-monsoon sediment samples, the potential sediment oxygen demand was found to vary between 13,485 to 35,380 g O_2/m^3 Sediment/day, and for winter samples it varied between 17,208 to 37,191 g O_2/m^3 Sediment/day. So, sediment associated oxygen demand appears to be higher during the winter periods compared to the pre-monsoon period.

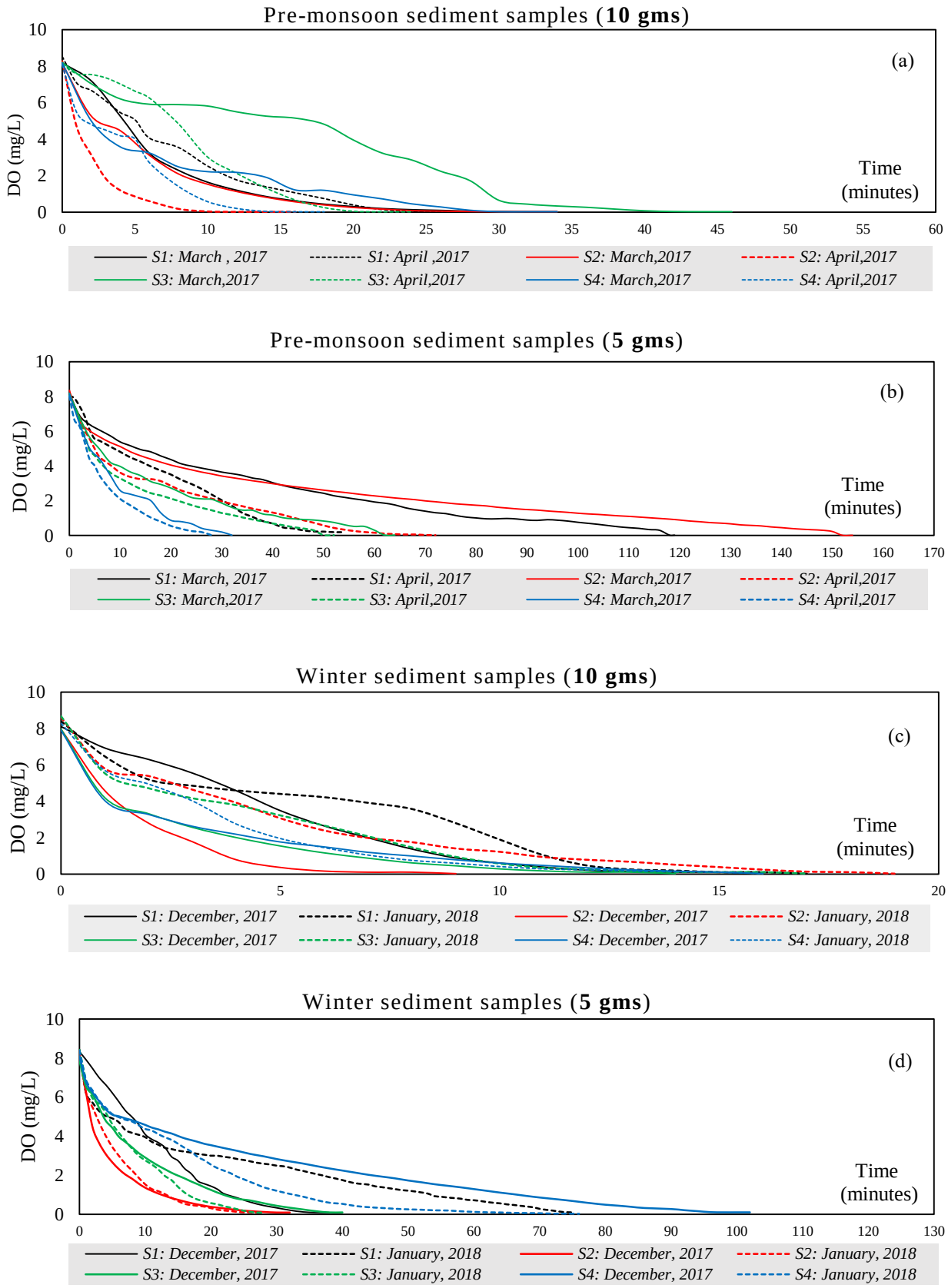

Figure 2. Changes in Dissolved Oxygen (DO) as a function of time for different sediment samples during ex-situ SOD measurement experiments.

Table 1. Potential Sediment Oxygen Demand (pSOD) of samples collected during pre-monsoon period from the Tongi khal.

	Sample	SOD mg O_2/gSediment/day (5g Sample)	SOD mg O_2/gSediment/day (10 g Sample)	Mean pSOD	
				mg O_2/g Sediment/day	g O_2/ m^3 Sediment/day
Mar 2017	S1	4.05	9.17	6.61	***15,534***
	S2	3.44	8.61	6.02	***13,485***
	S3	7.18	6.14	6.66	***15,984***
	S4	13.95	8.63	11.3	***20,999***
Apr 2017	S1	9.03	11.78	10.4	***22,590***
	S2	8.00	24.75	16.4	***35,380***
	S3	9.35	14.20	11.8	***23,678***
	S4	13.73	18.14	15.9	***26,922***

Table 2. Potential Sediment Oxygen Demand (pSOD) of samples collected from during winter season from the Tongi khal.

	Sample	SOD mg O_2/g Sediment/day (5g Sample)	SOD mg O_2/g Sediment/day (10 g Sample)	Mean pSOD	
				mg O_2/g Sediment/day	g O_2/ m^3Sediment/day
Dec 2017	S1	13.01	17.11	15.1	***30,982***
	S2	13.92	23.82	18.9	***37,191***
	S3	11.78	16.84	14.3	***26,828***
	S4	5.10	14.93	10.0	***17,208***
Jan 2018	S1	7.28	14.37	10.8	***17,369***
	S2	19.25	13.43	16.3	***24,107***
	S3	17.30	19.46	18.4	***36,597***
	S4	7.93	14.16	11.0	***16,856***

CONCLUSIONS

In this study, potential sediment oxygen demand (pSOD) of sediment samples collected from Tongi khal was measured by ex-situ approach. High level of pSOD (as much as 18.9 mg O_2/g Sediment/day) was found for the benthic sediment of this canal. Results show that winter season was more critical than pre-monsoon period due to comparatively high SOD. As government is planning to undertake major dredging operations of the Dhaka city peripheral rivers (including Tongi khal) as a part of ensuring navigation facility as well as ecosystem revival, it is important to assess sediment characteristics of these rivers. The findings of this study will be useful for designing possible dredging operation and assessment of its impact. Moreover, the results of this study would also be useful for water quality modeling of Tongi khal.

ACKNOWLEDGMENTS

This work was financially supported in part by the Committee for Advanced Studies and Researches (CASR) of Bangladesh University of Engineering and Technology (BUET). The authors would like to acknowledge the support from the research project "Research on Disaster Prevention/Mitigation Measures against Floods and Storm Surges in Bangladesh" Funded by JST-JICA (SATREPS) of Institute of Water and Flood Management of BUET for financing in sampling of sediment samples.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
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PERFORMANCE ASSESSMENT OF SECONDARY TRANSFER STATION FOR SOLID WASTE MANAGEMENT IN DHAKA NORTH CITY CORPORATION (DNCC)

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ABSTRACT
Waste generation in Dhaka city is increasing which renders a huge challenge to Solid Waste Management (SWM) in Dhaka. Secondary Transfer Station which was established by DNCC has reduced roadside dumping but the current practice is far away from standard practice. The objective of this study is to determine number and amount of waste handled by surveyed STS, Zone of Coverage around each STS and establish a relative picture of their performance. Questionnaire survey was conducted to get data of Rickshaw Van, Container, Transfer Vehicle and ArcGIS 10.3.1 software was used to create mapping and data analysis. From survey, functionality criteria to categorize STSs were set up and only 10 STSs were categorized as completely functional. Carrier, Compactor, Open truck or combinations of them have been used to haul waste. From ArcGIS analysis, it was found that maximum number of STS can handle waste about 500m radial distance around it. 21 STS's coverage areas are located outside from respective jurisdiction boundary by 50-80% which shows improper planning of STS. This study can help to take decision where STS can be located in a particular ward depending on presence of other STSs.

Keywords: Solid Waste Management; Municipal Solid Waste; ArcGIS 10.3.1; Waste Handling Capacity; Zone of Coverage.

INTRODUCTION
In Dhaka, waste generation rate is 0.5 kg/capita/day, collection efficiency by formal system is 40%-50%; recycling by informal system is 10-15%; illegal dumping (uncollected) is 35%-50% (Clean Dhaka Master Plan, 2005). As 50% dumping in Dhaka is happened by illegal dumping, that means around 22000 ton wastes has been dumped without any regulation. In DNCC, waste collects from roadside bins, street sweeping and demountable containers. Dumping of wastes at anywhere and transportation of large containers at peak hour indicates that Dhaka city has need of Transfer Station (TS). Before sitting a TS, road condition; land use pattern; waste generation rate; access to major transportation routes; sufficient space for onside roadways, queuing, parking; future extension capacity, space for recycling, composting; buffer space of that area should be considered (Zemanek et al., 2011). No long-term storage of waste occurs at TS, waste is quickly consolidated and loaded into a larger vehicle and moved off site, usually in a matter of hours (EPA, 2008). (Jahan et al., 2009) at their study discusses that in Door to Door collection system, rickshaw van is the preferable means to collect solid waste and in their study the STS locations are outlined only considering the zone of coverage surrounding TS covered by a manually driven Rickshaw van at a time i.e. per trip travelling capability. The existing Secondary Transfer Station (STS) in DNCC may prevent roadside dumping or odor. But without any waste minimization technique, this system loads same on landfill as before. That's why instead of addressing them as 'Transfer Station', they are addressed as 'Secondary Transfer Station (STS).The primary objectives of the study are to determine number of STS in every ward and

to determine zone of coverage around every STS to establish a relative picture of their performance. As STS has been newly employed SWM practice by DNCC, number of collection and transfer vehicles and their rated capacity was collected by site visit. Landfill consideration was not used in this study and all of the STSs in DNCC were not surveyed. This study doesn't give complete picture of Dhaka as DSCC was not included in the study.

METHODOLOGY

Study Area

Dhaka North is situated within Longitude 90º20' to 98º28' and Latitude within 23º44' to 23º 54'. Its total area covers 82.638 sqkm which consists of five zones including 36 Wards[1]. In Zone-1, 8 STS was found during survey. Similarly, the number of STS for Zone-2,3,4,5 were 10, 8, 7 and 11. Location of surveyed STS was taken by mobile GPS system (Longitude and Latitude). [Fig. 1] was created using ArcGIS to show location of surveyed STS as follows:

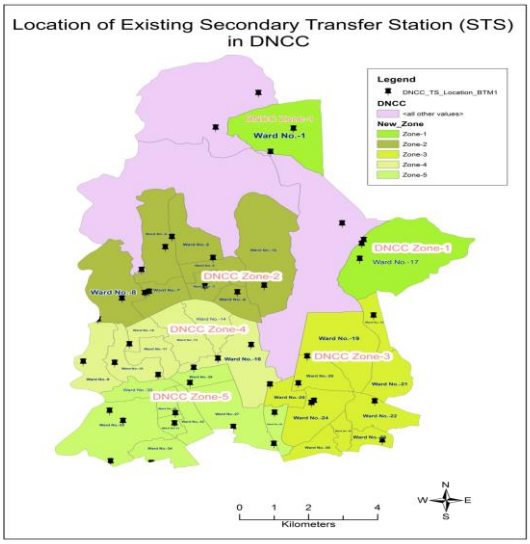


Fig. 1: Location of Surveyed STS in DNCC

Questionnaire Survey

A questionnaire was prepared based on transfer station at different countries and covered all basic requirements in this regard. The lists of items for the questionnaire survey are: number of van; number of transfer vehicle; rated capacity of transfer vehicle; number and rated capacity of container; future extension facility; presence of tin shed; waste dumping on road; road maintenance; adequacy of van or open truck or carrier; comfortability of drivers; leachate management; light, electricity, water supply problem ; presence of ward office; washroom facility, hygiene practice, guard, gate condition.

Waste Collection Scenario by Van into STS

In DNCC, primary waste collection vehicle is Hand Cart or Van and waste collection route mainly organizes by ward officer or the driver himself. DNCC is responsible for secondary waste collection to remove waste from its dustbins/containers, and transport the waste to final disposal sites (Clean Dhaka Master Plan, 2005). NGOs/CBOs/private sectors work as primary collection service provider (PCSP) to collect waste from door-to-door and transport to the dustbins/containers, compactor stations or sometimes to vacant lands, by rickshaw vans. The standard waste carrying capacity of a van is 250-300 kg but the driver has tendency to carry waste as much as they can. The number of trip given by van depends on how large the area to collect waste from & number of van available in the area. Trip number is usually 2-3 per day for Dry season & 3-4 per day for Fruit Season. To determine waste amount delivered into STS by van, Eq. (1) and (2) are used.

[1]Source: Website of Dhaka North City Corporation (URL: http: // old.dncc.gov.bd/ geographical-location-area-of- dncc/)

Trip Generation= Number of Van* Average Trip Generation Number(2 or 3 per van as primary waste collector suggests) (1)

$$\text{Waste Amount} = \frac{\text{Trip Generation per day} * \text{Waste Quantity } (\approx 500 \text{ kg per trip as waste collector suggests})}{1000} \quad (2)$$

Waste Amount Hauled from STS by Transfer Vehicle

Secondary collection is the collection of waste from communal bins, storage points, or transfer station, and transportation to the final disposal site (Rahman, et al., 2010). During site visit, it was seen that there are some STS where container (5 /7 /3 ton) was present. Collection system in which the containers used for the storage of wastes are hauled to the processing, transfer, or disposal site, emptied, and returned to either their original location or some other location are defined as hauled-container system (Peavy, et al, 1985). Carrier truck; designed to carry that particular capacity container; carries away the container from STS to disposal site at 22:00-23:00 usually. In some STSs where no container presents, van directly dumps the waste on the floor of STS. Then wastes are loaded into Open/Dump Truck by using Dozer/Payloader. Dozer/Pay Loader is better option than using hand shovel/sack to load waste into container or transfer vehicle. Though rated capacity of open truck is about 1.5/5/7 ton, workers have tendency to load double and 20-22 inch (avg.) side height has been maintained to avoid waste spilling from side. In some STSs, compactor has been used to carry waste to landfill and usual capacity of compactor is 5,7,3 ton. It takes 1.5~2hr to fill a compactor and usually reduces 1/3 rd volume of waste. In some wards, compactors are used to tackle extra waste produced occasionally, e.g., in vacation (Eid, Puja) or fruit season when waste load is extreme. Waste amount hauled from transfer vehicle can be found using Eq. (3) and (4).

Waste amount hauled by open truck/compactor (ton/day) =Number of Truck/Compactor * trip number * Rated capacity (3)

Waste amount hauled by Carrier(ton/day) =Number of container*Rated capacity of container (4)

Zone of Coverage of STSs

Zone of coverage means area surrounding a specific STS from where waste was disposed into that STS. So to determine the radial distance; population was estimated for different ward for the year 2016 from the data of 2011 and from the estimated population and waste quantity handled by STS per day, radial distance of Zone of coverage around a particular STS was determined by using Eq. (5).

$$\text{Coverage Zone} = 1000 * \sqrt{\frac{\text{Waste Quantity Handled by STS}}{\text{Population Density} * \text{Waste Generation Rate} * 3.1416}} \quad (5)$$

As Zone of Coverage overlapped with each other, to illustrate overlapped coverage area, 'Overlay Tools' and then 'Union' was used in ArcGIS. As coverage area of a STS can go outside of ward boundary, 'Intersection tool' from Geoprocessing Tool box was used to illustrate coverage area intersected with ward boundary. By using Eq. (6), coverage area of a particular STS inside their respective ward boundary can be determined.

$$\text{Now, Coverage Area inside respective ward boundary} = 100 * \frac{\text{Coverage area inside Ward}}{\text{Ward Area}} \quad (6)$$

RESULT AND DISCUSSION

Classification of STS

As no standard practice has been followed to set up STS by DNCC, from field site investigation, STSs can be categorized into five classes by taking consent from DNCC officials which are as follows:

i) *Completely Functional:* sufficient waste handling, future extension facility, tin shed presence, well road maintenance, no vehicle shortage, no light, electricity, water supply problem

ii) *Functional:* sufficient waste handling, roadside dumping, not whole ward covered, shortage of van, no shortage of transfer vehicle, road condition good, tin shed, no light, electricity, water supply problem

iii) *Semi- Functional:* insufficient waste handling, illegal dumping, vehicle maneuvering problem, shortage of available area for new STS, shortage of vehicle, no tin shed, no water supply-electricity

iv) *Non Functional:* Collection vehicle can't enter into STS due to poor road condition.

v) *Under Construction:* to be functional.

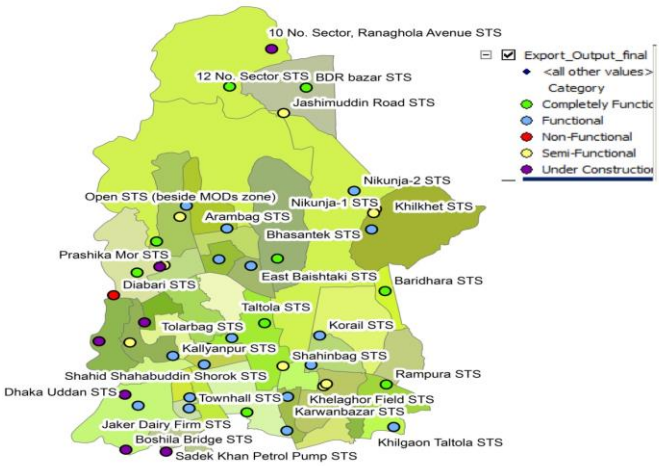


Fig. 2: Different category of STS in DNCC

Among 44 STS, 9 STSs are completely functional, 17 STSs are functional, 9 STS are semi-functional, 8 STS are under-construction, and 1 STS is not operated as in [Fig. 2].

Material-Balance Requirement in STS:

Total amount of wastes hauled to all disposal sites must be equal to the amount delivered to TS (materials-balance requirement) (Tchobanoglous et al.,1977). From survey, among 44 STS, 28 STSs have container and 16 STSs are discharging waste directly on STS floor. By using Eq. (1) and (2) waste amount disposed by van into different STS and then, waste amount disposed by van for all STS per zone was determined. Similar procedure was followed to determine waste amount hauled by transfer vehicle by using Eq. (3) and (4). Table 1 depicts that waste delivered by van is slightly higher than waste hauled from STS because van drivers sort waste which has market value and approximate data was used to calculate waste amount as there was no weighing machine to measure weight in STS.

Table 1: Waste disposed by Van and hauled by transfer vehicle for all surveyed STS in DNCC

Zone	Waste disposed by Van (ton/day)	Waste quantity hauled by Transfer Vehicle (ton/day)		
		Waste quantity (ton/day) carried away by Open Truck	Waste quantity (ton/day) carried away by Compactor	Waste quantity (ton/day) carried away by Carrier
1	348	518	0	0
2	380	0	65	203
3	364	369	10	51
4	313	0	28	188
5	310	0	55	224
Total	1715	1711		

Zone of Coverage

By using Eq. (5) , radial distance of coverage zone surrounding surveyed STS was determined and among 44 STSs, 15 STSs handle waste within 200-500m radius area, 13 STSs handle waste within 500-800m radius area, 7 STSs handle waste within 800-1100m radius area, 8 STSs handle waste within 1100-1700m radius area and only 1 STS handle waste within 2900-3200 m radius area around them and 23 STS can function within 500-550m radius area in average [Fig. 3]. This result may be helpful for future siting criteria of STS. Along with this, population density, slope of the area, road condition should be considered.

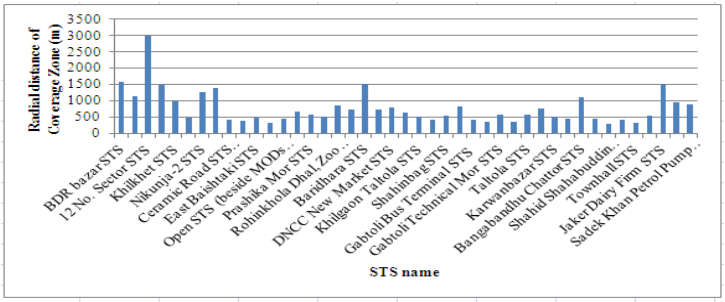
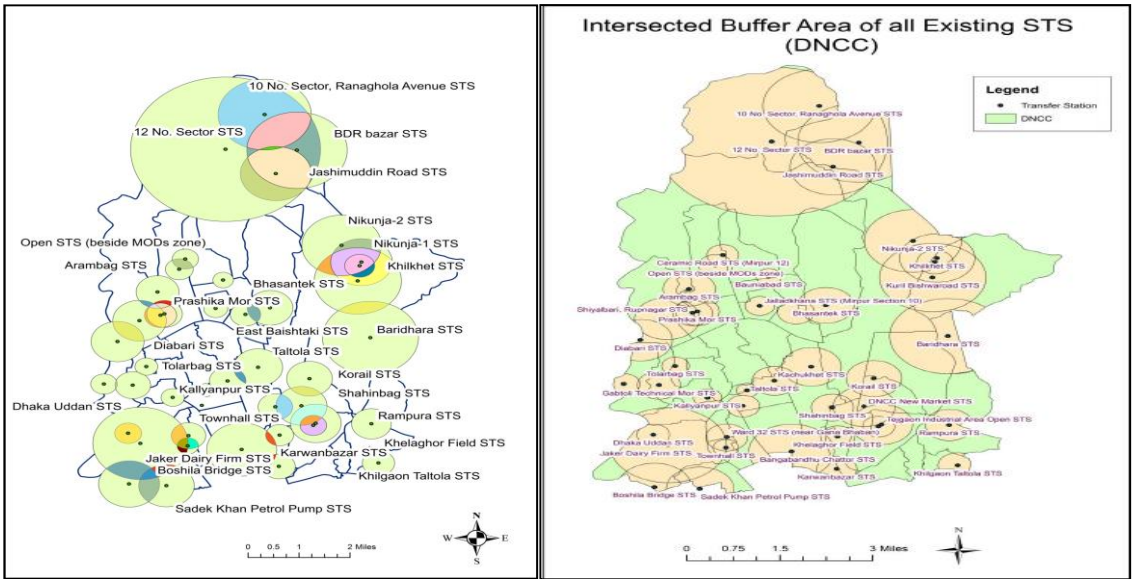


Fig. 3: Radial distance of Coverage Zone around each surveyed STS in DNCC

Coverage area around one STS can get overlapped with coverage area of other STS(s) as in [Fig.4 (a)] shows that coverage area has gone outside over jurisdiction area of DNCC. Using ArcGIS,[Fig. 4(b)] shows coverage area of STS within DNCC boundary respectively.



(a) (b)

Fig. 4: (a) Coverage area overlapped with each other and gone outside of jurisdiction boundary (b) Coverage area of STS within jurisdiction boundary

Using Eqn. 6,percentage of coverage area inside, outside of ward boundary of surveyed STSs was calculated and result has shown in [Fig. 5].

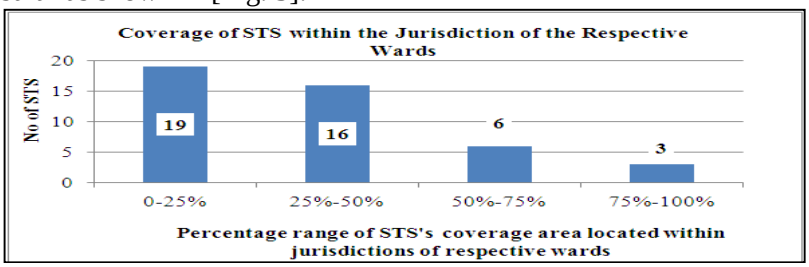


Fig. 5: Number of STSs and their percentage range of coverage area within jurisdiction of respective ward boundary

From analysis result, among 44 STSs, zone of coverage of only 3 STSs are lying within their respective ward boundary by 75-100% of their coverage area which implies only 3 STSs have less positional deviation considering their own jurisdiction boundary. Coverage area of 21 STSs are located outside from their respective ward by 50-80%. So, coverage area of most of the STSs enters other ward. This data helps to manipulate the transfer vehicle routing pattern.

CONCLUSION

DNCC's step towards SWM is appreciable but it needs further revising and proper planning. The following part *addresses gap in SWM practice in our country and relating outcome* of this study:

- In this case study, a number of issues have been found such as leachate outlet, nuisance effects, lack of water supply and hygiene problem which shows maintenance lacking. Based on functionality classification, 9 STS are titled as completely functional. Facilities provided by these STS, can be used as a benchmark and it's possible to upgrade facilities for other STSs with respect to 9 completely functional STS.
- As average radial distance of coverage zone is within 500-550m , so it can be considered that most of the van can carry waste from household to STS upto 550m radial distance. For future siting of STS in other ward, location of STS can be selected so that distance between household and STS can be located within 500-550m radial area.
- The zone of coverage of one STS can get overlapped with other STS. This study shows that before siting a new STS, coverage area of other existed STS should be considered so that efficiency of newly built STS can be ensured.
- As no study was made to explore areas where additional STSs can set up, Town planning department like RAJUK should provide some space for infrastructure facilities. GIS mapping from this study can be used to know the location of existing STS and zone of coverage of each STS which can be helped to determine the feasible radial distance of new STS. It can help to lessen the overlapping of coverage area with new STS and existing STS.
- GIS Mapping which shows coverage area around all existing STS can also help to decide the location where STS could be set up in future in DNCC.
- Zone of coverage of 3 STSs are within their ward boundary by 75-100% and 21 STS's coverage areas are located outside from respective ward by 50-80% which shows positional deviation resulting from improper planning of STS. Coverage area of 7 STSs are outside of the ward by 80-100% of their coverage area and waste coverage of their corresponding ward should be checked.
- Jurisdiction area or ward boundary plays an important role for siting new STS as these STS has been managed by Counterpart (Assistant Chief Waste Management Officer, Conservancy Inspector of DNCC). The acting counterpart of DNCC are responsible for fixing routing pattern of transfer vehicle and coordinating among van driver. From questionnaire survey, counterparts were suggested that routing pattern and transfer vehicle arrival pattern would be flexible if zone of coverage (radial distance where van driver collects waste from household and carries towards STS) lies within ward boundary. But irregular shape of ward boundary makes this task a complex one.

To develop a sustainable waste management system, a number of criteria such as land use pattern, access to major transportation routes, sufficient space for onside roadways, queuing, parking, space for recycling, composting, buffer space of that area should be considered which remains absent at present practice by DNCC. Haul cost minimization, landfill distance, water body, waste type, future waste generation and route map should be considered to get the proper design of transfer station.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

ASSESSMENT OF NOISE LEVEL AND ITS IMPACTS ON HEALTH IN DIFFERENT INDUSTRIES LOCATED IN KHULNA CITY

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ABSTRACT
Noise pollution is an alarming environmental breakdown issue nowadays. Recent industrialization around the world caused an abrupt increase in noise level compared to the past. This study aims at the industrial noise pollution and health effects of it on workers in various industries. Five different types of industries around Khulna city were selected and investigated thoroughly. Sound level was measured by an environmental meter and noise pollution indices $L_{10,}$ $L_{50,}$ $L_{90,}$ NC, NEI, $L_{eq,}$ and L_{np} were calculated. Two different questionnaire surveys were carried out for workers in each industry and for families living adjacent to the industries. It has been seen that the jute and power generation industry exceeds the 90 dB noise level limit described by OSHA. According to the questionnaire survey, 68% of total 75 workers had headache, 50.67% were annoyed, 29.33% were suffering from insomnia and 33.33% feel dizziness due to this noise. However, a Chi-square test was conducted to check the significancy of the effect of noise on worker's health. With a significance level of $p \leq 0.05$, chi-square test shows that the physiological and psychological effects of this noise including annoyance, headache, nervousness, dizziness and speech interference are statistically significant than insomnia and stressfulness.

Keywords: industrial noise, noise pollution indices, health risk of noise, noise standard, questionnaire survey on noise pollution

INTRODUCTION

Sound is a fundamental kind of energy which is produced by the oscillation and vibration of the particles. It remains pleasant until it doesn't create disturbance in usual life. Today's world is an improved, civilized and industrialized world. But it's a matter of fact that industrialization and civilization came up with abnormal increase of sound level upon human race. When sound level exceeds a certain limit beyond human's tolerance, it is called noise rather than normal sound. Noise pollution has increased with an alarming rate in last 100 years and it's doubling after every ten years (Pandey, 1992). As the problem is being more severe day by day, necessary steps must be followed to mitigate the noise pollution and its effects on human body as well. Noise pollution assessment in various countries including the treatment is being conducted with great importance (Kovalchik, Matetic, Smith, & Bealko, 2005). Many experts are forced by this minacious pollution issue to sit together and sort this problem out (Jansen G., 1992). For a developing country like Bangladesh, the amount of noise pollution occurring in different sectors mainly in industries are comparatively high and rate of assessing noise level with efficient noise removal facilities is comparatively low. Industries create a huge noise pollution with its rotors, wheels, cutting machine, electrical machines, driller, crusher (Al-dosky, 2014). As for Bangladesh, Khulna is a city with numerous industries of various categories. This study was conducted to picturize the condition of noise pollution in different types of industries located in Khulna city and to check if the sound level exceeds the permissible limit of sound level which is 90 dB described

by Occupational Safety and Health Administration (OSHA). This study also shows the effect of noise pollution on worker's health and on adjacent families who work in and live around of these industries. For Bangladesh, the assessment of noise level and removal of workplace noise pollution is very needy at this time. This study opens a scope to assess the sound level of different workplaces subjected to noise pollution and to take necessary measures to control the increasing noise level.

METHODOLOGY

Study Area

Five industries of different categories were selected around Khulna city, Bangladesh. The main categories were electrical equipment, cement, heavy metal, agriculture-based and power generation industries. The industries are located at khalishpur, lobon chora, shiromoni and shipyard road on the bank of Bhoirob river of Khulna. This study was conducted during the month of April, 2018.

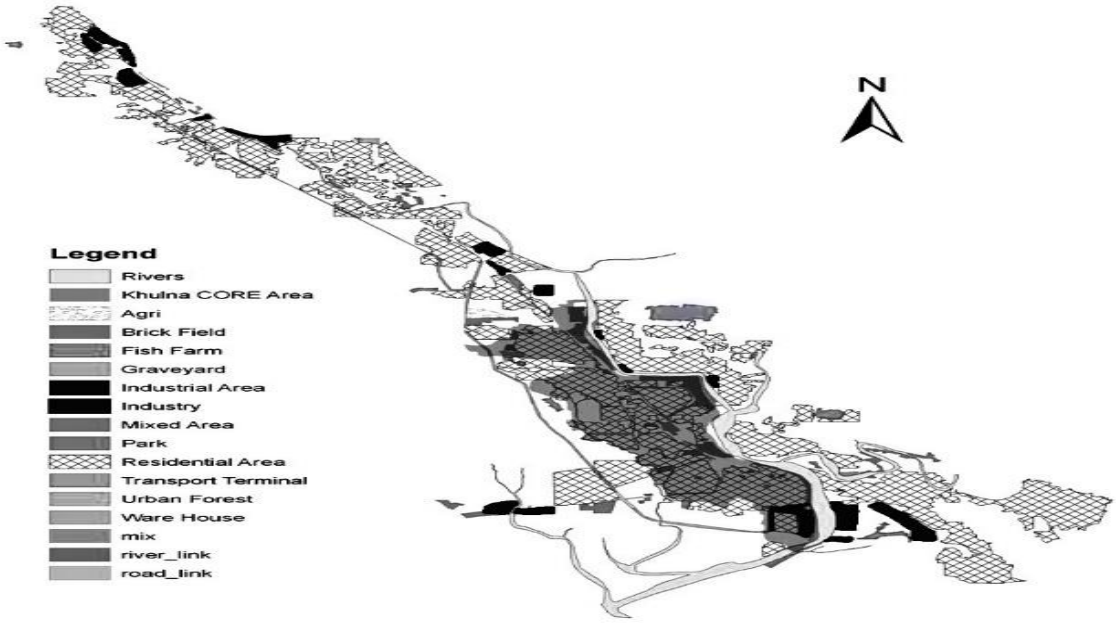

Fig. 1: Industrial areas of Khulna City

Measurement of sound pressure level in industries

The sound level of different locations of various industries was measured by a multi-functional environmental meter (Model: DT-8820) in decibels. The environmental meter was held at a height of human ear for several minutes at different spots where the movement of workers and working magnitude was high. The data was recorded from 8 am to 8 pm each day at a specific industry. Ten spots of each industry were marked and fixed to repeat the sound measurement at every hour for at least five minutes. The average sound level of this ten locations at a specific hour shows the overall sound pressure level of that industry at that hour.

Noise Pollution Indices

Various noise pollution indices like L_{10}, L_{50}, L_{90} were computed based on gaussian percentile to obtain the noise level of each industry and to express the magnitude of noise with various important terms like Noise Climate (NC), Equivalent Continuous Noise Level (L_{eq}), Noise pollution level (L_{np}) and Noise Exposure Index (NEI) (Tripathi et al., 2006). The following equations are used to compute noise pollution indices,

$$NC = L_{10} - L_{90} \quad (1)$$

$$L_{eq} = L_{50} + [(NC)^2/60] \quad (2)$$

$$L_{np} = L_{eq} + NC \quad (3)$$

$$NEI = (t_1 / T_1) + (t_2 / T_2) + ... + (t_n / T_n) \quad (4)$$

Where, L_{10} is the sound level exceeding 10% of the total measured time or peak sound level, L_{50} is the sound level exceeding 50% of the total measured time or mean sound level and L_{90} is the sound level that exceeds 90% of the total read time or residual sound at the background of the workplaces; t_1 to t_n is the actual limit of exposure of a corresponding sound level where T_1 to T_n is the permissible limit of exposure of a corresponding noise level. If the value of NEI is greater than 1 in any spot during a specific hour, the noise exposure level is considered to be as excessive (Hunashal & Patil, 2012).

Questionnaire survey

Two different questionnaire surveys were conducted among the workers and families living just near the industries to understand the noxious effects of noise on their health. The survey on workers contained thirty (30) questions about their gender, age, working year, knowledge of noise pollution, educational background, working hour and shift, responsibilities of industrial authority towards them, psychological and physiological effects of noise etc. Fifteen (15) workers of an industry were selected arbitrarily for this questionnaire program. Five (5) families living adjacent to each industry were questioned about their living year at those areas, physiological and psychological problems, noise effect on schools nearby and knowledge of permanent hearing loss etc. Physiological and psychological effects on workers and families include the problems of insomnia, dizziness, annoyance, headache, disturbance to the peace of mind, nervousness, stressfulness, speech interference, heart problem etc.

Statistical Analysis

All the measured data of sound level at different industries and questionnaire survey data was stored in Microsoft Excel 2013. Statistical Package for Social Scientists (SPSS) and Chi-square test were opted for understanding whether the noise effect on worker's health is significant or not.

RESULT AND DISCUSSION

Noise level measurement

The number of the surveyed industries according to their types, noise level range and mean noise level in these industries are demonstrated in table 1.

Table 1: Different type of industries, their noise range and mean noise level for 12 hour read-time

Industrial group	No. of industry	Noise level range	Mean noise level
Electrical Equipment (Cable)	1	80.6~86.67	83.63
Cement Manufacturer	1	72.44~74.98	73.79
Heavy Metal (Shipyard)	1	69.72~88.15	80.32
Agriculture (Jute)	1	88.07~92.59	90.78
Power Generation (Electricity)	1	88.45~96.23	92.53

Table 1 interprets that the maximum noise is produced by the power generation industry followed by jute industry, cable industry, shipyard industry and cement factory. Different noise pollution indices such as L_{10}, L_{50}, $L_{90,}$ NC, NEI, L_{eq}, and L_{np} were calculated for power generation industry and shown in Figure 2. Figure 2 demonstrates the overall noise atmosphere of a typical industry based on the noise it produces every day at a specific 12-hour working period interval (8am to 8pm). It shows that the maximum L_{10} was observed during working hour as 103 dB in between 3:00-4:00 pm. By same approach, the maximum L_{50} and L_{90} was 96.23 dB and 93.6 dB in between 3:00-4:00 pm. Equivalent continuous noise level (L_{eq}) uses L_{50} and NC for interpreting a stationary noise level of same sound energy from continuously fluctuating sound levels over time (Letters, 2015). Highest L_{eq} was recorded as 97.7 dB during 3:00-4:00 pm of the evening where the minimum L_{eq} was 88.94 dB at 8 am of the

morning. The highest L_{eq} value of power generation industry exceeds the permissible L_{eq} limit described by Central Pollution Control Board (CPCB, India 2000) which is 50 dB at best. This exceeding noise level specifically refers to a stable noise level which is opted from several fluctuating sound levels which were changing with time during the readings were taken.

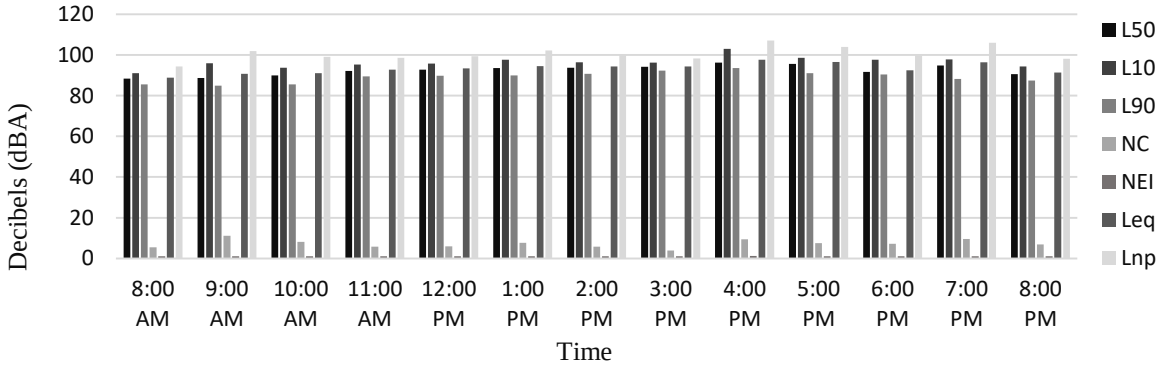

Fig. 2: Calculated noise pollution indices for power generation industry

The noise pollution index (L_{np}) takes both NC and L_{eq} into account to express a clear idea of noise pollution with fluctuations in stable noise level scale. Besides, L_{np} is considered as the best indicator of psychological and physiological health effects of noise pollution. The maximum magnitude of L_{np} was recorded as 107.1 dB during the time period of 3:00- 4:00 pm and minimum L_{np} was 94.3 dB at 8 am of the morning. From Fig. 2, the maximum sound for power generation industry was observed at 3.00-4.00 pm and minimum sound was heard and weighed at 8 am of the morning. L_{np} and L_{eq} values are maximum for power generation industries because this type of industries own automated or man-driven pilot-scale machines that contribute to a huge noise while production is active and running. The adverse effects and issues of noise pollution lift up to critical situation with the increase of the value of these noise pollution indices. However, table 2 shows the scenario of Noise climate (NC) and Noise Exposure Index (NEI) for five surveyed industries of Khulna city of different types.

Table 2: Data on noise pollution indices with respect to Noise Climate (NC) and Noise Exposure Index (NEI) for different industries of Khulna city at different time period

Time	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm
Electrical equipment (Cable) Industry													
NC	15.4	12.7	10.1	9.6	8.3	8.8	9.6	6.8	10.5	11.6	8.7	8.7	5.6
NEI	1.07	1.08	1.10	1.14	1.146	1.15	1.07	1.14	1.13	1.11	1.10	1.13	1.07
Cement Industry													
NC	23.3	22.3	21.7	22.1	19.4	19.9	19.6	18.3	20.6	21.9	21	20.9	21
NEI	.905	.906	.910	.919	.9298	.924	.916	.919	.928	.937	.934	.928	.929
Heavy Metal (Shipyard) Industry													
NC	21.9	21.7	14	15.4	15.8	16.8	44.5	21	17.5	17.1	14.3	13.3	11.3
NEI	1.05	1.06	1.063	1.07	1.082	1.09	1.05	1.10	.939	.885	.884	.871	.886
Agriculture (Jute) Industry													
NC	18	16.6	18.3	18.2	14.7	17.8	12.9	13.5	12.4	11.5	15.2	9.3	7.9
NEI	1.08	1.10	1.155	1.14	1.157	1.15	1.10	1.14	1.14	1.14	1.12	1.15	1.14
Power Generation (Electricity) Industry													
NC	5.4	11.1	8.1	5.8	6	7.7	5.7	3.9	9.4	7.5	7.2	9.6	6.8
NEI	1.04	1.04	1.057	1.08	1.092	1.10	1.10	1.10	1.13	1.12	1.07	1.11	1.06

Noise Climate (NC) values indicate a range of noise level over which the sound level can fluctuate with noise exposure period and finally expressed in dB (A) which depends on other basic noise level indices (Kumar & Srinivas, 2015). The maximum NC was observed at shipyard industry as 44.5 dB (A) at 2

pm which indicates a wide range fluctuation over maximum to minimum noise level at that specific hour. Minimum NC value was encountered as 3.9 dB (A) at power generation industry at 3 pm indicating that the maximum and minimum noise level were close enough during that hour. This close range of sound level indicates that sound was continuously exceeding the standard noise level limit in power generation industry for whole 12 hour duration. Noise exposure index (NEI) indicates whether the locations where noise is being produced are exposed to high noise exposure or not. Practically, Industries having NEI >1 are exposed to high frequency of noise exposure and workers can feel the differences of home and workplace's sound climate after having a long term work experience in these industries. In this study, NEI is greater than 1 for each industry except cement manufacturing industry and this implicates that the sound climate of these industries is not just salubrious for worker's health.

According to table 1, the magnitude of the noise level clearly showed that the jute and power generation industry is producing noise that exceeds the standard noise exposure limit of 85 dB for a 8-hour work shift described by NIOSH (Dotter, 1998). Workers working on high noise exposure spot for a long time suffer from serious health issues as long term noise exposure gradually makes human body unable to withstand the high frequency of noise pollution (Res, 2005). This serious scenario provides information about taking mandatory steps to control noise production such as active noise cancellation, use of ear protection equipment (EPE) and most importantly, shifting the workers to various locations within the industry in time to time instead of keeping them exposed to excessive noise exposure for a long period of time.

Questionnaire survey result

The relation between workplace noise and hearing loss is being observed for many years (Franks, 1988). To understand the scenario better, total 75 workers of 5 industries were questioned and each of them participated voluntarily. In this survey, the most irony point of real work zones came out that except shipyard industry none of this huge industries inspire to use ear protection equipment even don't show any interest on protecting workers from this devastating noise hazard. The age variation of workers remained between 17~60 years. According to the survey, tolerance of this noise increases proportionally with the working year of a worker. The educational level of workers ranges from class 5 to university level. The physiological and psychological effects of noise on workers were seen adverse as survey showed 68% suffers from headache, 50.67% were annoyed of this noise, 29.33% were insomnia patient and 33.33% experience dizziness due to this noise. 74.67% of them want themselves to be shifted in a quieter place. It was observed that no industry gives long term medical support to a worker suffering from noise hazards. While conducting survey on families living adjacent to the industries it was seen that, all the industries except power generation industry situated at a minimum distance from the residential area. For this reason, families living adjacent to the power generation industry are the victims of this huge, gigantic noise for all day and night. Survey showed that families living in this area for more than twenty years have at least a member who have lost his/her hearing capability for good. It was also seen that, new families are not interested to buy or rent houses in this area as well.

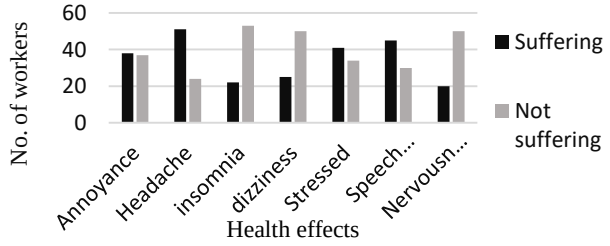

Fig. 3: Health effects on worker's health

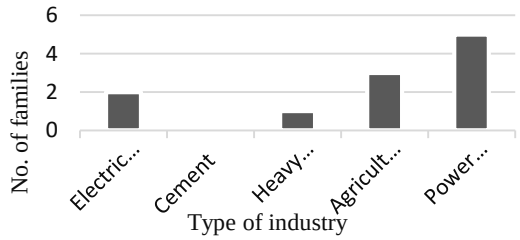

Fig. 4: No. of families affected with respect to industries

Statistical Results

IBM SPSS 25 was used to carry out the Chi-square test to check the significancy of the physiological and psychological effects of this industrial noise pollution on worker's health and the results are tabulated with standard deviation in table 3. According to this test, health effects for which $p \leq .05$ are significant on worker's health based on asked questions in "yes or no" answer formation.

Table 3: Chi-square values of different health effects of industrial noise pollution and their significancy to the worker's health

Types of effects	Total Chi-square value	Asymptotic Significance, p (2 sided)	Mean Asymptotic Significance	Standard Deviation (σ)	Relationship between the types of health effects and significancy of them based on answers of workers p ≤ .05
Annoyance	4.669	.031	.165	.051	Significant
Headache	22.443	.000		.062	Very Significant
Insomnia	.279	.597		.163	Not Significant
Dizziness	6.926	.008		.06	Significant
Stressfulness	.436	.509		.130	Not Significant
Speech Interference	14.460	.000		.062	Very Significant
Nervousness	7.365	.007		.06	Significant

CONCLUSION

This study mainly shows that we have an alarming issue with industrial noise pollution in Bangladesh as it had grown so fast in recent years and yet increasing with an abnormal rate. Long term work experience in noise pollution drives into abnormal breakdown of health and imbalance of the mental condition of an individual. The condition of industrial noise of Khulna city is not beyond limit but it is surely unhealthy to work in that noisy environment for long time. Removal of this industrial noise is not completely possible. Using Ear Protection Equipment (EPE), opting active noise cancellation method, raising awareness about industrial noise pollution among the workers are the only ways to be safe from industrial noise. However, industrial authorities should take responsibilities of worker's health, give long term medical support in this regard, provide ear protection equipment and make the use of it mandatory inside the industry premises. This study can be enlarged by assessing noise level for all the industries throughout the country, educational institutions, residential areas, market places for the betterment of the people's health and mind by controlling the noise pollution threat so far.

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USE OF GROUND CHICKPEA AS BIO-COAGULANT IN SURFACE WATER TREATMENT

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ABSTRACT
Water is very important for the survival of both plant and animal. Consumption of safe water is a must for humans because polluted water causes different types of water borne diseases. In a 3rd world country like Bangladesh, it is quite difficult to ensure a safe water collection zone. Due to excess withdrawal of water in the ground water level of Dhaka city, in last 7 years about a 6 meters drop has occurred. Therefore we need to use our surface water sources which are contaminated due to disposal of uncontrolled domestic and industrial waste water. Coagulation is a conventional step of water purification and bio-coagulant is a new horizon to go green. Cicer arietinum, which is known as chickpea, can be used for the treatment of surface water. The coagulant of such kind may not replace synthetic conventional coagulant like alum but be an alternative at times of crisis. In this study, removal of turbidity and colour of the water of Hatirjheel, a lake of Dhaka city were conducted at different periods using different doses of coagulant with consistent pH level and approximately 70% removal of suspended materials were observed.

KEYWORDS
Coagulation; Flocculation; Turbidity; Colour; Filtration

INTRODUCTION
Water is such an element that is very important for the livings. Water holds the major portion of the world. Though there are plenty of water, most of the sources do not have water having consumption capability fir humans. For an example, sea water is very salty to consume though it is the largest source of water. For human consumption, mostly surface water and ground water is used. Apart from drinking, water is needed in almost all daily activities of human. Besides, industrial sector uses large amount of water. Water is consumed and then after usage, it is left in the environment in a polluted form. So there is the imbalance, pure water is collected and polluted water is dumped. Nature refines the polluted water through hydraulic cycle and turns it into pure water. But the rate is very low. So polluted water is treated artificially for usage. Most of the surface water sources are polluted by man produced waste. Again there are some countries with limited water sources. Sometimes there are not enough technologies or procedure for water treatment. So people consume untreated water and diseases spread. So water pollution problem must be handled. Treatment of waste water is a major priority of today.

There are many procedures for waste water treatment. Some of them are cheap and small scale treatment. There are some treatment plant where large scale water treatment is done and also consumes

huge money. Like all other sectors, we need a sustainable, cheap solution for water treatment to ensure easy human consumption. There are mainly three plant based water treatment procedure.

1. Biological Treatment Process
2. Physico-Chemical Treatment Process
3. Physico-Chemical and Activated Sludge Process

Each of the process needs coagulation for settling where coagulants are used. Coagulation is the process of coagulating colloidal particles due to the addition of synthetic materials to neutralize charged particles thus forming a precipitate due to the force of gravity. Synthetic materials such as Ferrous Sulphate ($FeSO_4$), and Aluminium Sulphate or alum ($Al_2(SO_4)_3$) etc. are used to do so. Normally different synthetic coagulants are used for this process. Coagulation is used also in small scale water purification in households. Alum is such conventional coagulant. But as we are trying to find greener solution for every sector, bio-coagulants can bring about an evolution. Chickpea can work as a bio-coagulant and provide fine performance in comparison with the conventional synthetic coagulants.

CHICKPEA

The chickpea (*Cicer arietinum*) is a legume of the family Fabaceae. Its different types are variously known as gram or Bengal gram. Indian subcontinent produces major portion of total chickpea production in the world. It is also available in Africa where safe water sources are limited. Usage of chickpea can bring evolutionary changes there. The reasons of choosing chickpea as coagulant asr followings:

- It can be used in the coagulation tanks as a major part of the treatment process and this research shows positive result on the performance of chickpea as a coagulant.
- Again consumption of water treated by synthetic coagulants may have long term disease effect like Alzheimer on the human body.
- Chickpea is also cost efficient.
- Chickpea is available in the tropical countries like Bangladesh.
- Chickpea can perform without bringing major fluctuation in the pH level whereas Alum cannot do that.

METHODOLOGY

For experimenting the performance of chickpea in surface water purification, sample water from Hatirjheel was taken. Waster was collected in grab sampling method and in different season (temperature) as water quality fluctuates in different season.

Collection and Processing of Chickpea

- Middle aged chickpea is needed for the process
- Seed coat is removed and air dried
- Then chickpea is grinded and powdered

Apparatus and Procedure

1) Colour test: HACH, DR/2010 spectrophotometer
2) Turbidimeter: 2100P Turbidimeter
3) Pocket pH meter

Sample Preparation

Water was collected from Hatijheel (Badda) portion at different periods.
Water pH level was determined and it was around 6 to 7.5.
Diluted HCl and NaOH was used to keep the pH of the sample at 7 before the whole procedure and it took very small volume of these to control the pH level.

Jar Test

– To conduct the jar test, the sample in six beakers each of 500 liters were taken.
– An estimated amount of the grinded chickpea in each of the beakers were added.
– Then the beakers were stirred for about one minute.
– Then the beakers were placed on "jar test" apparatus.
– The speed of the rotation was chosen about 250 rotation per minute for 1 minutes and after that 30 rotations per minute for 15 minutes and then allowed to settle (40 rpm for 1 minute and later 25 rpm for 15 minutes for alum)
– We found the turbidity and colour of each sample.

DATA COLLECTION

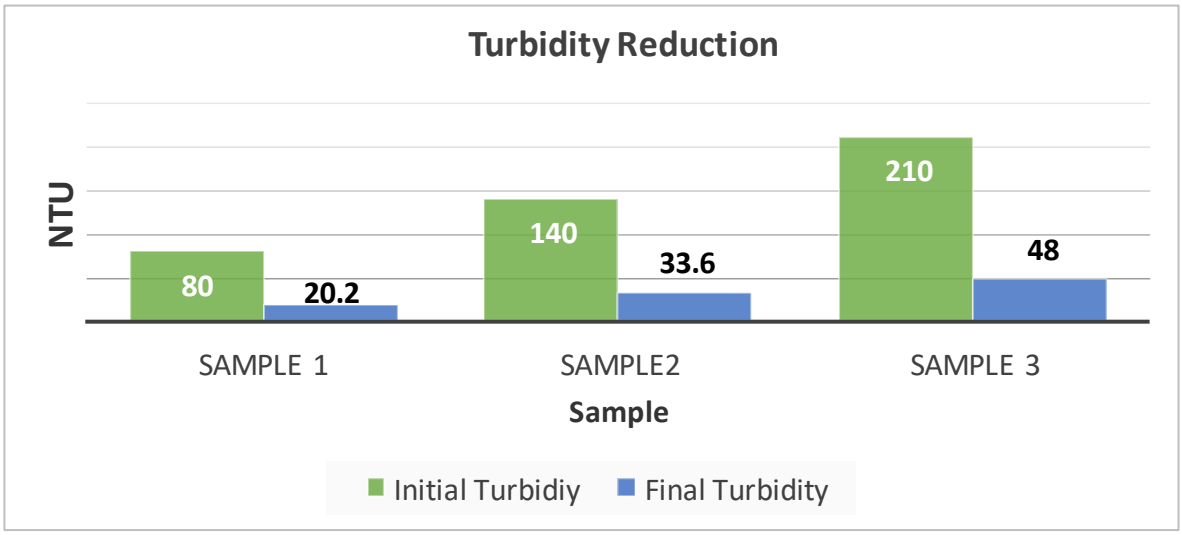
Initial Turbidity (NTU):80					
Initial pH:7					
Initial Colour (Pt-Co):140					
Jar No.	**Dose (mg/L)**	**Final Turbidity (NTU)**	**Final pH**	**Optimum Dose (mg/L) and Turbidity (NTU)**	**Performance**
1	.015	32	7.3	.026 g/L 20.2 NTU **Colour** 25 Pt-Co	Suspended Particle Removal = **74%** Colour Removal = **82%**
2	.02	31	7.1		
3	.026	20.2	7.1		
4	.04	23.9	7		
5	.05	24.6	7		
6	.064	25.3	6.9		

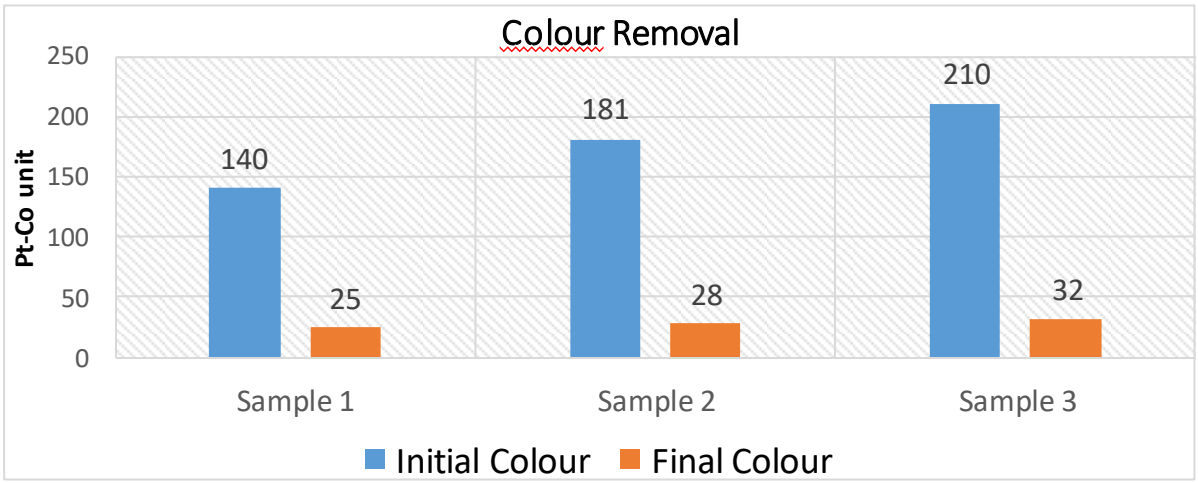
Initial Turbidity (NTU):140					
Initial pH:7					
Initial Colour (Pt-Co):181					
Jar No.	**Dose (mg/L)**	**Final Turbidity (NTU)**	**Final pH**	**Optimum Dose (mg/L) and Turbidity (NTU)**	**Performance**
1	.027	55.8	7.5	.0572 g/L 33.6 NTU **Colour** 28 Pt-Co	Suspended Particle Removal = **76%** Colour Removal = **85%**
2	.0358	53	7.5		
3	.0426	49.9	7.6		
4	.0458	46.7	7.5		
5	.0572	33.6	7.3		
6	.07	37.3	7.4		

Initial Turbidity (NTU):210
Initial pH:7
Initial Colour (Pt-Co):280

Jar No.	Dose (mg/L)	Final Turbidity (NTU)	Final pH	Optimum Dose (mg/L) and Turbidity (NTU)	Performance
1	.025	65	7	.043 g/L 48 NTU **Colour** 32 Pt-Co	Suspended Particle Removal = **77%** Colour Removal = **89%**
2	.032	56.4	6.8		
3	.039	59.6	6.7		
4	.043	48	6.9		
5	.05	55.5	6.9		
6	.059	71.4	6.9		

RESULT





Experiment Place
Laboratory of Environmental Engineering
Department of Civil Engineering
Bangladesh University of Engineering & Technology

CONCLUSION

Chickpea is capable of working in all the condition of this surface water without bringing major changes in the pH level. Moreover, it reduces colour and turbidity at a high rate with very less usage. So it definitely can be an alternative to the conventional synthetic coagulants. Then again, chickpea is available in tropical counties. Subcontinent produces the major portion of the total production in the whole world. So for a country like Bangladesh having less safe water collection zone, chickpea can play vital role in both large and small scale water purification. If treated water is filtered, safer water will be obtained. Mass production of chickpea is necessary to replace synthetic coagulants from the treatment process along with further testing on this. Further tests on this biological coagulant are being conducted to evaluate its performances in BOD, COD reduction. And it has given promising result so far.

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4thInternational Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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EFFECT OF LOW TEMPERATURE ON HYDRODYNAMICS OF A HYBRID ANAEROBIC BAFFLED REACTOR (HABR)

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ABSTRACT
This paper presents a study on the effect of low temperature on hydrodynamics of a hybrid anaerobic baffled reactor (HABR) with seven compartments, in which first five were anaerobic baffled reactor and the rest two were floated/fluidized bed reactor. The reactor was run with a constant hydraulic retention time (HRT) of 10 h at 25°C (normal water) and 10°C (cold water). Residence time distribution studies were carried out by tracer experiment to evaluate the hydrodynamic flow characteristics under variable temperature. The mean residence time of the reactor at 25°C was found 4.77% greater than the other temperature. No significant difference in mixing pattern was observed after the first chamber due to temperature change. However, it was observed that the dispersion number (1/Pez) is 57% higher in the first chamber in case of normal water than cold water. Dead space from 1st to 5th chamber was changed due to temperature change. Dead space in the 5th chamber at 10°C was found 80% higher than 25°C. As dead space was 0 in the 6th chamber for the two temperatures; therefore, the optimal number of chamber of the reactor should be 6 for both temperatures. A very good hydraulic efficiency ($\lambda p \geq 0.75$) was obtained from 4th to effluent for the two different temperatures.

Keywords: anaerobic baffled reactor; hydrodynamics; temperature; residence time distribution; tracer.

1. INTRODUCTION

Nowadays, a lot of completely controlled reactors have been used for treating wastewater. Over the last 20 years, it has been observed that significant advances have been made in anaerobic reactor design (Speece, 1996). These advances have allowed reactors to have a high solids retention time (SRT 20±100 days) while maintaining the hydraulic retention time (HRT) to a minimum (1.3±20 h), and have enabled economic treatment of a variety of dilute wastes, like sewage (Langenhoff, 2000a). Among of them a novel type of reactor is the Anaerobic Baffled Reactor (ABR). Initially, McCarty and his co-workers developed the anaerobic baffled reactor at Stanford University to treat high strength wastewater (McCarty, 1982). ABR basically represents an arrangement of a series of the up-flow anaerobic sludge blanket (UASB) reactors. There is an arrangement of vertical baffles that guide the wastewater to flow under and over them (Barber & Stuckey, 1999). Anaerobic digestion technology has some advantages, like larger biomass retention, proper system stability, needs no aeration, and high COD removal efficiency (Chen et al., 2011; Demirel, Yenigun, & Onay, 2005; Lu, Ma, Liu, & Li, 2011). Now the treatment efficiency of an anaerobic digestion process primarily depends on two important factors: reactor's hydrodynamics and the performance of the microbiological processes which are predominantly influenced by its construction (Ascuntar Rios et al.,2009)

Hydrodynamics and Hydraulics of flow are among the crucial factors in the design and operation of various wastewater treatment technology. The efficiency of wastewater treatment processes in any biological reactor largely depends on the hydrodynamic behaviour of that reactor. The extent of contact between the substrate and bacteria is greatly influenced by the degree of mixing that occurs within a biological reactor, thus controlling mass transfer (Mansouri et al., 2012). Therefore, hydrodynamic characteristic is an important factor for good reactor configuration.

The efficient treatment of low strength wastewaters in an anaerobic baffled reactor (ABR) at mesophilic temperature (at low retention times) has been described elsewhere (Langenhoff, 2000a). Almost every full-scale treatment systems work below the mesophilic temperatures (30±35°C). However, the temperature a huge amount of wastewaters, including domestic sewage, is lower than 35°C, heating is required and which increases the costs of treatment. Therefore, if anaerobic treatment systems able to treat wastewater at low temperatures (10±2°C) it will reduce the treatment costs for low-temperature wastewaters, and could significantly enhance the range of anaerobic treatment (Langenhoff, 2000b). The performance of an anaerobic reactor can be affected by the Reduction of the operating temperature as biological processes are affected by temperature (Nachaiyasit & Stuckey, 1997). So it is clear that temperature has a significant effect on the first factor (performance of the microbiological processes) on which the treatment efficiency of a reactor depends. But the effect of temperature on the hydrodynamics of an anaerobic baffled reactor which is the second crucial factor is not clear yet.

2. METHODOLOGY

2.1. Reactor Configuration

The hybrid anaerobic baffled reactor, which is a type of ABR with two fluidized bed reactor can be used to treat high strength wastewater. A laboratory scale anaerobic baffled reactor with seven compartments, first five are anaerobic baffled reactor and rest two are fluidized bed reactor was developed. The walls and baffles are constructed with clear acrylic plastic (celluloid sheets). The reactor is rectangular in shape. The total volume of the reactor was 38.6L and has a length of 90 cm, width of 20cm and a height of 30cm. The 7 compartments are separated by standing baffles. There are also hanging and inclined baffles which make the water path zigzag in pattern. As a result, there is an up-flow and down-flow section in a ratio of 4:1 in every compartment. The length of the first chamber was 22cm, second to fifth was 11cm, and last two chamber was 12cm in length. The lower portion of the inclined baffles was bent at 45° to route the flow to the centre of the up-flow chamber, thus achieving better contact and greater mixing of feed and bio-solids. There is a sampling port at each chamber to collect sample. The last two chambers of the baffled reactor were packed with Shredder plastic bottle cork worked as fluidized bed reactor. The main advantages of this type of filter media are that it has a lower specific gravity than water. So it floats above water and does not block the water way. A dispensing pump was used to flow water into the reactor. Temperature of effluent water was controlled by water bath (Nuve BM30) up to ±2°C.

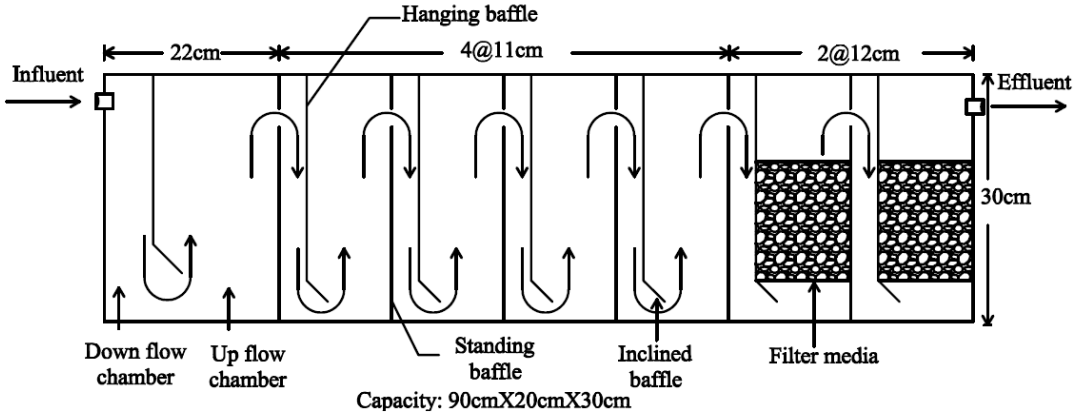

Fig. 1.The schematic diagram of experimental setup.

2.2. Experiment method

Tap water of 25°C (normal water) and 10°C (cold water) was used as influent at a constant HRT (10HRT). Residence time distribution (RTD) studies were performed to analyse the hydrodynamics of the reactor by injecting an inert tracer to the reactor by pulse input method and response was observed thus, the RTD curve was plotted. Tracer was injected instantaneously before the inlet at the very beginning of the run. The effluent samples were taken from the sampling port of the reactor at regular intervals from the time of impulse and the total sampling time was 2.5 times of nominal HRT. The EC of the samples were measured. From the measured EC concentration of tracer was calculated.

2.3. Theoretical Interpretation

The normalized RTD curve is developed in terms of normalized time against normalized tracer concentration

$$\text{Normalized time}, \theta = \frac{\text{time(h)}}{\text{HRT(h)}} \qquad (1)$$

$$\textit{Normalized concentration}, C\theta = \frac{C(t)\ \textit{concentration}(mg/L)}{\text{Co}\ \textit{nitial concentration}(mg/L)} \qquad (2)$$

Where C_Θ is the normalized tracer concentration at dimensionless time Θ. The tracer concentration at time t is C(t) and the initial tracer concentration is C_0 (Grobicki & Stuckey, 1992b).

Equation [1] and [2] provide the expressions of normalized concentration (C_Θ) as the vertical-axis and normalized time (Θ) as the horizontal-axis for comparisons between the RTD studies.

The normalized curve is also called RTD curve, and when tracer is used by a pulse input method, the area covered by the normalized curve is known as E curve (exit age curve), that is the time take for the fluid to come out of the outlet. The area under the E curve is equal to 1.

$$\int_0^{\alpha} E(t)dt = 1$$

Here E(t) is the RTD function. The RTD function, E(t), value is correlated to the C(t) value as shown in Eq. (4) & (5), which was used to calculate E(t), the mean residence time τ and σ^2 variance of RTD studies (Renuka et al., 2015).

$$E(t) = \frac{c(t)}{\int_0^{\infty} \text{c(t)dt}} \qquad (3)$$

$$\tau = \frac{\int_0^{\infty} \text{tE(t)dt}}{\int_0^{\infty} \text{E(t)dt}} = \int_0^{\infty} \text{tE(t)dt} \qquad (4)$$

$$\sigma^2 = \int_0^{\infty} (t-\tau)^2 E(t)dt \qquad (5)$$

Dead space could be calculated as:

$$X = \left(1 - \frac{\tau}{HRT}\right) * 100 \qquad (6)$$

Dispersion model: $$\sigma_\theta^2 = 2\left(\frac{D}{uL}\right) - 2\left(\frac{D}{uL}\right)^2 \left(1 - e^{-uL/D}\right) \qquad (7)$$

Where, N = number of theoretical tanks in series, D = molecular diffusivity (cm2/s), u = average liquid velocity (cm/s), L= liquid path length through reactor (cm). If D/uL = 0, the reactor approximated to the ideal plug-flow reactor (PFR, D/uL= 0). If D/uL =∞, the reactor approximated to the ideal continuous-flow stirred-tank reactor (CSTR, D/uL= 1). In case of non-ideal flow, D/uL value was between 0 and 1

(0 < D/uL< 1) (Xu, Ding, Xu, Geng, & Ren, 2014). N, the main parameter of the Tank in series model, could be calculated by Eq. 8. The tank-in-series (TIS) model simulates the number of actual CSTR reactor (with the same volume) in series. If N → 1, the reactor represented as a CSTR, and if N→∞, the reactor represented to plug flow reactor (PFR) (Renuka et al., 2015).

$$N = \frac{1}{\sigma_\theta^2} \qquad (8)$$

The hydraulic efficiency represents the ability of the system to distribute its flow uniformly throughout its volume, maximizing the contact time of pollutant in the system and optimizing the ability to break down the pollutants (Renuka et al., 2015). The value range of hydraulic efficiency varies from 0 to 1, and classified into three groups: (1) good hydraulic efficiency with $\lambda > 0.75$, (2) satisfactory hydraulic efficiency $0.5 < \lambda \leq 0.75$ and (3) poor hydraulic efficiency $\lambda \leq 0.5$.

$$\lambda = e\left(1 - \frac{1}{N}\right) \qquad (9)$$

Where, e is the effective volume, calculated as one minus dead space and N is the number of on continuous stirred tanks in series(Sarathai, Koottatep, & Morel, 2010).

RESULTS AND DISCUSSIONS

RTD of ABR

The RTD curves for the two different temperatures 25^0C and 10^0C obtained by plotting normalized time vs. concentration (mg/L). Fig. 2(a) shows the RTD of 1-, 2-, 3-, 4-, 5-, 6-, 7-chamber and effluent of the HABR at 25^0C and Fig. 2(b) at 10^0Crespectively. As shown in the figures, the reactor residence time curve firstly rises and then drops, forming one single peak. With the increase in the ABR chambers, the peak value of the RTD curves decreased as well, while the distribution width of the RTD curves turned wider on the time axis for both temperatures. (a)

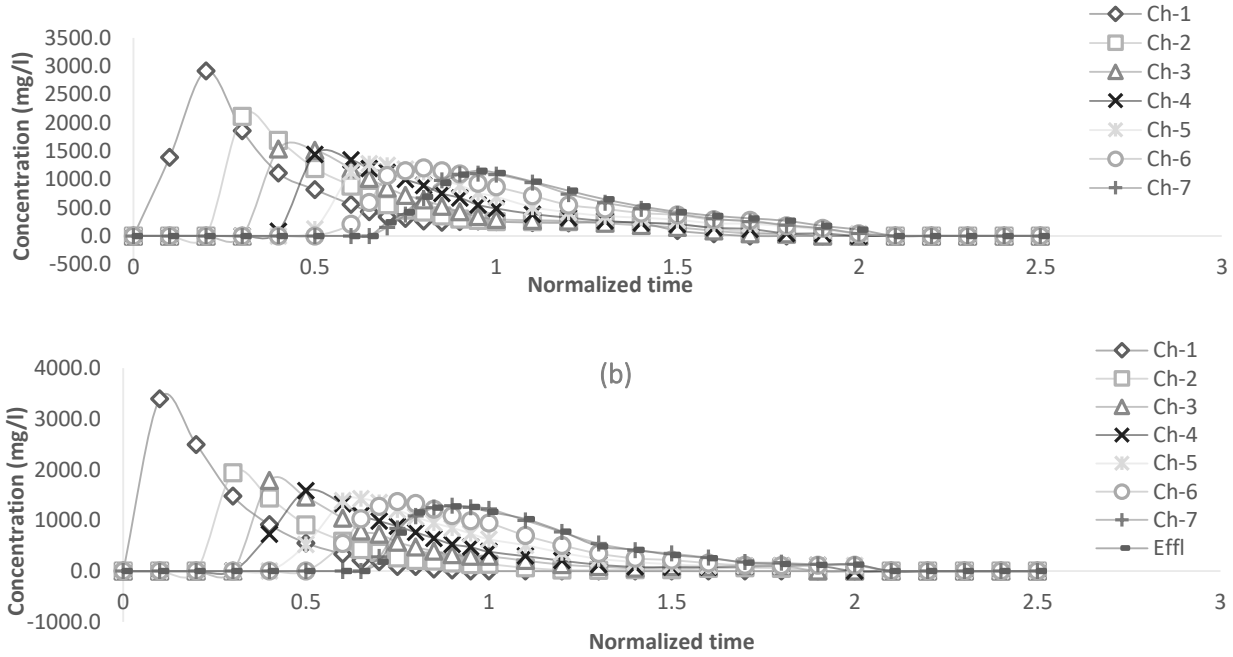

Fig. 2.RTD curves of HABR for normal water (a). RTD curves of HABR for cold water (b)

Mean Residence Time

The analysis of the RTD for the two different temperatures showed that, with the increase in the ABR chambers, the mean residence time also increase. The mean residence time for 25°C was found 4.8% greater than 10°C. The mean residence time was obtained at chamber-6 for normal water and chamber-7 for cold water. That's mean the atoms leave the reactor to spend enough time Fig. 3(a).

Mixing pattern

The term ul/D is called peclet number (Pez). It was found that 1/Pez of normal water is 57% higher than cold water but after first chamber temperature had no significant effect on mixing pattern. As the value of D/ul moved to 0 with the increase of number of chamber, the fluid in the reactor increasingly took the form of plug flow Fig 3(b).

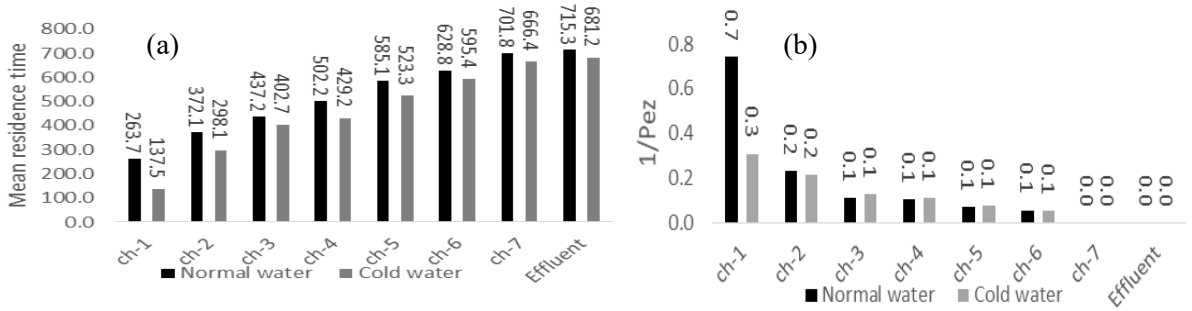

Fig .3. Mean residence time of various chambers & effluent at 25^0C and 10^0C (a). 1/Pez of chambers and effluent of the ABR at 25^0C and 10^0C (b).

Dead Space

Dead space in the reactor generally represents the hydraulic dead space and biomass dead space. But in this study, tap water was used to analyse the hydrodynamic characteristics so dead space represent only the hydraulic dead space. As shown in Fig. 4(a) temperature had effect on dead space till 5th chamber. Dead space in 5th chamber at 10°C was found 80% higher than 25°C.But dead space was found 0 in 6th chamber for all the three temperature. Therefore, the optimal number of chamber of the reactor shall be 6 for all the three temperature.

Hydraulic Efficiency

Fig. 4(b) shows that in first two chamber the hydraulic efficiency is poor for normal and cold water. The hydraulic efficiency in the third chamber is satisfactory. But for the 4th to 7th chamber and effluent, hydraulic efficiency was very good as the values of λp were greater than 0.75. As the hydraulic efficiency characteristic was more or less same at each chamber for both temperatures, it is independent of temperature.

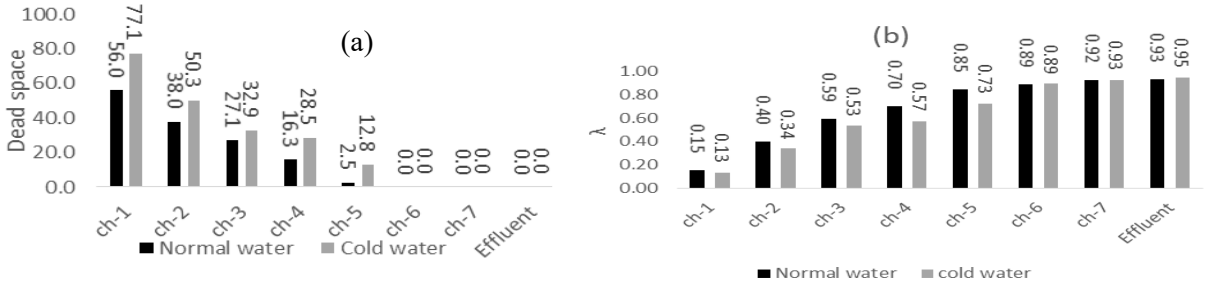

Fig .4. Percentages of dead space in chambers and effluent of the ABR at two different temperatures (a). Hydraulic efficiency in chambers and effluent of the ABR at two different temperatures (b).

CONCLUSIONS

From the RTD analysis it has been shown that temperature has some effect on hydrodynamics of a HABR. Mean residence time of the reactor at 25°C was found 4.7% greater than 10°C. Dead space showed different behaviour at different temperature till 5th chamber. In 5th chamber dead space at 10°C was found 80% higher than 25°C. But it was found 0 in 6th chamber for both temperatures. Therefore, the optimal number of chamber of the reactor shall be 6 for the two temperatures. No significant effect of temperature on mixing pattern and hydraulic efficiency was observed. A very good hydraulic efficiency ($\lambda p \geq 0.75$) was obtained from 4th to effluent for both temperatures. This paper clearly demonstrates a qualitative and quantitative relationship between temperature change and hydrodynamic of a HABR.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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PERFORMANCE STUDY OF CONCRETE BLOCK MADE WITH WASTE MATERIALS AS PARTIAL REPLACEMENT OF SAND

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ABSTRACT
This study has attempted to reuse of sludge, fly ash and pet granules in making concrete block with partial replacement of sand. Environmental concern has been raised against uncontrolled extraction of sand and unplanned disposal of sludge and fly ash. Pet bottles are disposing here and there after using. These incremental problems may be reduced by partial replacement of sand through sludge, fly ash and pet granules in making concrete block. These newly adopted concrete blocks can fulfil a demand part of brick in addition and can save the environment from the air and soil pollutions. This study has been done in ratio 1:4 (cement and sand), at water cement ratio 0.45, where sand has been replaced by using sludge, fly ash and pet granules with different percentage such as 5, 10, 15, 20, 25 and 30%. The mechanical properties of samples such as compressive strength were tested for 28 days. In this experiment Concrete blocks strength have increased till 60% replacement with 20% sludge, 20% fly ash and 20% pet granules on sand. The strengths of blocks was decreased when replacement of sand is above 60%.

Keywords: PET Bottles; Sludge; Fly Ash;

INTRODUCTION

Concrete block is the most used construction material in the industrialized countries. In Society concrete plays a vital role in the construction of almost everything, it is being used to build schools, hospitals, apartment blocks, tunnels, dams, pavement and more. The most important ingredients which are used in building construction that is cement, sand and bricks or concrete blocks. All the materials are important to build a structure but concrete block are of prime important. Using concrete block in construction is significantly reduces cost of construction in various ways. To produce brick, hectors of land, tons of wood and coal are wasted. We can save these natural resources by using concrete block to build our home, offices, roads and any other construction. Each block can save approximately 25% than using brick(*Benefits of Concrete Blocks | Mir Concrete Products Limited*). However, the concrete production needs natural resources (sand and stone) and cement. On the other hand disposals of waste materials are also becoming a major waste management problem in earth. In order to reduce the use of sand and reuse of waste materials, sludge, fly ash and PET granules have been used in this study in making concrete block.

(Srinivasan *et al.,* 2016) has used sludge in concrete as partial replacement of sand. That study concluded, Sludge can be used as an effective replacement of fine aggregate and it can be replaced with 20% in concrete. Compressive strength is under controlled with the addition of sludge up to 20% replacement.(Deo and Pofale, 2015) has used fly ash on partial replacement of sand in concrete. He concluded that the use of fly ash as partial replacement of sand is an economical solution for making green and denser concrete. In that study 27% sand was replaced by fly ash. The study was done by percentage of weight. The compressive and the flexural strength of concrete mixes with partial replacement of sand by fly ash were found to be 15% higher than conventional concrete. Finally that

study concluded that fly ash could be very conveniently used as partial replacement of sand in structural concrete where its proportion and replacement of sand could be efficiently done by using minimum voids method for higher compressive strength, flexural strength and workability and lower voids at lower cost.

In recent years, more and more attention has been given to the potential use of waste plastics as concrete aggregate. S.Vantitha et al., in India used 0%, 2%, 4%, 6%, 8% and 10% waste plastics to replace the same amount of aggregate for M20 concrete. (Ramadevi and Manju, 2012) also carried out the experimental investigation on the properties of concrete with plastic PET (bottles) fibers as fine aggregates. It was found that replacement of fine aggregate with 2% of PET bottles fibers will be reasonable than other replacement percentage like 4% and 6% as the compression and split tensile strength reduces gradually.

(Raongjant, Jing and Khamput, 2016) made concrete by replacing 100g, 150g, 200g fine aggregate with plastics EVA. That study concluded the compressive strength of concrete blocks tended to decrease with increases in the plastics EVA proportion in concrete.

(Saikia and Brito, 2013) used plastic waste in his study as partial replacement of fine aggregate in concrete. He concluded compressive strength concrete containing all types of PET aggregate behaves like in conventional concrete.

Above mentioned in all types of study, waste materials such as sludge, fly ash and plastics or PET granules have been used singly as partial replacement of sand. That means when sand has been replaced, it has been replaced only by sludge or fly ash or Plastics. Those three types of waste materials have not been used yet at a time in replacement of sand in concrete. So in this study an attempt has been made to investigate the possibility of using PET granules, sludge and fly ash at a time as partial replacement of sand in concrete block. It has been also tried to save the environment from the impacts of PET bottles, sludge and fly ash wastes disposing.

METHODOLOGY

Sludge has been collected from unimex textile mills limited gazipur, Bangladesh. Fly ash has been collected from coal power plant, Boropukuria, Dinajpur, Bangladesh shown in figure.1. PET granules were collected from Konabari, Gazipur, Bangladesh. Cement and Sand was collected from local market.

Collected sludge was dewatered in sun for six days. After dewatering it has dried in oven at 105 F. Unnecessary materials were removed from fly ash, sand and PET granules.

The chemical elements contents in waste materials are written in below. Sludge from waste water treatment plants contains silicate (SiO_2), Alumina (Al_2O_3) and ferric oxide (Fe_2O_3 (Campbell et al 1975).

PET granule is a material consisting of poly ethylene terephthalate and a wide range of synthetic or semi synthetic organic compounds that are malleable and so can deform irreversibly in without breaking out. It is typically organic polymers of high molecular mass and often contains other substance (York et al., 2016).

Fly ash comprised of very fine particles, the majority of which are glassy sphere. Fly ash contains large quantities of Silica (SiO_2) alumina (Al_2O_3) ferric oxide (Fe_2O_3),) and various other oxides and alkalis.

To identify the physical properties of waste materials pH of raw materials was determined by pH meter in DUET laboratory. By using Pycnometer specific gravity was also determined for each raw material. Existences of Sulphate and chloride contents in raw materials were determined. It was also made a sieve analysis for raw materials to determine FM for each material.

Volumetric percentage of cement, sand, sludge, fly ash and PET granules were measured according to combination of material which has shown in table 1. Sand has been partially replaced by sludge, fly ash and PET granules. Water cement ratio has been controlled at 0.45.

A steel mold size of 10*5*3 inch (shown in figure 2) was used to cast the concrete blocks. All kinds of aggregate have been mixed by small mixer machine.

Fig.1 :Image of collecting fly ash

Fig.2: Steel mold size

Table 1: Combination of different sample

Sample	cement	Sand	Sludge	Fly ash	plastics
C-1	100%	100%	0%	0%	0%
C-2	100%	85%	5%	5%	5%
C-3	100%	70%	10%	10%	10%
C-4	100%	55%	15%	15%	15%
C-5	100%	40%	20%	20%	20%
C-6	100%	25%	25%	25%	25%
C-7	100%	10%	30%	30%	30%

Fresh concrete has been placed on steel mold in required amount in three steps. Every step has been compacted by small vibrator machine to reduce the void in fresh concrete. After the blocks formed, specimens were immersed in water for curing for 28 days.

After completing the curing samples were oven dried at 105F and conducted to different tests in laboratory for performance observation of concrete block made with waste materials. A sample is being tested shown in figure.3 in universal testing Machine to determine the compressive strength capacity of sample. To know the water observation capacity, Samples were oven dried shown in figure.4 after taken submerging in water. Specific gravity of samples was determined by Archimedes law.

Fig.3: Testing sample in Universal testing machine

Fig.4: Sample are being dried in oven

RESULTS AND DISCUSSIONS

The physical properties of raw materials were determined in laboratory. Properties have been mentioned in table.2. pH of sludge and fly ash is near to the safe limits. F.M of PET granules are large as compared to sand, but it behave as coarse aggregate.

Table 2: physical properties of raw materials

Parameter	Unit	Cement	Sand	Fly ash	Sludge	PET Granules
pH	---	---	---	6.3	6.70	---
Specific gravity	---	3.15	2.67	3.70	1.05	1.38
chloride	$mgkg^{-1}$	---	---	10	400	---
Sulphate	$mgkg^{-1}$	---	---	4.65	21	---
F.M	---	---	---	1.8	2.8	4.5

Water Absorption Test

For the water absorption test, the specimens were made to dry in an oven for 24 hour at 110°C temperature (shown in figure 4). Immediately upon cooling, the specimens were weighed. The specimens were then emerged in water at agreed upon conditions at 23°C for 24 hours (According to ASTM C140 / C140M - 17a Standard Test Methods). Water absorption of different samples has shown in figure 5 below.

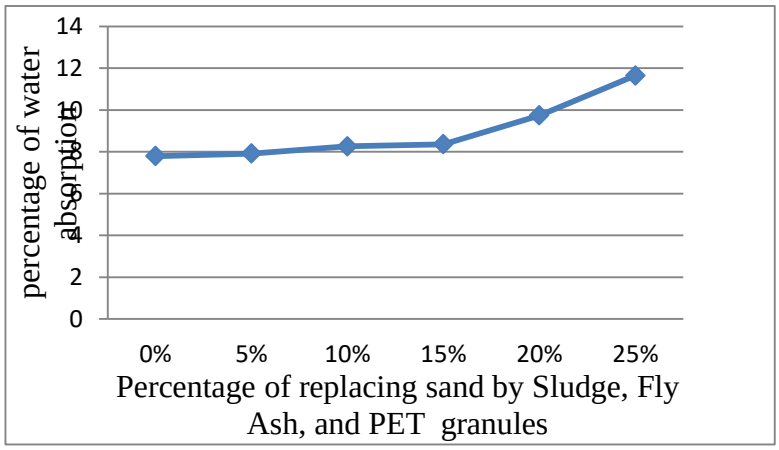

Figure.5: water absorption capacity vs percentage of replacing sand

Apparent Specific Gravity Test

Apparent specific gravity is the ratio of the weight of a volume of the substance to the weight of an equal volume of water. The water density is at 4°C. All of the specimens were weighed and made the results averaged.

Then it's were compared with the weight of water of equal volume of specimen to determine the specific gravity. Every sample's specific gravity has been shown in figure.6 below.

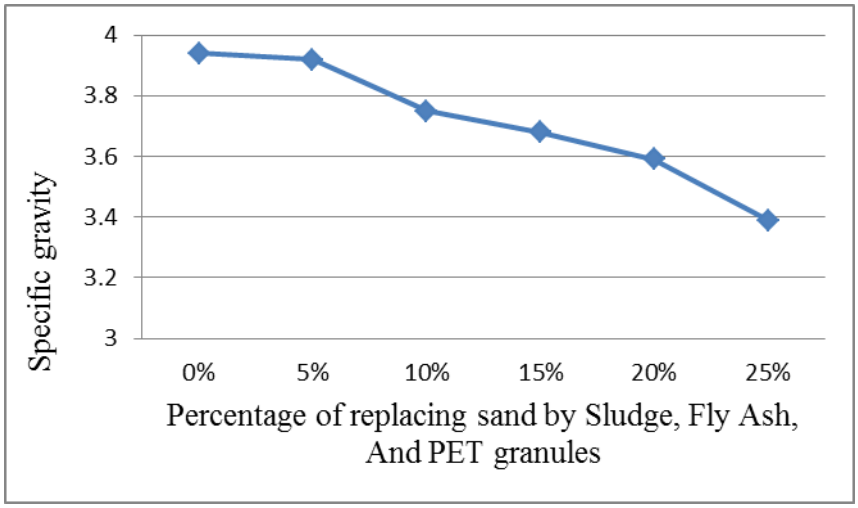

Fig.6: specific capacity vs percentage of replacing sand by sludge, fly ash, PET granules

Compressive Strength Test

Compressive strength is the most important test for assuring the Engineering quality of a building material. Specimens were tested in universal testing machine (that has been shown in figure 7) to determine the compressive strength. The strength of Concrete block did not significantly changed because of existing fly ash, which have cementing property. Compressive strength of the concrete blocks with the percentage of replacing sand has been shown in figure 7 below.

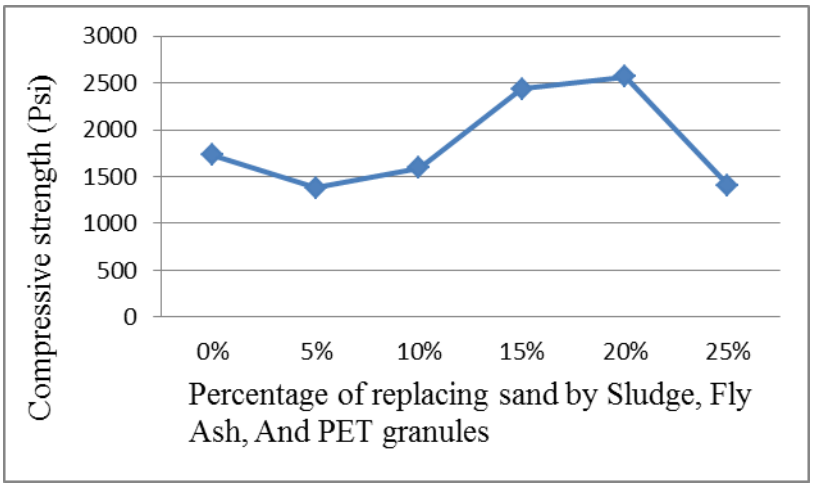

Fig.7: compressive strength vs percentage of replacing sand by sludge, fly ash, PET granules

CONCLUSIONS

- Compressive strength has been increased gradually with increasing the percentage of replacing materials up to a certain limit and that is 20%. Among the entire sample C-5, exert the maximum compressive strength 2564 psi that is greater than control specimen (C-1) strength 1727 psi.

- Specific gravity of every type samples has been lowered gradually as compared to control specimen. Because specific gravity of sludge, fly ash, and PET granule is low as compared to sand. So from this method, it can be made lightweight concrete also.
- Maximum water absorption of concrete block is 11.9 % and minimum is 7.79%. That is greater than control specimen water absorption capacity is increasing with increasing the percentage of adding sludge, fly ash and PET granules. Water absorption of C-5 specimen is 9.74% where ASTM C140 allows up to 7% water absorption of concrete.
- Finally this study disclosed that specimen C-5 can be practiced in concrete block making which expert's much strength as compared to conventional concrete block and simultaneously it can save the environment from the impacts of waste materials disposing.

ACKNOWLEDGMENTS

First, the authors would like admit the gracious blessings of the almighty Allah, which has enabled them to carry out the study successfully.

The authors would like to thank his supervisor, Professor Dr. Ganesh Chandra Saha, Department of Civil Engineering, DUET for the patient guidance, encouragement and advice. I am really extremely lucky to have a supervisor who cared so much about my work. The authors would also like to thank the DUET authority and the Department of Civil Engineering for providing the scope and facilities to carry out this study.

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POTENTIAL OF IRON-COATED JUTE FABRICS TO DECREASE ARSENIC CONCENTRATION OF GROUNDWATER IN IRRIGATION CHANNEL

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ABSTRACT
In Bangladesh, groundwater from shallow aquifer is widely used to irrigate dry season boro rice. But shallow aquifers in many regions are highly contaminated with arsenic (As). Reduction of As concentration of groundwater within irrigation channel could be an effective way to reduce arsenic loading in rice fields. Results from batch studies suggest that iron oxide coated jute fabrics have significant capacity to remove arsenic from groundwater. This study focuses on assessment of removal of arsenic from groundwater under flowing conditions. Experimental channels have been fabricated using PVC pipes and the channels have been coated with iron oxide coated jute fabrics. Arrangements have been made for flow of arsenic bearing groundwater from one end of the channel to the other. Experimental results showed appreciable removal of As within the irrigation channels; but well below the removal achieved under equilibrium condition in batch experiments. With an initial As concentration of about 230 μg/l, As removal varied from a maximum of about 40% to a minimum of about 22%. These results suggest that iron-coated jute fabrics have significant potential of reducing As loading to rice fields in arsenic affected areas of Bangladesh.

Keywords: Arsenic; irrigation water; iron coating; jute fabric.

INTRODUCTION
Bangladesh is an agro-based developing country where agriculture is the mainstay of Bangladesh economy. Agriculture contributes about 22 percent of the gross domestic product (GDP), out of which rice alone contributes 9.5 percent (BBS, 2008). Mainly three varieties of rice are cultivated in Bangladesh, which includeAush, Aman and Boro. Among theseBoro (the dry season rice) currently accounts for about 50 percent of total rice production in the country (BRRI, 2006). Being a dry season crop,Boro rice requires irrigation. Irrigation water is extracted mainly from shallow aquifers. But in many regions of Bangladesh, presence of high concentration of arsenic (As) in shallow groundwater has become a major concern (BGS & DPHE, 2001). Irrigation with arsenic bearing water is increasing arsenic concentration in agricultural soil, and in rice plants, which in turn is increasing human exposure to arsenic (Alam and Sattar, 2000; Meharg and Rahman, 2003). Because of lack of other sources of water for irrigation, reducing arsenic concentration within the irrigation channel can be an effective way to tackle this problem.
Dissolved As concentrations in flowing water tend to decrease with increasing distance from wells (Hossain et al., 2008; Roberts et al., 2007). A research conducted by Lineberger et al. (2013) on arsenic removal from water flowing through irrigation channel, provide evidence that soil-water contact is essential for arsenic removal and long winding channels can minimize arsenic concentration

to some extent. Further studies reveal that lining the distribution channels with physical structures can promote arsenic reduction from flowing irrigation water and for minimizing cost it can be done by local materials like jute mesh. This increased removal in amended channels is mainly due to increased residence time (Polizzotto et al., 2015). Yet significant arsenic removal could not be achieved only by jute mesh. A study was carried out to check the removal efficiency of 'iron coated jute fabrics' through laboratory batch experiments (Ramim et al., 2017). The iron coated jute fabrics have been found to be very effective in removing both As (III) and As (V) from groundwater, compared to uncoated fabrics.

The aim of the present study is to determine whether or not significant arsenic removal could be achieved in flowing condition by using low cost jute-mesh structure, coated with iron oxide, in artificial channel. This study involves assessment of removal efficiency of As (III) from groundwater, as arsenite is typically the predominant species in groundwater (Roberts et al., 2007).

METHODOLOGY

Materials: Water used for carrying out experiments in artificial channel for assessing arsenic (As) removal by iron coated jute fabrics, was natural chlorine free groundwater. Following the study of Ramim et al. (2017), locally available brown jute fabric was used in this study as it has better Asremoval capacity compared to white jute fabric. Arsenic Trioxide was used to prepare As (III) stock solution. Ferric Nitrate, $Fe(NO_3)_3$ and Sodium Hydroxide (NaOH) solutions were used for providing iron oxide coating on jute fabrics.

Preparation of jute fabric for coating: The jute fabrics were cut into pieces of 5"x12". After cutting the jute fabrics, they were thoroughly washed with distilled water to get rid of any foreign material on their surface and then dried at room temperature. In the present study, the method reported by Ramim et al. (2017) has been used for providing iron oxide coating on jute fabric.

At first two pieces of jute fabrics were taken in a tray. Next 400 ml of prepared 0.25M $Fe(NO_3)_3$ solution was poured into the tray to soak the jute fabrics. Then the iron was precipitated by neutralization with the addition of 25 ml of prepared 10M NaOH solution and adjusting the pH to about 10.0. In this study, the coated jute fabrics were dried at room temperature for one week. During this one week, the coated jute fabrics were flipped on the other side after 3/4 days. After drying, the fabrics were washed with distilled water in a beaker to remove any loose iron particles from the fabric. Then these were kept at room temperature for further drying.

Assessment of As removal from flowing groundwater: In laboratory, experimental channels have been fabricated using PVC pipes, having a length of 4 feet and inside diameter of 3 inch. These pipes were cut through the middle to replicate the irrigation channels. Concrete blocks were used to keep the pipe in position. Arrangements have been made for flow of arsenic bearing groundwater from one end of the channel to the other, and also for collection of samples at the terminal end of the channel.

Experiments were carried out under the following conditions: (1) Removal of As in irrigation channel lined with iron oxide coated jute fabric, as a function of time, for a particular flow rate; (2) Removal of As in irrigation channel lined with iron oxide coated jute fabric, as a function of time, for different flow rates; and (3) Removal of As in irrigation channel lined with uncoated jute fabrics at a particular flow rate.

The experimental procedures for all of the conditions were same. In all cases four pieces of 5"x12" jute fabrics were used to line the artificial channel completely. Groundwater spiked with As (III) (at a concentration of about 300 ppb) was discharged to the channel at a specific flow rate, with the help of a pump. After the channel was completely filled, the flow started and samples were collected at definite time intervals.

For the first experimental condition mentioned above, the flow rate was kept around 280 ml/min with a corresponding residence time of 10 minutes. The arsenic bearing groundwater was allowed to fall on the artificial channel lined with iron coated jute at a rate of 280 ml/min. After about 9.5 minutes the channel was filled and the flow started. The first sample was collected at the end of the channel in a 100 ml beaker, 5 minutes after start of flow. The experiment was continued for about 1 hour and a total of 10 samples were collected at 5 minutes interval. A second raw sample was collected around halfway of the flow (in this case at approximately after 35 min) and pH of the sample was measured. At the end of the experiment, the final raw sample was collected and the final pH at the outlet was also recorded. The same jute fabric lined channel was used to repeat the whole procedure two more

times at a similar flow rate. All collected sampleswere analyzed for arsenic concentration using an Atomic Absorption Spectrophotometer (AAS, Shimadzu, AA 6800).
Subsequently, the same fabric coated channel was used to conduct a similar experiment, but this time with a decreased flow rate of 130 ml/min with a corresponding residence time of 20 minutes. The channel was filled after about 20 minutes and the duration of the experiment was about 70 minutes. A total of 10 samples were collected at the outlet of the channel at 5 min interval and were analyzed for pH and As concentration.
Another set of experiment was carried out in an artificial channel lined with uncoated jute fabrics, through which As bearing groundwater was passed at a flow rate of around 280 ml/min. As before, water samples were collected at the channel outlet at an interval of 5 minutes, and were analyzed for As and pH.

RESULTS AND DISCUSSIONS

The first four sets of experimentswere carried out over a period of four days using the same artificial channel covered with one set of iron coated jute fabric. Each day, experiment was conducted for a period of about 1 hour. The flow rate of arsenic bearing (179 to 256 ppb) water was kept at about 280 ml/min (270 to 285 ml/min) (corresponding residence time of about 9.5-10.5 minutes) during the first three days. On the fourth day, the flow rate was reduced to about half at 130 ml/min (corresponding residence time about 20 minutes), in order to assess the effect of flow rate/contact time on removal.
Arsenic removal on Day 1:Fig. 1 shows concentration of arsenic as a function of time for water samples collected at the outlet of the artificial channel. In this experiment, initial arsenic concentration was about 232 ppb.Arsenic concentration in water at channel outlet varied from 139 to 181 ppb, corresponding to removal of 40.1% and 22.0% (of 232 ppb), respectively. Arsenic removal appears to decrease slightly with time. The pH of the water sample did not change significantly during the experiment; pH varied from 7.0 to 7.2.
Arsenic removal on Day 2:The concentration of arsenic as a function of time for water samples collected at the outlet of the artificial channel is showed in Fig. 2. In this experiment, average arsenic concentration was about 237 ppb. Fig. 2 shows that arsenic concentration in water at channel outlet varied from 176 to 208 ppb, corresponding to removal of 25.7% and 12.2% (of 237 ppb), respectively. Arsenic removal appears to decrease slightly with time. Comparison of Fig. 1 and 2 suggests that arsenic removal decreased to some extent on day 2. As before, the pH of the water sample did not change significantly during the experiment; initial pH was 7.2, which increased to 7.6 at the end of the experiment.

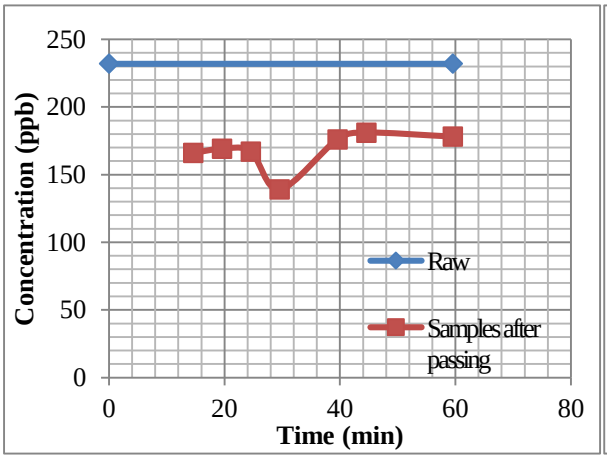

Fig. 1: As concentration in water at channel outlet as a function of time on day 1 of experiment

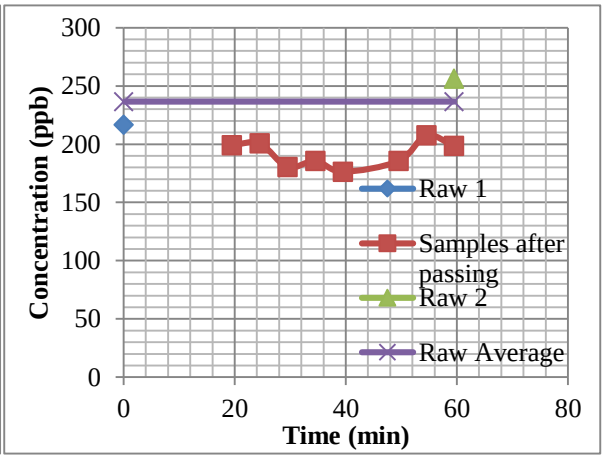

Fig. 2: As concentration in water at channel outlet as a function of time on day 2 of experiment

Arsenic removal on Day 3:Fig.3 shows concentration of arsenic as a function of time for water samples collected at the outlet of the artificial channel. Average initial arsenic concentration was about 198 ppb in this experiment (lower than the initial arsenic concentration on the first two days).

Fig.3 shows that arsenic concentration in water at channel outlet varied from 169 to 175 ppb, corresponding to removal of 14.6% and 11.6% (of 198 ppb), respectively. Arsenic removal appears to decrease slightly with time. Comparison of Fig. 1, 2 and 3 suggests that arsenic removal gradually decreased with time. The pH of the water sample varied from an initial concentration of 6.9 to 8.0 at the end of the experiment.

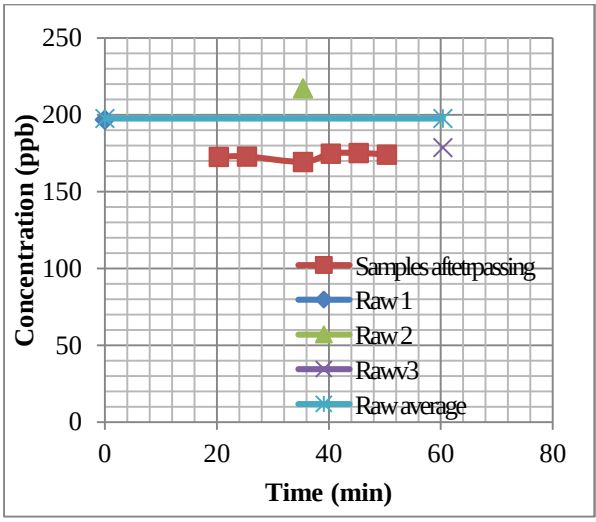

Fig.3: As concentration in water at channel outlet as a function of time on day 3 of experiment.

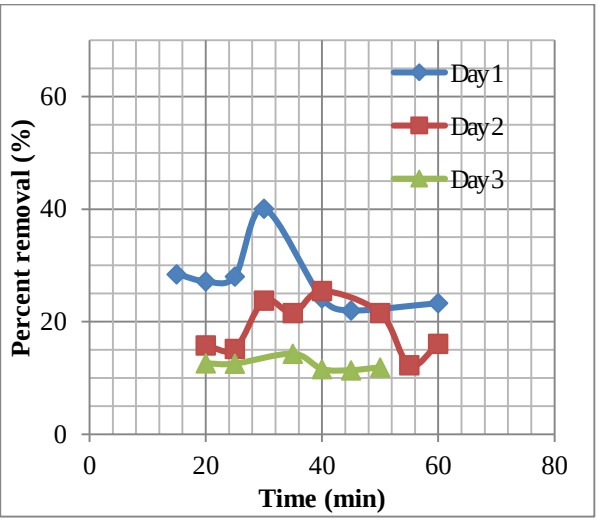

Fig. 4: Percent removal of arsenic within artificial channel during the 3 days of experiment

Comparison of arsenic removal on different days:The percent removals of arsenic within the artificial channel during the three days of experiment are shown in Fig. 4. It shows that removal of arsenic in the channel decreased with time under similar experimental condition.On day-1, arsenic removal (with initial As of 232 ppb) varied from 22% to 40.1%. On day-2, for an initial concentration of 237 ppb, removal achieved varied from 12.2% to 25.7%. Finally, on day-3, for the initial As of 198 ppb, 11.6% to 14.6% arsenic was removed. Thus, it is evident that the removal of Asdecreased with time throughout the experimental period.This is most likely due to the gradually reducing adsorption capacity of jute fabrics with time, as adsorption progresses. This indicates that arsenic removal capacity of jute fabric reduces considerably with time.

Effect of flow rate on arsenic removal in artificial channel:In order to assess effect of flow rate on arsenic removal, one set of experiment was carried out on Day-4 with the same set up, where flow rate was reduced to 130 ml/min, about half of the flow rate used during the first three days of experiment. During the first three days of experiment, the residence or contact time was 9.5 min to 10.5 min; whereas in this experiment, residence/contact time was about 20 min.

Fig. 5 shows arsenic concentration in water at channel outlet at different times. The average initial arsenic concentration was 232 ppb. Fig.5 shows that arsenic concentration in water at channel outlet varied from 198 to 219 ppb, corresponding to removal of 14.7% and 5.6%, respectively. In this case also, arsenic removal appears to decrease slightly with time.

Fig.6 shows a comparison of arsenic removal on Day-3 and Day-4. As shown in Fig.4, arsenic removal decreases with passage of time; arsenic removal on Day-3 was significantly lower than arsenic removal achieved in the artificial channel on Day-1. Following this trend, one would expect an even lower removal of arsenic on Day-4, under similar condition. However, Fig. 6 shows that arsenic removal on Day-4 (at a flow rate of 130 ml/min) is almost same as that achieved on Day-3 (at a flow rate of about 280 ml/min). This is due to significantly lower flow rate used in experiment on Day-4. It shows that flow rate (or contact time) has a significant effect on arsenic removal in the jute fabric coated channel. When the velocity of flowing water is low, it gets longer contact time with the iron coated jute fabric; longer contact time results in more removal of arsenic.

Removal of arsenic in channel lined with un-coated jute fabric: As noted above, one set of experiment was carried out where the artificial channel was lined with uncoated jute fabric. In this set of experiment, the flow rate was maintained at 285 ml/min, and initial arsenic concentration was 259 ppb. Fig. 7 shows arsenic concentration in water at channel outlet as a function of time. It shows not very significant removal of arsenic from water. The arsenic concentration in the channel outlet water varied from 204 to 239 ppb, corresponding to removal of 21.2% and 7.7%, respectively. Fig.8 shows comparison of arsenic removal by coated and uncoated jute fabrics.Both iron coated and uncoated jute fabric can remove arsenic from groundwater. It is observed in Fig.8 that 22.0% - 40.1% (initial As 232 ppb) arsenic was removed using iron coated jute fabric, whereas only 7.7% - 21.2% arsenic (initial As 259 ppb) was removed using uncoated jute fabric. So it can be said that iron coating significantly increases arsenic removal capacity of jute fabric.

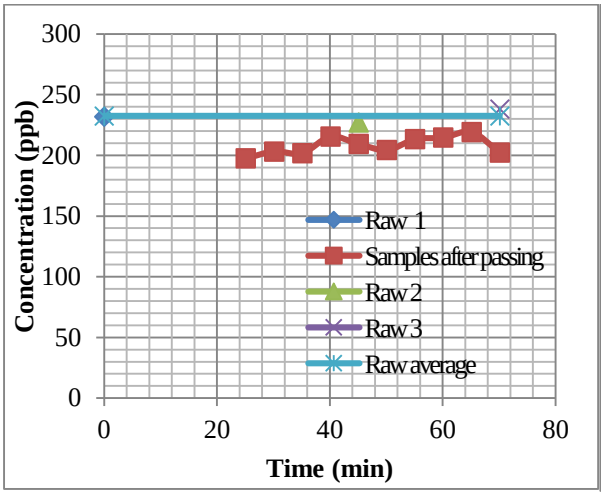

Fig. 5: As concentration in water at channel outlet as a function of time on day 4 of experiment, carried out at a slower flow rate of 130 ml/min.

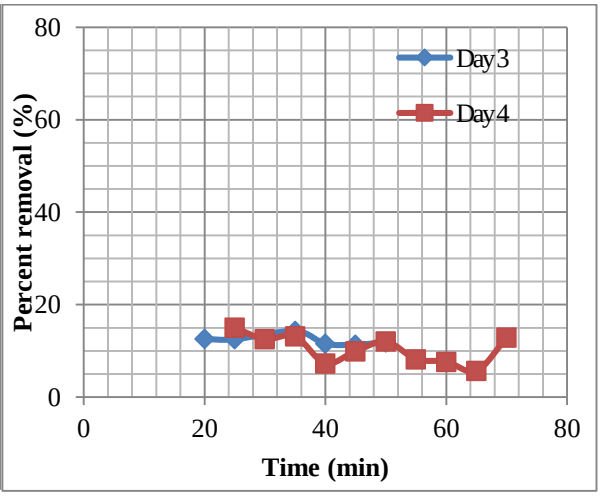

Fig. 6: Percent removal of arsenic in artificial channel on day-3 at a flow rate of 270 ml/min, and on day-4 at 130 ml/min.

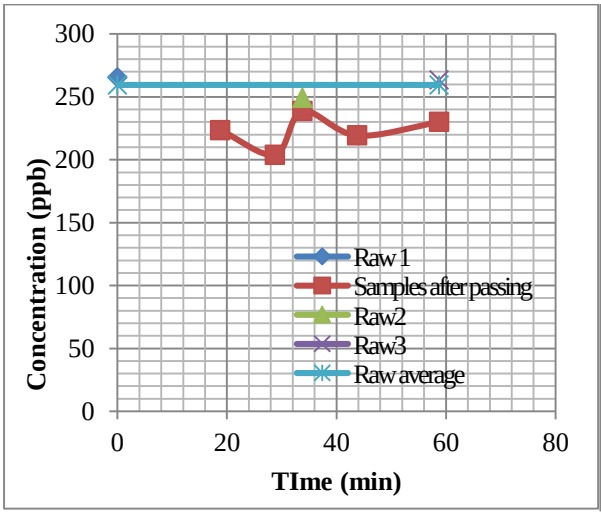

Fig. 7: As concentration in water at channel outlet as a function of time using un-coated jute fabric.

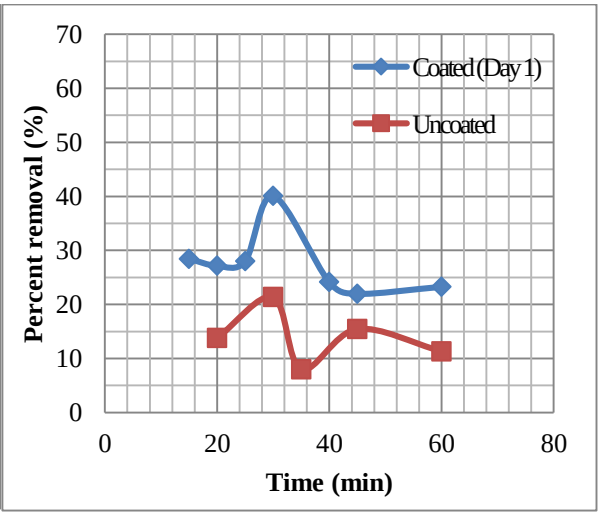

Figure 4.8: Percent removal of arsenic within artificial channel using iron coated jute fabric and uncoated jute fabric

CONCLUSIONS

The study assesses the effectiveness of iron coated jute fabric in removing arsenic from groundwater flowing through an artificial channel. It was found that while iron oxide coated jute fabric can removeappreciable amount of As from flowing groundwater (compared to uncoated fabric), capacity of the coated fabrics decreases with time. This study also suggests that flow rate through the channel can significantly affect As removal; lower flow rate (and higher contact time) promotes higher removal. Arsenic removal achieved in artificial channel lined with iron oxide coated jute fabrics appears to be much lower than those achieved in batch experiments reported in Ramim et al. (2017), where a contact time of 30 minutes was allowed for equilibration, and the water and jute fabrics were constantly mixed with a stirrer. The removal of arsenic in channel appears to be limited by kinetics of adsorption (mixing and contact time). Thus, more work is needed to assess kinetics of arsenic adsorption, and to devise ways to enhance removal of As in irrigation channel.

ACKNOWLEDGEMENTS
The authors would like to express appreciation to Bangladesh University of Engineering and Technology for supporting the research work.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

ENHANCED COAGULATION FOR REMOVAL OF ORGANIC CARBON FROM POLLUTED SURFACE WATER

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ABSTRACT
In Bangladesh, contribution of surface water to water supply is increasing due to the lowering of groundwater level and excessive arsenic, iron and manganese in groundwater. Surface waters bodies in Bangladesh are characterized by high concentration of organic matters, contributed by both domestic and industrial sources. The presence of organic matter causes many problems in water treatment processes, including formation of disinfection by-products. While "enhanced coagulation" has been used for removal of natural organic matter from water, it is important to assess effectiveness of this process for removal of organic matter from anthropogenic origin. Alum has been found to be effective in removing TOC from water. For a water sample with initial TOC of 17.14 mg/l, TOC removal increased from about 24% to 66% as alum dose increased from 20 mg/l to 150 mg/l. TOC removal has been found to be a strong function of pH. Since almost all surface water treatment plants in Bangladesh use alum coagulation for removal of suspended solids (SS), it appears that alum dosing could be optimized for effective removal of both SS and organic matter. This would improve treatment efficiency and reduce the risk of DBP formation.

Keywords: Enhanced coagulation; TOC; Natural organic matter; DBPs.

INTRODUCTION

Natural organic matter (NOM) is defined as a complex matrix of organic materials present in all natural water. It affects many aspects of water treatment including (i) negative effect on water quality by causing color, taste and odor problems, (ii) formation of disinfection by-products (DBPs) upon chlorination, (iii) biological growth in distribution system, and (iv) increased levels of complexed heavy metals. NOM reacts with disinfectants during the disinfection process and produces disinfection by products (DBPs), including halogenated compounds like trihalomethane (THMs), and Haloacetic acids (HAAs) which have significant adverse health effects (Reckhow et al., 1990; Singer and Billy, 2002). It is therefore important to remove organic matter from surface water as a part of water treatment processes.

One of the most common methods for removal of NOM is the addition of coagulant and flocculation aids such as alum, ferric chloride, poly aluminium chloride (PAC) etc. **(**AWWA, 1997**)**; this is often referred to "enhanced coagulation". In the United States, this technique is mandatory for surface water having TOC greater than 2 mg/l. Table 1 shows the TOC removal requirement in the USA for utilities using conventional water treatment. It shows that the removal requirement depends on initial TOC concentration and alkalinity of raw water.

A major advantage of enhanced coagulation is that it removes both turbidity and TOC without extensive change in the treatment plant infrastructure. Apart from pH and Alkalinity of water, both quantity and quality of NOM have significant effect on water treatment process. NOM are divided into hydrophobic and hydrophilic fractions (Sharp et al., 2006). The hydrophilic fraction of NOM mostly consists of aliphatic carbon and nitrogenous compound (e.g., Carboxylic acid, carbohydrates and protein) whereas hydrophobic NOM consists of humic substances (humic and fulvic acids) (Thurman, 1985). The characteristics of organic matter present in surface water bodies in Bangladesh are likely to be different from those in developed countries (where organic matter in surface water comes from natural sources e.g., decaying plant, plant leaves), because most of it comes from anthropogenic sources (domestic and industrial effluent). It is therefore important to assess the effectiveness of "enhanced coagulation" in removing organic matter present in typical surface water in Bangladesh. Since alum is the most widely used coagulant in Bangladesh, it is important to assess its effectiveness in the removal of organic matter from surface water. This paper presents as assessment of the removal of organic matter from polluted surface water by alum coagulation.

Table 1: Required removal of TOC by enhanced coagulation and enhanced softening for plants using conventional treatment in the USA

Source water TOC (mg/l)	Percent removal of TOC		
	Alkalinity: 0 – 60 mg/l as $CaCO_3$	Alkalinity: > 60-120 mg/l as $CaCO_3$	Alkalinity: > 120 mg/l as $CaCO_3$
> 2.0 – 4.0	35.0	25.0	15.0
> 4.0 – 8.0	45.0	35.0	25.0
> 8.0	50.0	40.0	30.0

METHODOLOGY

Sampling: Raw water samples were collected from Hatirjheel in Dhaka and Sitalakhya River, prior to each experiment. A total of 5 water samples were collected from Hatirjheel during November 2017 to January 2018; one water sample was collected from Sitalakhya River in March 2018. Organic content (and hence TOC content) of Hatirjheel varies significantly with season, with higher values during wet season (when sewage-mixed storm water overflows into Hatirjheel), and lowest during the dry season (when there is no overflow). Therefore, water samples from Hatirjheel were collected during both dry and wet season to have raw water with varying levels of TOC. Since water from Sitalakhya River is used as raw water for Saidabad water treatment plant, one sample was also collected from the Sitalakhya River. After collection, the water samples were filtered to remove suspended materials. The samples were then analysed for a wide range of parameters including pH, colour, turbidity, alkalinity, and EC.

Jar test: To assess the removal of total organic carbon, batch coagulation experiments were carried out in Jar Test Apparatus. Alum was used as coagulant. In batch experiments, removal of TOC was assessed by varying Alum dose**.** For Hatirjheel water samples, Alum dose was varied from 20 to 300 mg/l, and for Sitalakhya River water samples, alum dose was varied from 20 to 150 mg/l. pH was adjusted to assess its effect on TOC removal. The Jar Tests were carried out in a series of 500 mL beakers. After addition of specific coagulant dose, the water samples in the beakers were subjected to 1 minutes of rapid (40 rpm) mixing, and 14 minutes of slow (15 rpm) mixing. The contents of the beakers were then allowed to settle for 15 minutes. Supernatant samples were then collected from each beaker with a pipette for analysis of pH, turbidity and TOC; residual aluminium was also measured for selected samples.

***pH adjustment*:** Effect of pH on removal of TOC was evaluated by varying pH of water with dilute sulphuric acid (H_2SO_4, 1N) or sodium hydroxide (NaOH, 1N) solutions, to obtain pH values between 5 to 8.

***Analysis*:** TOC of the water samples was measured by a TOC analyzer (Aurora Model 1030 Auto sampler Model 1088), and residual aluminium concentration was measured Spectrophotometer (DR 6000, 2010). A pH meter, a turbidity-meter and an EC meter were used for measurement of pH, turbidity, and EC, respectively' alkalinity was measured following Standard Methods.

RESULTS AND DISCUSSIONS

Characteristics of water sample: Table 2 shows the characteristics of raw water samples collected from Hatirjheel and Sitalakhya River. It shows that the Hatirjheel water samples contains relatively high concentration of both TOC (varying from 15.48 to 39.32 mg/l) and alkalinity (198 to 293 mg/l). On the other hand, water from Sitalakhya River contains relatively low concentration of TOC (3.77 mg/l) and alkalinity (28 mg/l).

Effect of alum dose of TOC removal: Table 3 shows results of coagulation experiments carried out with a water sample collected from Hatirjheel in November 2017. It shows that residual TOC as well as turbidity of water decreased as alum dose increased. Residual TOC decreased from 17.14 mg/l (in raw water) to 4.45 mg/l at 300 mg/l alum dose. Addition of alum also resulted in decrease of pH of water; pH decreased from 8.09 (in raw water) to 6.32 at 300 mg/l alum dose.

Table 2: Characteristics of water samples collected from Hatirjheel and Sitalakhya River

Sl. No.	Parameters	Hatirjheel	Sitalakhya River
1	pH	7.70-8.40	7.61
2	Color (Pt.Co)	61-340	89
3	Turbidity (NTU)	4.45-55.7	12.1-15
4	EC (µs/cm)	563-772	150
5	Alkalinity (mg/l as $CaCO_3$)	198-293	28
6	Initial TOC (ppm)	15.48 - 39.32	3.77

Table 3: Results of coagulation experiments carried out with a water sample collected from Hatirjheel in November 2017

Alum Dose (mg/L)	pH	Turbidity (NTU)	Residual TOC (ppm)
Raw Water	8.09	9.75	17.14
20	7.80	11.80	13.01
50	7.54	10.30	9.82
100	7.18	7.80	7.80
150	6.89	4.90	5.77
200	6.73	3.30	5.24
300	6.32	3.40	4.45

For raw water sample: Alkalinity=198 mg/l; EC=563 S/cm; Color=114 Pt.Co.

Figure 1 shows removal of TOC from water samples collected from Hatirjheel (initial TOC = 17.14 mg/l) as a function of alum dose. TOC removal increased from about 24% to 74% as alum dose increased from 20 mg/l to 300 mg/l; the corresponding pH is 6.32 and turbidity 3.40 NTU (see Table 3).

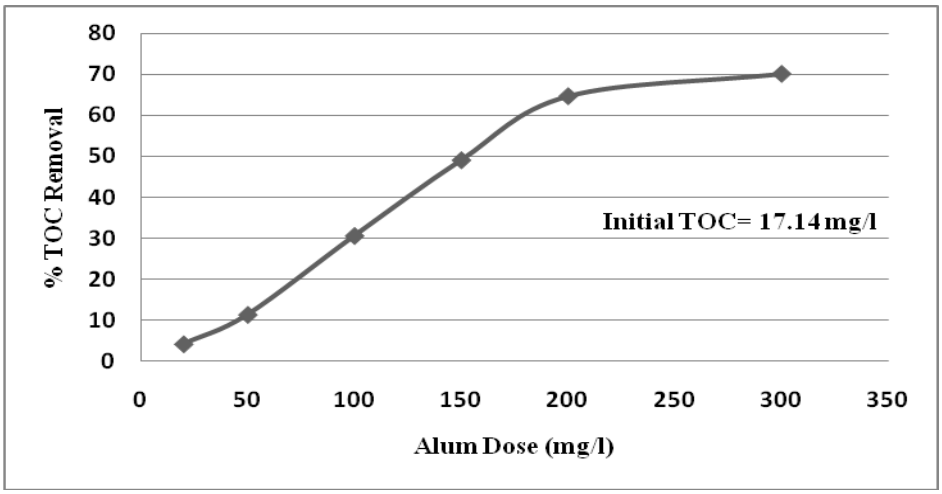

Fig. 1: Removal of TOC from a water sample collected from Hatirjheel in November 2017 as a function of alum dose

Table 4 shows results of another set of coagulation experiment carried out with a water sample collected from Hatirjheel in December 2017. It also shows reduction in residual TOC with increase of alum dose. Residual TOC decreased from 15.48 mg/l (in raw water) to 4.64 mg/l at 300 mg/l alum dose; and pH decreased from 8.4 (in raw water) to 6.9 as alum dose increased to 300 mg/l. Figure 2 shows removal of TOC (initial TOC = 15.48 mg/l) as a function of alum dose; TOC removal increased from about 4.2% to 70% as alum dose increased from 20 mg/l to 300 mg/l; at this alum dose of 300 mg/l, residual turbidity was 3.40 NTU and pH was 6.32.
Figure 3 shows removal of TOC from a water sample collected for Sitalakhya River. TOC removal increased as alum dose increased up to about 10 mg/l; then TOC removal decreased slightly with increase in alum dose. Maximum removal of 47.7% was recorded at an alum dose of 100 mg/l.

Table 4: Results of coagulation experiments carried out with a water sample collected from Hatirjheel in December 2017

Alum Dose (mg/L)	pH	Turbidity (NTU)	Residual TOC (ppm)
Raw Water	8.40	7.18	15.48
20	8.10	11.5	14.83
50	7.80	7.20	13.72
100	7.50	6.20	10.75
150	7.30	4.10	7.89
200	7.10	2.70	5.48
300	6.90	2.20	4.64

For raw water sample: Alkalinity=198 mg/l; EC=590 S/cm; Color=75 Pt.Co.

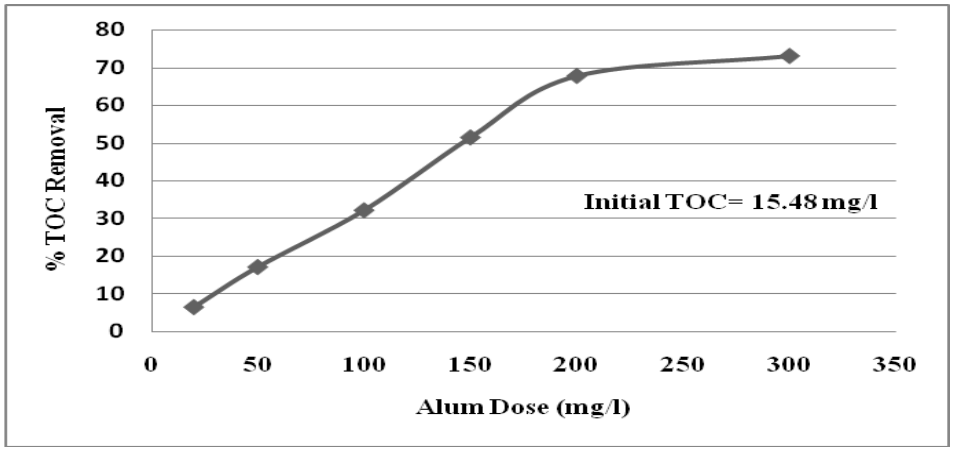

Fig. 2: Removal of TOC from a water sample collected from Hatirjheel (initial TOC=15.48 mg/l) in December 2017 as a function of alum dose

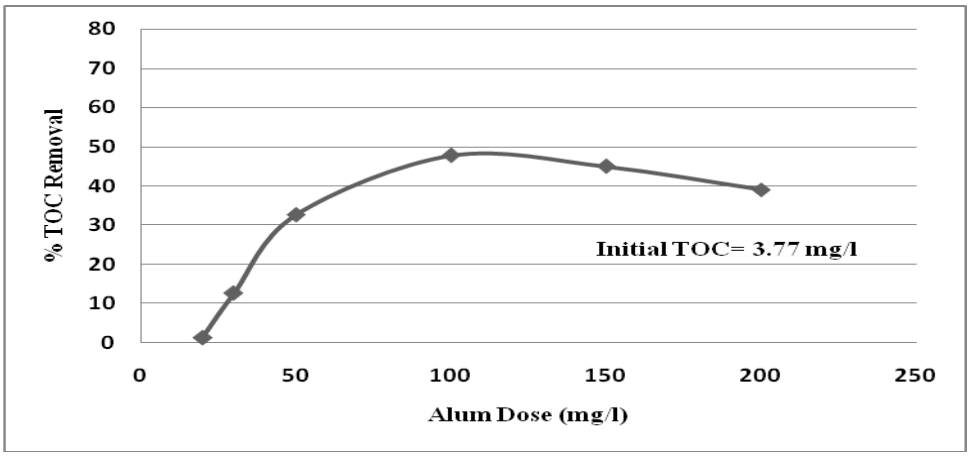

Fig. 3: Removal of TOC from water samples collected from Sitalakhya River (initial TOC=3.77 mg/l) as a function of alum dose

Effect of pH on TOC removal: Table 5 shows results of a set of coagulation experiment carried out with a water sample collected from Hatirjheel in December 2017 for assessment of the effect of pH on TOC removal. In this set of experiment, initial TOC concentration of raw water was 18.97 mg/l; alum dose was fixed at 100 mg/l and pH was varied from 5 to 8. Table 5 shows that TOC removal increases significantly as pH decreases; TOC increased from about 12.8% at pH 8.0 76% as pH decreased to 5.0. Table 4 shows that turbidity also improves with lowering of pH.

Table 6 shows results of another set of coagulation experiment carried out with water samples collected from Hatirjheel in January 2018. The initial TOC and alkalinity of the water sample collected in January 2018 was very high, 39.32 mg/l and 248 mg/l, respectively. As before, alum dose was fixed at 100 mg/l, and pH was varied from 4 to 9. Table 6 also shows significant effect of pH on TOC removal; TOC removal increased from about 4% at pH 9 to about 40% as pH decreased to 4.0. Figure 4 shows the effect of pH on removal of TOC for this experiment. Table 5 also shows increased turbidity removal at lower pH values.

Table 5: Results of coagulation experiments carried out with a water sample collected from Hatirjheel in December 2017 to assess the effect of pH on TOC removal

Alum Dose (mg/L)	pH	Turbidity (NTU)	Residual TOC (ppm)
Raw Water	8.10	4.45	18.97
100	8.0	4.93	16.54
100	7.0	6.41	10.19
100	6.5	4.00	6.44
100	6.0	3.28	5.68
100	5.5	1.84	4.66
100	5.0	1.53	4.56

For raw water sample: Alkalinity=190 mg/l; EC=577 S/cm; Color=61 Pt.Co.

Table 6: Results of coagulation experiments carried out with a water sample collected from Hatirjheel in January 2018 to assess the effect of pH on TOC removal

Alum Dose (mg/L)	pH	Turbidity (NTU)	Residual TOC (ppm)
Raw Water	7.7	55.7	39.32
100	9.0	47.3	39.30
100	8.0	45.7	37.66
100	7.0	43.7	33.58
100	6.0	16.0	25.98
100	5.0	7.10	25.07
100	4.0	13.3	23.54

For raw water sample: Alkalinity=248 mg/l; EC=772 S/cm; Color=340 Pt.Co.

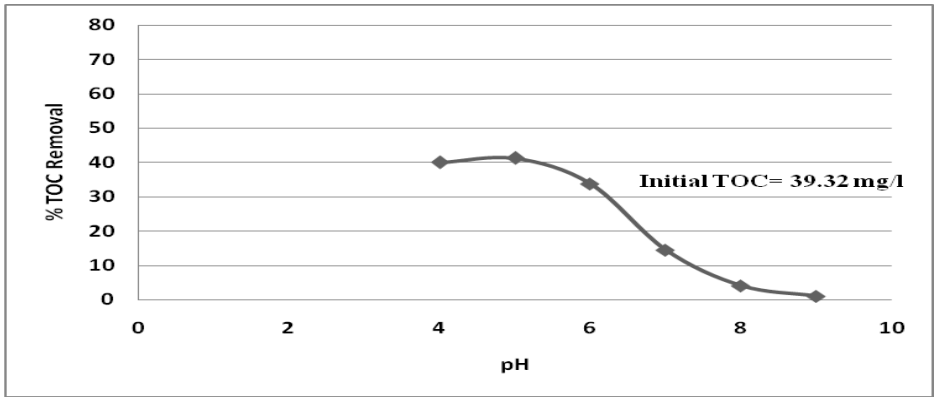

Fig. 4: Effects of pH on TOC removal from a water samples collected from Hatirjheel in January 2018

CONCLUSIONS

This study presents as assessment of the removal of TOC from contaminated surface water by alum coagulation. It shows that significant TOC could be removed from water by alum coagulation. For all water samples collected from Hatirjheel, the initial TOC was greater than 8 mg/l and alkalinity was greater than 120 mg/l as $CaCO_3$; therefore, according to Table 1, the target TOC removal is 30% for these water samples. For the water samples collected from Sitalakhya River, the target TOC removal is 35%. Results from this study suggests that the target TOC removal could be achieved with alum dose ranging from 50 to 100 mg/l. Depending on TOC concentration, pH and alkalinity of water, the alum dose could be adjusted for optimum TOC and turbidity removal in a water treatment plant.

ACKNOWLEDGMENTS

The authors are grateful to the laboratory attendants of the Civil Engineering Laboratory, BUET and the operators of Hatirjheel Water Taxi for their assistance in carrying out this study.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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MUNICIPAL WASTEWATER TREATMENT BY USING NATURAL COAGULANTS

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ABSTRACT
Water quality remains one of the most significant environmental issues. Especially surface water contains both dissolved, suspended and colloidal particles. Coagulation has been practiced since earliest times to remove colloidal impurities and turbidity. Nowadays, there has been great attention in the improvement and implementation of natural coagulants in wastewater treatment for their least cost. In the present study, wastewater collected from different locations of municipal primary drain in Rajshahi City were tested for various physical and chemical parameters to characterize. An attempt has been taken to check how natural coagulants such as Acacia nilotica, Moringa oleifera, banana stem, banana peels and Ficus carcia can remove the TDS, TSS and turbidity from wastewater through coagulation process at its optimum condition so that this treated water becomes suitable to safely discharge into river or directly use for irrigation. Based on the experimental results, it is found that the maximum removal of TSS, TDS and turbidity are obtained 75% by banana stem, 69% by Ficus carcia and 99% by Ficus carcia and banana stem respectively.

Keywords: *natural coagulant; turbidity; impurity; dissolved and suspended particles*

INTRODUCTION

Water pollution issues now dominate public concerns about national water quality and maintaining healthy ecosystem (EPA, 2004.). Municipal waste-water is a combination of different types of waste waters originating from the sanitary system of commercial housing, industrial facilities and institutions, in addition to any groundwater, surface water and storm water that may be present (Ibrahim, et al., 2012). To control the environmental and health hazards, municipal wastewater must immediately be treated appropriately before final disposal. The protection of the environment with public health and socio-economic concern is the ultimate goal of wastewater management (Clescerl, et al., 2001).
Different wastewater treatment technologies are used worldwide. Each one has its advantages and disadvantages in terms of construction costs, energy consumption, operatonal costs, energy consumption, operational complexity, effluent quality, reliability, land requirements, and environmental impact. Recently some modern technologies were reported for waste water treatment like up flow anaerobic sludge blanket (USAB) (Tawfik, et al., 2006; Axberg, et al., 1980; Camp, 1973), multi stage bubble column reactor (El-Hallwany, 2005), sequential batch reactor (SBR) (EPA, 2004), fixed film anaerobic filter (AF) (Renault, 2009), expanded granular sludge bed (EGSB), which is a

modification to UASB (Heber, 1985), up flow septic tank (USBR) (Yu, et al., 2010), submerged membrane hybrid system (Sahu, et al., 2009), anaerobic-anoxic-aerobic bioreactor (kemira, 1990).
Coagulation-flocculation process, which is widely used, due to its simplicity and cost-effectiveness is the most important step in wastewater treatment. The efficiency of coagulation-flocculation strongly affects the overall treatment performance; hence, the increase of the efficiency of coagulation stage seems to be a key factor for the improvement of the overall treatment efficiency (Tzoupanos, et al., 2008).The whole treatment process of coagulation-flocculation can be divided into two distinct procedures, which should be applied consecutively. The first one termed coagulation, is the process whereby destabilizatiom of a given colloidal suspension or solution is taking place. The second sub-process, termed flocculation, refers to the induction of destabilized particles in order to come together, to make contact and thereby, to form large agglomerates, which can be separated easier usually through gravity settling (Bratby, 2006).
Coagulants can be applied in wastewater to reduce or remove suspended solids, nutrients, organic matter and different pollutants and also in sludge treatment processes (Prodanović, et al., 2013). Natural coagulant is a natural based coagulant (carbofydrates and proteins) that can be used in coagulation process of wastewater treatment for reducing turbidity (Saharudin and Nithyanandam, 2014). These natural coagulants can be formed or extracted from animal, microorganisms and also plant. Natural coagulants usage is profitable in wastewater treatment since the treatment cost is low, the steady pH levels in the treated water and because they are highly biodegradable. The application of natural coagulants is based on their traditional use in tropical, rural areas (Prodanović, et al., 2013). A prime concern of the environmental engineer today is how to lower the coagulants cost (Abdelaal, 2004). Therefore, this study was carried out to analyze the effect of Acacia nilotica, Moringa oleifera, banana stem, banana peels and Ficus carcia as a primary coagulant in clarifying municipal wastewater in coagulation process at its optimum speed.

METHODOLOGY

Materials Collection and Preparation

The plant based natural coagulants such as *Acacia nilotica, Moringa oleifera*, banana stem, banana peels and *Ficus carcia* were used as coagulant to avoid the drawbacks of chemical coagulation .These *natural* coagulants were collected from tropical trees which contain water soluble, positively charged proteins that act as an effective coagulant for water and wastewater treatment. The five coagulants used are shown in Fig. 1

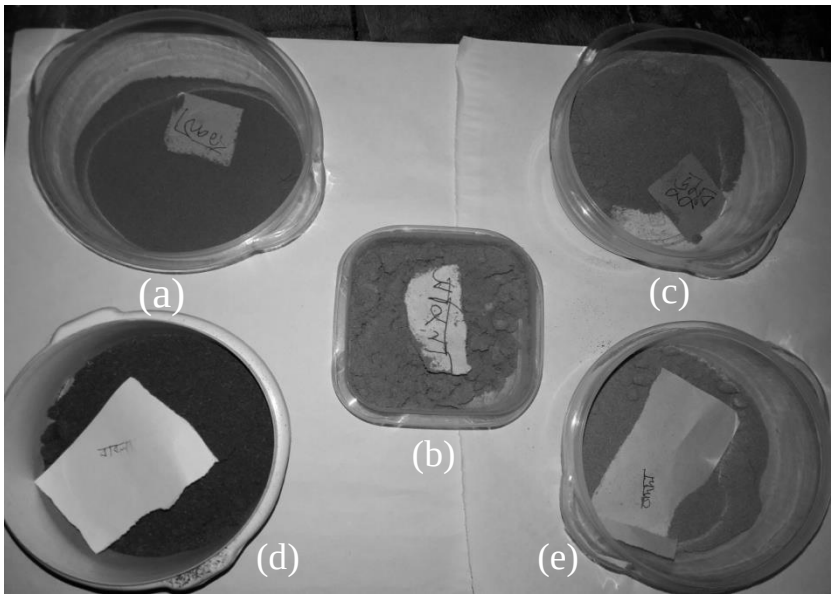


Figure 1:Natural coagulants: (a) Banana peels, (b) Banana stem, c) Moringa oleifera, d) Acacia nilotica and (e) Ficus

Wastewater sample Collection and Characterization

Wastewater samples were collected from five different primary drains located near Padma garden and were collected in PET bottle in sufficient quantity by standard procedure.

The collected Wastewater samples were characterized before going for treatment. The characteristics of all samples were determined based on TDS, TSS, turbidity, pH, alkalinity and conductivity.

Experimental Instrument

The turbidity values of the wastewater sample were measured by using a turbidity meter (Turbidimeter-TN-100) from Eutech Instrument. The bench top Jar-Tester (Model: SF6 and power 220V, 50Hz) was used for coagulation experiment Fig. 2.

Figure 2: Jar-Tester (Flooculators)

Treatment

Based on the characterization results, the worst wastewater samples were selected for treatment using different natural coagulations separately. The treatment process was proceed by variation in speed.

Speed Variation

Wastewater samples of 100 ml were taken in 500 ml flask. The flask was placed in the Jar-Tester flocculator (Model: SF6) for coagulation and flocculation. The speed was varies as 30rpm,50 rpm, 70 rpm, 90 rpm and 110 rpm while coagulant dose was kept fixed at 75m g/l and contact time at 30 minutes. After 30 minutes, the flasks were removed from the machine and kept for sedimentation. The supernatant was tested for TDS, TSS and turbidity and percentage removal was determined.

RESULTS AND DISCUSSIONS

Characterization experiments were carried out for raw wastewater to determine the strength of pollutantsd. The highly polluted sample was selected for treatment to remove the total suspended solids, total dissolved solids and turbidity through coagulation process with locally available natural materials. The results are presented and discussed in the following sections.

Characteristics of Raw Wastewater

Table 1: Characteristics of raw wastewater collected from different municipal drains

Sampling location	TDS (mg/l)	TSS (mg/l)	Turbidity (NTU)	pH	Alkalinity (mg/l)	Conductivity (micro-mohoes/cm)
Padma garden	1100	100	31.00	6.08	240	2025
Suvo filling station	912	88	27.10	6.85	215	1800
Dorgapara	633	77	16.48	7.11	230	1900
Bornali	829	71	25.71	7.14	220	1950
Talaimari	740	60	22.90	7.45	225	2025

The dissolved solids, suspended solids, turbidity, pH, alkalinity and conductivity vary from 633 to 1100 mg/l, 60 to 100 mg/l, 16.48 to 31.00 NTU, 6.08 to 7.45, 215 to 240 mg/l and 1800 to 2015 micro-mohoes/cm, respectively. From the results it is revealed that the pollutants levels are varying in wide ranges from drain to drain. It might be due the source of wastewater, velocity of flow, interval of cleaning of drain, sampling location and surroundings. During the sampling it was observed that most of the cases the flow is almost laminar and solid were deposited at the bottom of the drains. Considering the all parameters, it is found that sample collected from the primary drain near the Padma garden is more polluted compared to others.

Treatment of Wastewater

The treatment was carried out to reduce the concentration of pollutants. The treatment efficiency was determined based on removal of TDS, TSS and turbidity. The effect of variation of speed on the removal of these pollutants were examined. The performance of each natural material was also evaluated. The results are discussed in the following section.

Effect of Speed

Speed is also an important parameter for coagulation process. Speed was varied from 30 rpm to 150 rpm at an interval of 20 rpm. The removal of TDS, TSS and turbidity with respect to contact time with different coagulants are presented in Figure 3 to 5 where coagulant dose and contact time were maintained at 75 mg/l and 30 minutes, respectively as fixed parameters.

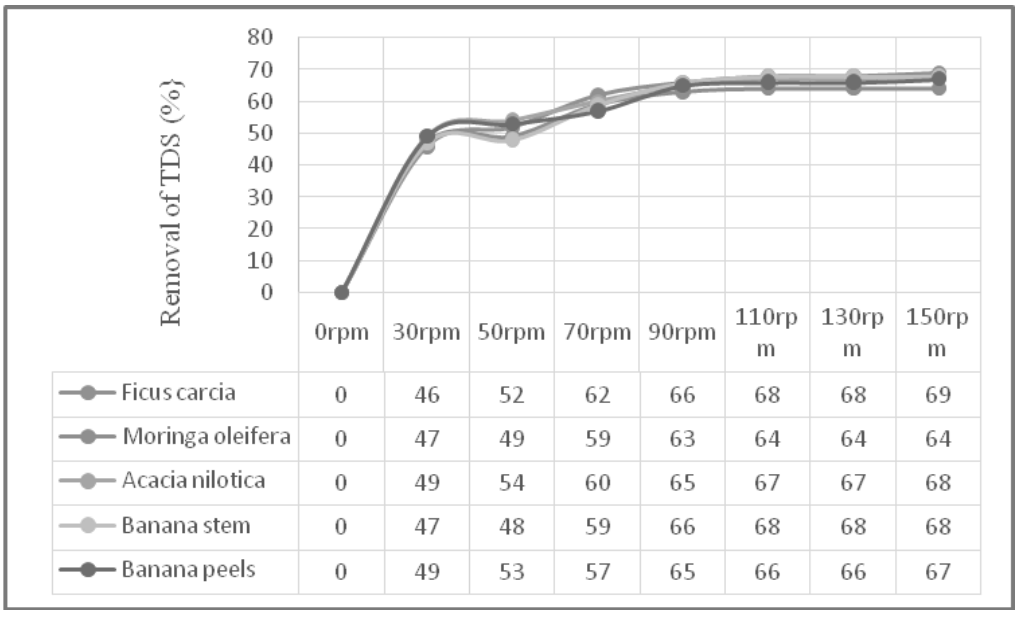
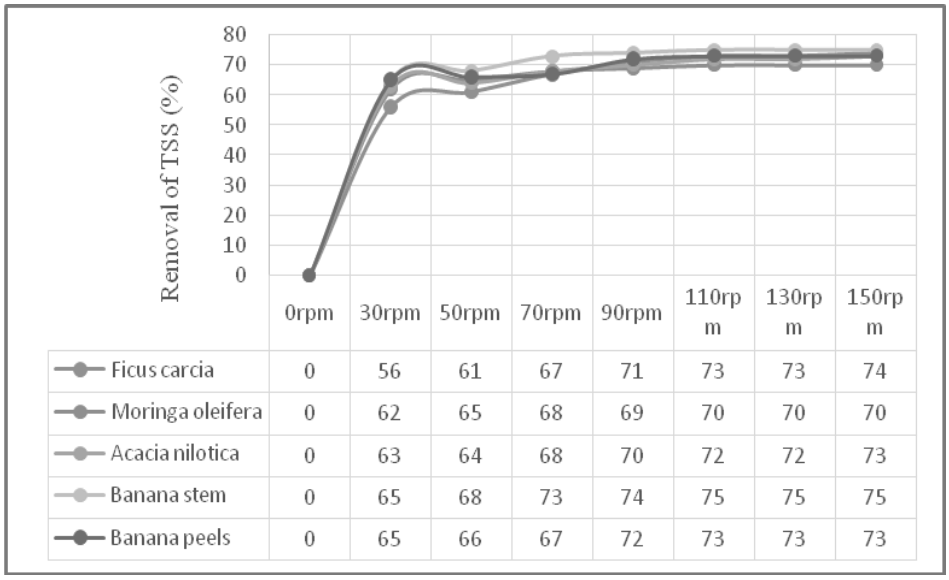


Figure 3: Removal of TDS with variation of speed for different coagulants

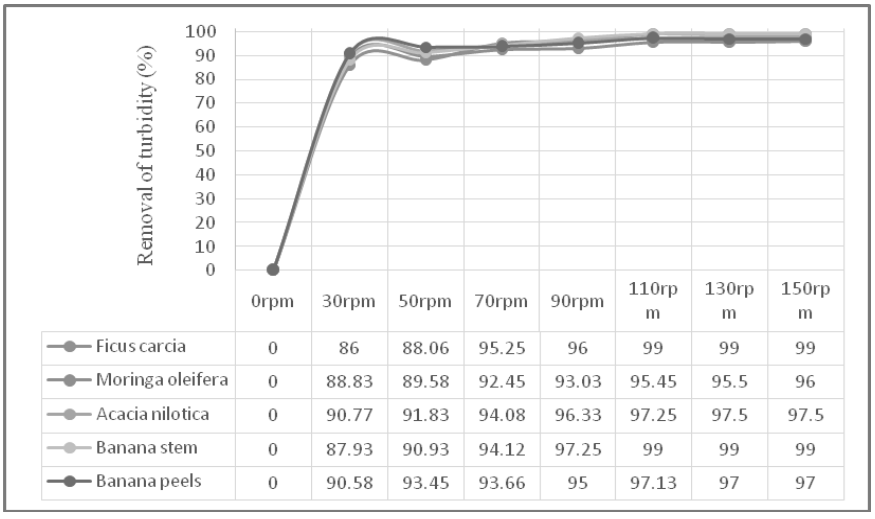
Total dissolved solid of the sample is reduced considerably, being highest 759 mg/l (69%) for 150 rpm for *Ficus Carcia* coagulant which is within maximum permissible limit. However, it is remarkable that the incremental rate of removal is quite same after 90 rpm of speed. Therefore, it would better to consider the other parameters and interactive effect in removing dissolved solids to find out the optimum speed.



	0rpm	30rpm	50rpm	70rpm	90rpm	110rpm	130rpm	150rpm
Ficus carcia	0	56	61	67	71	73	73	74
Moringa oleifera	0	62	65	68	69	70	70	70
Acacia nilotica	0	63	64	68	70	72	72	73
Banana stem	0	65	68	73	74	75	75	75
Banana peels	0	65	66	67	72	73	73	73

Figure 4: Removal of TSS with variation of speed for different coagulants

Total Suspended solid of the sample is reduced considerably, being highest 75 mg/l (75%) for 110 rpm, 130 rpm and 150 rpm of speed with Banana stem coagulant and it is within maximum permissible limit. Similar to dissolved solids removal suspended solids removal is also increasing with increase of speed but not significant.



	0rpm	30rpm	50rpm	70rpm	90rpm	110rpm	130rpm	150rpm
Ficus carcia	0	86	88.06	95.25	96	99	99	99
Moringa oleifera	0	88.83	89.58	92.45	93.03	95.45	95.5	96
Acacia nilotica	0	90.77	91.83	94.08	96.33	97.25	97.5	97.5
Banana stem	0	87.93	90.93	94.12	97.25	99	99	99
Banana peels	0	90.58	93.45	93.66	95	97.13	97	97

Figure 5: Removal of turbidity with variation of speed for different coagulants

From Fig. 5 it can be said that effect of speed on removal of turbidity is quite same after 90 rpm of speed. Turbidity from wastewater sample is reduced considerably being highest 0.31 NTU (99%) for 110 rpm, 130 rpm and 150 rpm for *Ficus carcia* and Banana stem coagulants. From this treatment, turbidity can be possible to reduce within maximum permissible limit and can be used for irrigation or discharging to the natural receiving bodies.

CONCLUSIONS

It could be concluded from the obtained results that municipal wastewater of Rajshahi City Corporation area is highly turbid (16.5 to 31 NTU) due to the presence of large amount of suspended and dissolved solids. In this study, about 69% removal of TDS, 75% removal of TSS and 99% removal of turbidity was achieved. Therefore, all five selected materials *Moringa oleifera*, *Acacia nilotica*, *Ficus Carcia*, banana stem and banana peels are found to be potential coagulants for the treatment of municipal wastewater of Rajshahi city. The optimum speed is obtained to be of 110 rpm for all types of materials used as coagulants for the maximum removal of TSS, TDS and turbidity.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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SOLID WASTE MANAGEMENT IN CHATTOGRAM CITY CORPORATION AREA

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ABSTRACT
Solid Waste management (SWM) or waste disposals are all the activities and actions required to manage waste from its inception to its final disposal. This includes amongst other things collection, transport, treatment and disposal of waste together with monitoring and regulation. Nowadays these waste materials are not treated as waste, these have different significance in our social and economic condition. This paper deals with the present scenario of solid waste management of Chattagram City Corporation (ChCC). From this study we found that, in present total waste in Chattagram City Corporation is about 2289 ton per day but only negligible amount is properly recycled and a large amount of waste is not under recycling process. The study also deals with the estimation of the population and waste generation for the year of 2051, so that the future condition of waste materials management of Chattagram City Corporation can be predicted. This paper includes an opinion survey, economic survey and environmental assessment due to solid waste of the study area. Secondary data was collected from CDA, BWDB, newspaper and also some previous survey. Finally possible management system was discussed to meet the needs of the present and which will help for the future sustainable development in a proper way of Chattagram City Corporation.

Keywords: SWM, ChCC, Sustainable development, MSW etc.

INTRODUCTION
Solid waste management is the activity and action required to manage waste from its inception to its final disposal. This includes amongst other things collection, transportation, treatment and disposal of waste together with necessary monitoring and regulation. Bangladesh is highly dense populated country having population density about 965 per square kilometer with 3.27% per annum urban population growth. At present, there are about 522 urban centers in Bangladesh which included 254 municipalities and 12 city corporations which generated a huge amount of solid waste every day (Hossain & Alam, 2012).(But these generated solid waste posing a serious threat to the city people especially to the decision makers.
In 2012, Waste generation rate in Bangladesh was about 22.4 million tons per year or 150 kg/capita/year whereas in 2003 and 2005 on an average 5650 and 7690 tons of municipal solid wastes were generated every day from major cities of Bangladesh (Islam, 2016, Alamgir and Ahsan, 2007). Per capita consumption for three major city was reported as 0.4 Kg/capita/day and the value was 0.352 Kg/capita/day for the Chattagram city only but on an average only 0.2 kg/day had been carried out to the disposal sites(Ashraf et al. 2013, Halder et al. 2014, Ahsan et al. 2014) Among the solid waste contain radio-active elements and pathological substances and 15-20% of these wastes are highly dangerous for human lives (Yasmin, 2017).

About 40-60% generated waste are not properly collected, stored or disposed which causes water and atmospheric pollution (Alamgir & Ahsan, 2007).
Chattagram city corporation (ChCC) has been chosen as study area. Chattagram is the second largest city as well as the port city of Bangladesh having 28 million people of whom 5 million live in Chattagram Metropolitan Area (BBS, 2011). The area of ChCC is about 185 sq. km (60 sq. miles) having population of 25, 82401(BBS, 2011). ChCC is divided into 11 thanas, 41 yards and 211 mahallas, 5, 56,451 households (BBS, 2011) equipped with 1350 dustbins, 95 metal containers(ChCC, 2018). The Objective of this study is to assess the status of existing solid waste management system of ChCC and estimation of generated solid waste for the year of 2051 as well as a proper solid waste management system.

METHODOLOGY

Methodology starts with collection of primary and secondary data. Primary data was collected through field investigation, depth discussion with stakeholders, employees, housewives, truck drivers, waste collectors, labor to assess the situation of solid waste management. Secondary data about population, existing management system, numbers of dustbins, generated waste etc. were collected from Chattagram City Corporation, reports of different institutions, web materials, research articles, book, and journals.
About 20 sites were selected for collecting data from 41 wards in Chattagram City Corporation area. Data were collected from 23 July, 2017 to 05 May, 2018 in three stages to evaluate the seasonal variation of waste generation rate. Sampling was done form waste generation sources and also from the dump trucks on the disposal sites. A total 73 respondents from different sectors were selected for questionnaire survey and detailed information. Preliminary survey was conducted to categorized physical composition of generated waste and contribution of different waste generation sources. Per capita waste generation rate was calculated from daily average amount of generated solid waste in household level. Total amount of generated waste estimated using the population data, capacity of the trucks and their numbers. Projected population and solid waste generation estimated using Incremental Increase Method (IIM) and Regression Analysis (RA). For future population estimation and expected waste generation, year 2051 has been selected considering time required for implementation and phase development of the project also considering the consumption pattern and socio-economic profile variation of the population.

RESULTS AND DISCUSSIONS

Present scenario of SWM in ChCC

Conservancy Department of ChCC bears the responsibilities for solid waste management. Different organizations collect the waste from households and dumped in Secondary Transfer Stations (STS) by local transportation system. Dump trucks and container movers from ChCC conveys the wastes to the major two dumping sites Arefin Nagar in Pahartali and Anandabazar in Halishahar having effective area about 83 acres (Ashraf et al., 2013). About 84 trucks and container trucks expected to have 4 to 8 trips per day as per demand and more than 507 rickshaw vans are collecting wastes from households level with 2 to 4 trips (Ashraf et al., 2013). Figure 01 shows number of dustbins are available in 41 wards in different locations of Chattagram City Corporations area. 1350 dustbins and 95 containers are placed at different locations by ChCC (CCIDP, 2017).

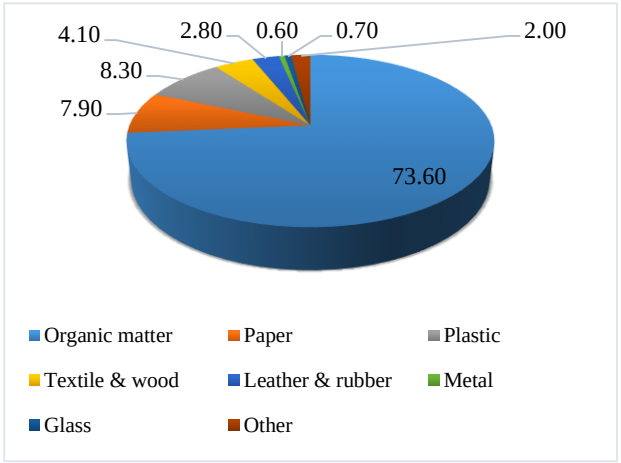
Generation, Distribution & Characteristics of Solid waste

Estimation of the total generated solid waste is so important for decision making as well as to evaluate the effect on environment. Generation of solid waste is mainly dependent on socio-economic factors of the inhabitants like habit, economic status, age, food pattern, life style, gender member, season, population density etc. The inhabitants of ChCC produce solid wastes from different sources such as residential, commercial, industrial, market place, medical, institutional and so on. Amount of wastes generation and their characterization is important to evaluate the effect on environment as well as to make decision for the policy makers. Physical compositions of solid wastes helps in having the concept of amount of wastes generated from different sources. Physical components of wastes from residential, commercial, industrial and market areas in different location in ChCC are shown in Table 01.

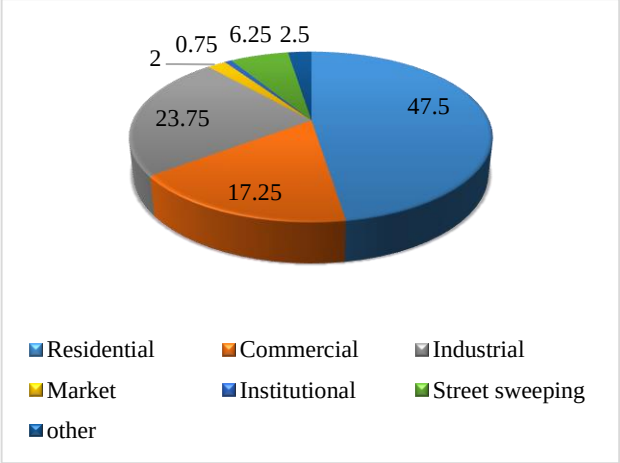
Table 01: Physical compositions of solid waste

	Location Name	Organic Matter (%)	Paper (%)	Plastic (%)	Textile & Wood (%)	Leather & Rubber (%)	Metal (%)	Glass (%)	Others (%)
Residential	East Bakalia	65.0	5.0	20.0	1.0	2.0	2.0	2.0	3.0
	Dewan Bazar	80.0	2.0	7.0	2.0	2.0	0.0	1.0	6.0
	Jamal Khan	80.0	5.0	10.0	2.5	1.0	0.0	0.5	1.0
	Agrabad Hajipara	50.0	7.0	30.0	5.0	4.0	1.0	2.0	1.0
	PC Road Rampur	74.0	10.0	7.0	3.0	2.0	0.1	1.0	3.0
	CDA-23 No	82.0	4.0	7.0	3.0	2.0	0.8	0.2	1.1
	Hathazari	85.1	4.1	2.7	1.7	0.6	0.7	1.7	3.4
	Bayezid	90.6	1.3	2.6	1.3	0.8	0.5	0.3	2.6
	Chandgong	92.2	2.0	1.6	1.0	1.0	0.7	0.4	1.0
	Average	77.7	4.5	9.8	2.3	1.7	0.6	1.0	2.5
Commercial	Enayet Bazar	75.0	12.0	8.0	2.0	1.5	0.1	0.5	1.0
	South Halsahar	82.0	4.0	7.0	3.0	2.0	0.8	0.2	1.1
	North Potenga	74.0	10.0	7.0	3.0	2.0	0.1	1.0	3.0
	Average	77.0	8.7	7.3	2.7	1.8	0.3	0.5	1.7
Industrial	Halishahar	85.0	3.0	4.0	4.0	1.1	0.7	0.3	2.0
	Madarbari Railgate	45.0	5.0	10.0	18.5	20.0	0.5	0.1	1.0
	Sadarghat	55.0	25.0	5.0	10.0	2.0	0.3	0.1	2.7
	South Potenga	50.0	7.0	30.0	5.0	4.0	1.0	2.0	1.0
	Average	58.8	10.0	12.3	9.4	6.8	0.6	0.6	1.7
Market	Mia Khan Road	83.0	6.0	5.0	1.5	0.5	1.0	1.0	2.0
	Pathantuli	82.0	7.0	3.0	2.5	1.5	1.0	0.6	2.5
	Andarkilla	78.0	12.0	3.5	2.0	1.0	0.4	0.5	2.6
	Average	81.0	8.3	3.8	2.0	1.0	0.8	0.7	2.4
Total Average Value		73.6	7.9	8.3	4.1	2.8	0.6	0.7	2.0

The study revealed that biodegradable fraction is comparatively higher than other components while leather, rubber, metal and glass were the smallest.



(A)



(B)

Fig 01: (A) Physical composition of waste. (B) Contributions of different sectors in generated waste.

The combined percentage of generated waste from different location of ChCC was found about 73.6% organic matter, 7.9% papers, 8.3% plastic, 4.1% wood and textile, 2.8% leather and rubber, 0.6% metal, 0.7% glass and 2% other materials. Fig. 1(B) shows the contributions of different sources in generation of total solid wastes where residential wastes contributes nearly about 47.5% of the total generated waste. 23.75% and 17.25% came from industrial and commercial sector and rest are from other sectors.

Per capita generation and future estimation

Per capita waste generation is mainly dependent on income of the people, ages along with some other factors like life style, socio-economic status, climate etc. A survey has been conducted in ChCC area based on economic conditions and ages to estimate the rate of weighted average per capita consumption of domestic waste and the result is shown in Table 02.

Table 02: Per capita domestic waste generation rate for ChCC.

Type of Population	Income Level (TK/month/family)	Domestic Waste Generation Rate (Kg/cap./day)			Age	Domestic Waste Generation Rate (Kg/cap./day)
		Dry Season	Wet Season			
High Income	10,000>	0.49 to 0.51	0.47 to 0.51		1 to 10	0.29 to 0.39
Middle Income	40,000>,>=10,000	0.41 to 0.48	0.38 to 0.43		20 to 45	0.38 to 0.47
Low Income	>=40,000	0.34 to 0.38	0.31 to 0.35		> 45	0.46 to 0.53

Per capita consumption found in the study area has been found 0.31 to 0.51 Kg/cap./day and total waste generation in the area is 2289 ton/day. The study found that high income people and the people aged above 45 produce more wastes than others. The result also revealed that there prevails a variation of waste generation rate between dry season and wet season. Solid wastes contain more moisture during the wet period that's why the weight is higher in wet season than dry season.

Estimation of future waste generation and management model

There is significant effect on waste generation with the growth of urban population. The population of ChCC area in the year of 1991, 2001, and 2011 was about 1392958, 2023489, and 2592439 and during 1999 the domestic waste generation rate was about 666 ton/day (SCI, 1999) and in 2007 the rate was 1315 ton/day (Alamgir & Ahsan, 2007). Estimation of the waste generation for the year 2051 was done by Regression Analysis (RA) factoring expected population growth and per capita generation rate. The result is shown in Fig. 02 and Fig. 03.

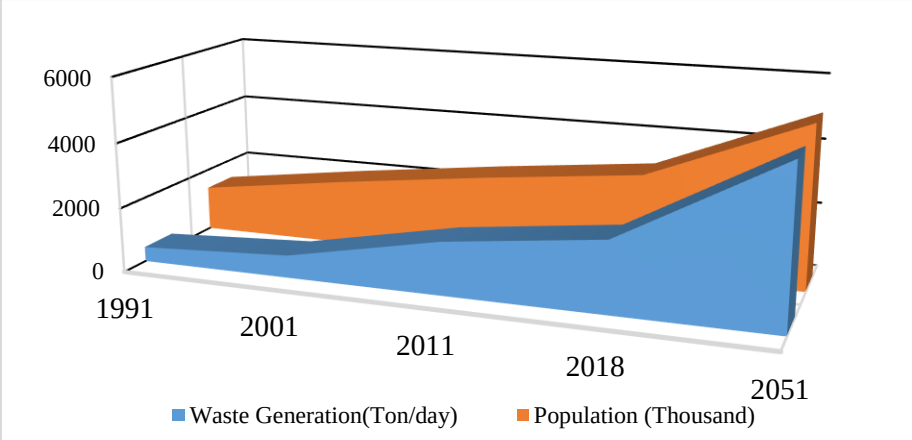


Fig. 02: Relationship between Generated wastes with population. (Source : Misuk, 2015, BBS 2001, BBS, 1991, BBS, 2011, ChCC, 2018, Hossain & Alam, 2012)

R^2 Value for waste generation found to be 0.884 and estimated population and waste generation rate for the year of 2051 was found 5036516 and 4885 ton/day. Fig 02 also shows how generated waste changes with growth of the population. The physical compositions of the generated solid wastes in 2018 and estimated generated solid waste has been illustrated in Fig. 04.

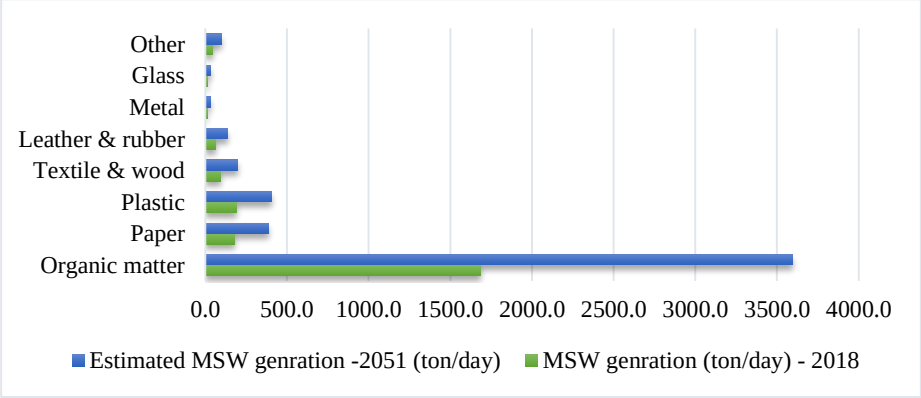


Fig 03: Present and future physical composition of generated Municipal Solid Waste

The most significant component found in 2051 is organic matter which is 2.13 times than present generated waste. Paper, plastic, textile and wood, leather and rubber also have significant contribution.

Due to resemblance in waste generation dispositions, coupling of waste are sorted into Industrial/Commercial Solid Waste & Domestic Solid Waste. In the first the individuality of wastes from market area bestowed separately in variant bins consonant to their peculiarity. Then the Callous wastes are separately excerpted in suitable wherewithal and exiled to the processing position Bio wastes transfer into compost, are disposed in BOD ponding. Non Bio wastes propagators goes to the landfill procedure and other propagators turns in re-cycle action. Biogas can be formed by domestic solid waste, it can be turned into heat electricity. In Fig. 04 the solid waste management model is shown.

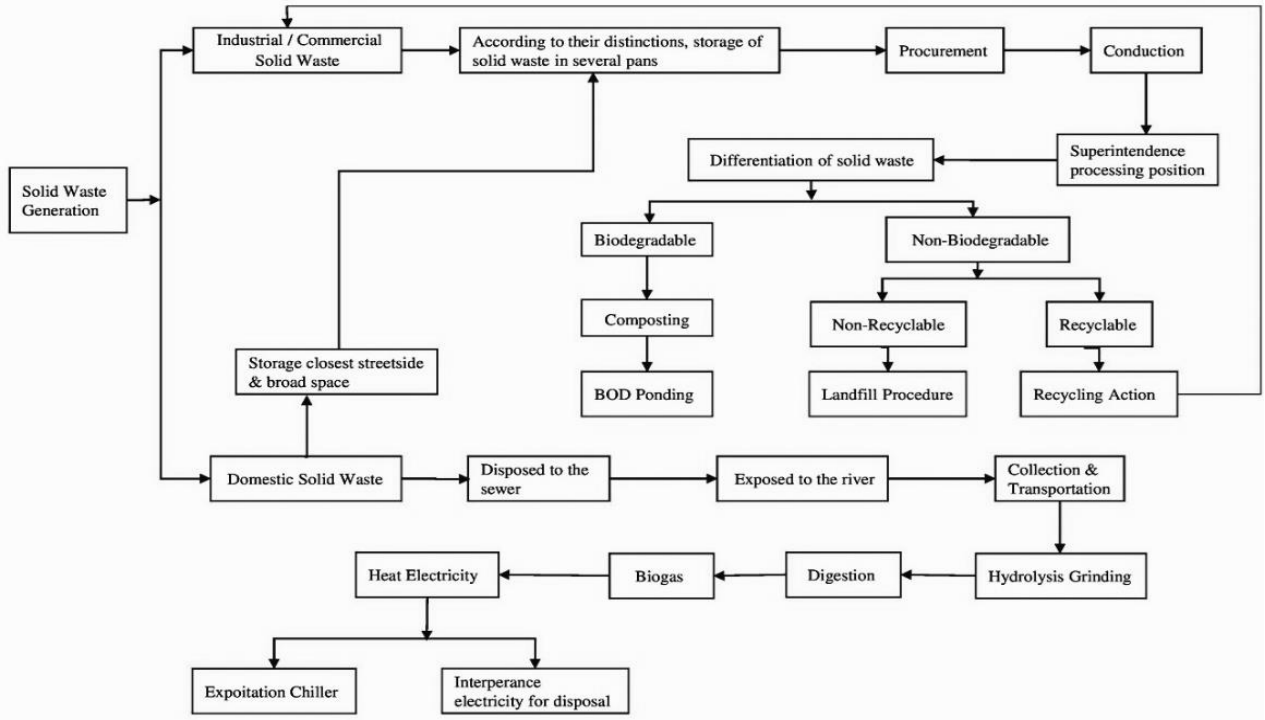


Fig 04: Solid waste management model.

CONCLUSIONS

Solid waste generation nature is changing rapidly with the explosion of world population. This paper summarized the silent features of solid waste management scenario in ChCC area. Average generated solid waste per capita has been found as 0.31 to 0.51 Kg/day although there prevails seasonal variation of waste generation rate and estimated solid waste generation for the year 2051 has been found 4885 ton/day. Average composition of generated waste has been found about 73.6% organic matter, 7.9% papers, 8.3% plastic, 4.1% wood and textile, 2.8% leather and rubber, 0.6% metal, 0.7% glass and 2% other materials. Based on the data and characteristic of waste an integrated solid waste management has been proposed. Successful solid waste management calls the combined participation of the stakeholders, local people and politicians. Development of long and strategic framework along with empowering and capacity building of manpower, improvement of collection system, waste recycling as a treatment option, awareness building in community level should be done towards the integrated sustainable development approaches. The findings of this study surely give essential message to the decision makers in of Chattagram City Corporation.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
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DEVELOPMENT OF A RESPIROMETRY AND COD BASED RAPID EXPERIMENTAL PROTOCOL FOR ANALYZING WASTEWATER SAMPLE

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ABSTRACT
Biological parameter analysis is an important issue in regard to biological treatment of wastewater. Presently, biochemical oxygen demand (BOD) is widely used as a unique bioactivity performance indicator in our local effluent treatment plants (ETPs). However, application of respirometry may be an important alternative in the operation and maintenance of wastewater treatment plants. The main objective of the study is to develop a low-cost wastewater respirometer to determine some important respirometric parameters such as Oxygen consumption rate (OCR), Carbon dioxide evolution rate (CER) and respiratory quotient (RQ) of wastewater samples. Validation of the newly fabricated respirometer was done by checking repeatability of the test results using standard sodium sulfite deoxygenating method. Finally, five wastewater samples covering (both municipal and industrial) low range chemical oxygen demand (COD) value were tested in the respirometer for three hours of incubation period to obtain respirograms to calculate OCR, CER and RQ. Similarly, another five wastewater samples covering (both municipal and industrial) high range COD value were also tested in the respirometer for three hours of incubation period to obtain similar patterns of respirogram for finding OCR, CER and RQ.

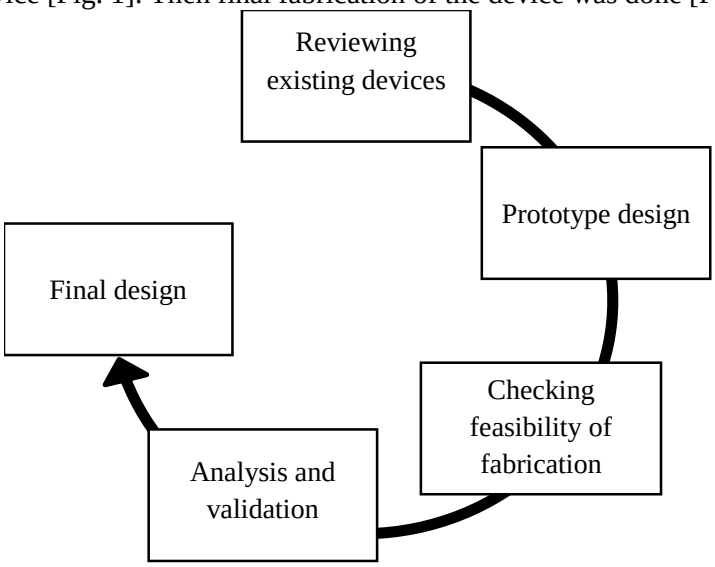
Keywords: Carbon dioxide evolution rate; Oxygen consumption rate; Respiration; Respirogram; Respirometer; Respiratory quotient; Wastewater.

INTRODUCTION
In our country, biochemical oxygen demand (BOD) is being used as a unique wastewater quality index from academic to industrial level for both design and operation of effluent treatment plant (ETP). It is very important to develop a relatively faster and cost effective way for understanding the biodegradation phenomena that are taken placed in a reaction tank of an ETP (Spanjers and Vanrolleghem, 1995; Young and Cowan, 2004). Respiration is generally considered as a general measure of the microbial activity (Rahman and Islam, 2015). Therefore the respiration process and its qualitative and quantitative phenomena could be an effective indicator of the on-going condition of a typical biodegradation process. Respirometric parameters such as Cumulative Oxygen Consumption (COC), Oxygen Consumption Rate

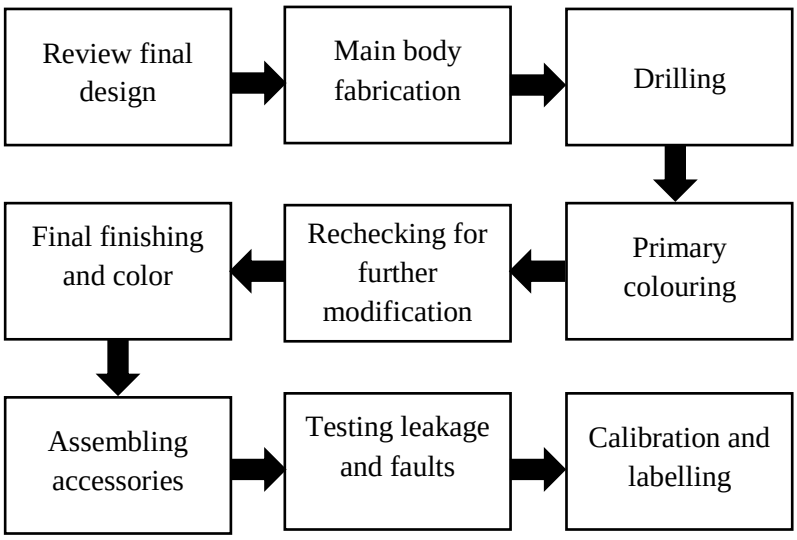
(OCR), Cumulative Carbon-dioxide Evolution (CCE), Carbon-dioxide Evolution Rate (CER) and Respiratory Quotient (RQ) can ascertain the presence of organic matters, microbes and respiration type present in wastewater by observing microbial activities (Rahman and Islam, 2015). These parameters can provide a reliable and scientifically sound assessment of biodegradable criteria. Oxygen consumption and Carbon dioxide emission are directly associated with both biomass growth and substrate removal (Vanrolleghem, 2002). It can be considered as one of the most important information sources in activated sludge process modelling and process control. Respirometry is used to assess wastewater toxicity to heterotrophic and nitrifying bacteria in activated sludge (Hartmann et. al, 2013). Respirometry is a direct method for measuring sludge activity and thus toxicity to sludge (Ren, 2004). The method for analyzing wastewater based on Respirometry and COD is comparatively new to the dominant part of higher educational institutions in Bangladesh. From this research different parameters as stated earlier like OCR, CER and RQ can be known which will give a clear picture about the concentration of organic matters and biodegradation status of wastewater under some treatment. Thus this study can present an improved quick test protocol for analyzing wastewater with locally available materials and technology.

METHODOLOGY

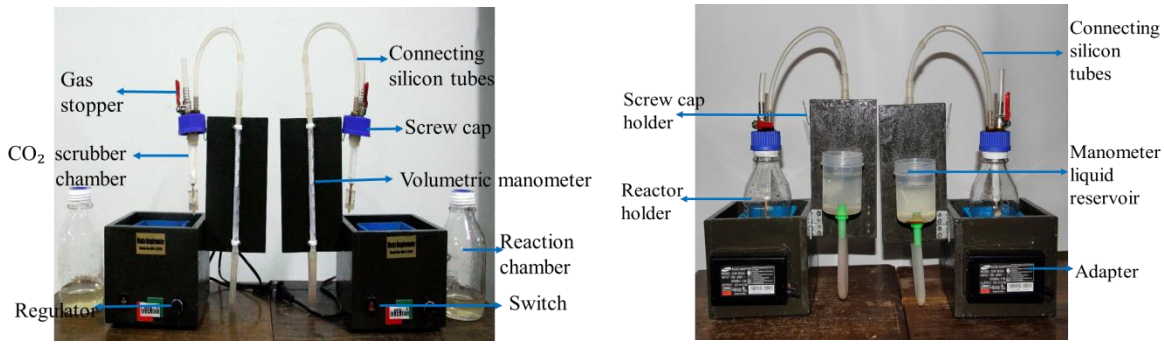
Before starting design and fabrication of the present respirometer, a survey was done to find existing devices in the market and nearby laboratories. After that a prototype device was built to test the feasibility of the concept and device [Fig. 1]. Then final fabrication of the device was done [Fig. 2 and Fig. 3].



[Fig. 1] Design approach for the fabrication of the device



[Fig. 2] Fabrication approach of the device



[Fig.3] Fabricated 'Waste Respirometer'

Technical specifications

Technical provisions that are embedded in the model are pointed out in the following **Table 1**.

Table 1: Technical specifications of the present device 'Waste Respirometer'

Features	Description
Measuring principle	Volumetric and/ or manometric
Reactor volume	595 ml
Power supply	110-220 V (AC), 50/60 Hz [Converted to 12 V DC]
Power efficiency	4 watts
Stirrer speed	0-4100 rpm
Sound level	44 dB
Weight	2 kg (Approx.)
Manometric liquid	Diluted methyl orange
Application	Determination of OCR, CER, RQ Comparative respirometric analysis.

Validation of the 'Waste Respirometer'

Validation of test results obtained from standard method is expressed here in terms of standard deviations. It can be divided into two components i.e. 1) repeatability and 2) reproducibility. Repeatability is the measurement of variability found when the same sample is tested by the same operator. Reproducibility is the measurement of variability found when the same sample is repeatedly tested by different operators.

However, in this study, repeatability checking is important as it is closely related to the test result variation. The current device satisfactorily produces repeated data with a good precision for a set of experiments performed. A control test with sodium sulfite (Na_2SO_3) solution in presence of cobalt chloride ($CoCl_2$) was done to assess the precision of the instrument (Kessick, 1976). Sodium sulfite functions as oxygen scavenger in presence of cobalt chloride within the reactor of the respirometer and total oxygen consumption was read out from the manometer readings. The results of such a precision test are presented in **Table 2.** From the test results it is found that the relative standard deviation is only 3.44% and 3.15% respectively, which fairly proves the preciseness of the machine data.

Table 2: Repeatability checks of the test results obtain from the present device

Respirometer No.	Test no.	Total Oxygen Uptake, mL	Mean	Standard deviation	Relative Standard deviation,%
Respirometer No. 1	Test 1	4.3	4.275	0.147	3.44
	Test 2	4.5			
	Test 3	4.2			
	Test 4	4.1			
Respirometer No. 2	Test 1	4.2	4.125	0.129	3.15
	Test 2	4.3			
	Test 3	4			
	Test 4	4			

Operation of the device

The following steps are followed to run a test sample using this waste respirometer.

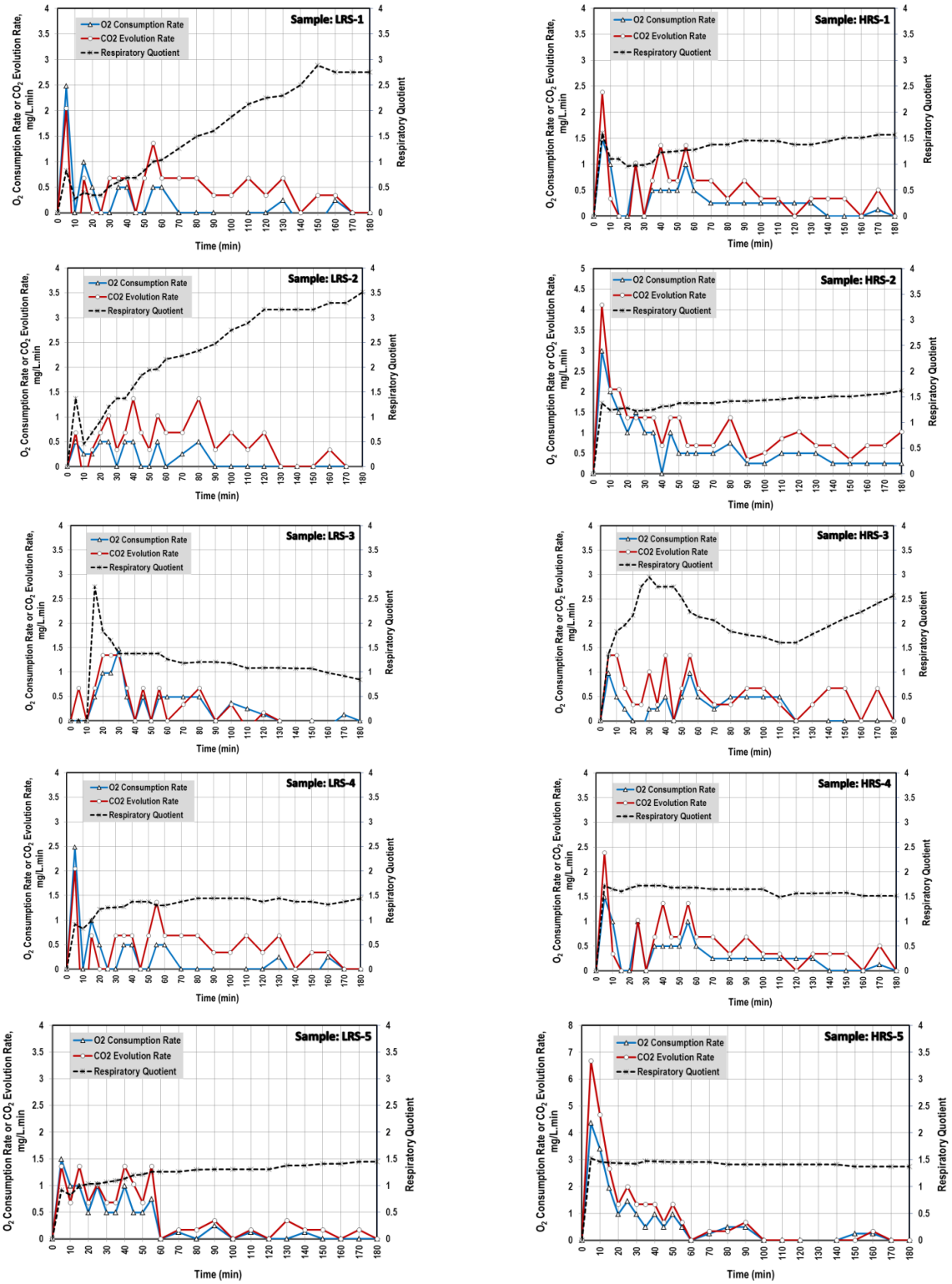
1. All joints and connections have to be perfectly airtight.
2. Leakage test should be performed. If leakage exists, it should be sealed with strong adhesive glue, silica gel, grease or petroleum jelly.
3. Weight and volume of sample should be determined.
4. 100ml sample should be placed in reactor.
5. Remaining air volume of reactor should be determined. Total volume of sample, stirrer bar, KOH container and cap should be subtracted from volume of reactor. Approximately 10ml can be considered as replaced volume for stirrer bar, KOH container.
6. Magnetic stirrer bar should be placed in reactor if the sample is liquid.
7. 10-20 pellets of KOH should be placed in CO2 scrubber container.
8. The gas stopper should be adjusted in such a way so that the reactor is directly connected to the manometer.
9. The magnetic stirrer should be turned on (if needed). RPM should be adjusted as required (optional).
10. Manometer readings should be tabulated for further analysis.

Along with the above steps, room temperature, sample temperature and humidity were also measured. For the analysis of wastewater total solid, dissolved solid, suspended solid, pH, COD of the samples were measured at the starting time of experiment and after three hours of incubation period.

RESULTS AND DISCUSSIONS

All the output respirograms of the tested wastewater samples for both low range COD and high range COD category is presented in the figure 4. It is seen that the first peaks were detected at early age of experiment in both case of OCR and CER. The peaks indicate that the respiration rates of samples were high in these points. Gradually, with the increase of time the respiration rates were decreasing. Sometimes OCR and CER value has shown some small peaks which indicate that respiration activity of the samples were intermittent type. Sometimes respiration was at high rate and some other time at lower rate. Since,

there was sufficient amount of oxygen inside the reactor at the initial time, therefore respiration response in the beginning of the test was high. But as long as inside oxygen dropped down, the respiration rate also decreased.



[Fig. 4] Respirograms of the wastewater samples for low range COD (left) and high range COD (right) category

Increased value of RQ with time means that organic substrates present in the sample are continuously degraded. While RQ was below 1, aerobic respiration was going on. When it reached above 1, it means the presence and degradation of organic acid and presence of anaerobic micro-organisms (Dilly, 2001; Kovacs et al., 2007). Sample no. 5 of high range COD (HRS-5) has the highest peak of OCR and CER, which means that it has the highest respiration rate of all the samples and is enriched with micro-organisms. It contains organic acid since RQ was constantly above one. At 100 minutes of the experiment OCR and CER of HRS-5 was around zero which means the sample was fully degraded. Sample no. 1 and 4 of low range COD (LRS-1 and LRS-4) has the highest peak amongst the samples of low range COD. These samples were of domestic wastewater and wastewater of a food shop respectively. Since these types of wastewater contain high amount of organic content, the respiration rates OCR and CER are high. Irregular variation of RQ of these samples indicates that samples are of mixed type composition. In most analyses CER was higher than OCR because of the presence of anaerobic micro-organisms thereby anaerobic respiration. During the ending period of experiment LRS-1, LRS-2, LRS-4, HRS-1, HRS-3, HRS-4 had CER only, OCR was around zero. Because after consuming the whole oxygen available in the reactor aerobic respiration stops, only anaerobic respiration remains.

CONCLUSIONS

This work proposed a unique idea to design cost-effective, good performance respirometer in the laboratory from locally available materials. The developed 'Waste Respirometer' could trace both the oxygen consumption and carbon dioxide evolution at the same time in a typical biodegradation process. The biomonitoring parameters (OCR, CER and RQ) proposed in the study could be used in various decision and policy making activities concerning biodegradation of different test substrates and design, operation and management of ETP.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
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DEVELOPMENT OF AN ELECTRO-RESISTIVITY BASED WASTEWATER ANALYZER FOR INDIRECT ESTIMATION OF COD, TDS, TURBIDITY AND DISSOLVED CO_2

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ABSTRACT
Parametric analysis is an important routine task for making decision about treatment and reuse of wastewater generated from different sources. Available commercial products in the market under different brands which measure some special wastewater parameters such as total dissolved solids (TDS), turbidity, chemical oxygen demand (COD) and dissolved carbon dioxide (CO_2) are very costly and can determine only one parameter at a time. The main objective of the study is to develop a method and to design and fabricate a cost-effective micro-processor based "**Waste Analyzer**" for indirect estimation of all these parameters using electro-resistivity principle from a single test observation. For developing the correlation between electro-resistivity values generated by the fabricated device and these four parameters, thirty samples were collected from three different types of sources (inland surface water, open drain wastewater and industrial wastewater) to perform test experiments in the laboratory. A "Python language" based software was developed to control micro-processor for estimating results. For testing validity of the device, ten unknown wastewater samples were taken for measuring the above four parameters using both commercial and developed device. The output results were limited from 30µS/cm to 10000µS/cm for conductivity determination. However, the result was found fairly close to the same values as the commercial devices produced in all the cases.

Keywords: COD; Conductivity; Dissolved carbon dioxide; TDS; Turbidity.

INTRODUCTION

There are many types of testing appliances for determining wastewater quality in terms of total dissolve solids, turbidity, COD and dissolve carbon dioxide in different scientific sectors (Oyem *et al.*, 2014). To measure all these parameters, one has to buy four individual instruments that can provide information separately. So far it is known, there is no single device which can determine all these important parameters under single operation. Therefore, the main objective of this study was to design and fabricate a low-cost single unit device to measure total dissolve solids, turbidity, COD and dissolve carbon dioxide of wastewater samples on electro-resistivity principle and to validate the performance test of the device by measuring the abovementioned parameters for different municipal and industrial wastewater (Ali et al., 2012). For this study, total 30 samples collected form three types of sources like as inland surface water, drain wastewater and industrial wastewater were used. All of the samples were collected from different sources in Sylhet city area, Bangladesh.

This study attribute in different ways in relation to the present academic and industrial field. The design of this device and the relevant fabrication work can be a learning prototype in academic level to increase the innovative skill of students, teachers and researchers. Students would be benefited by using this single robust device which could determine the four wastewater parameters simultaneously (Archie, 1942). Research which explores the advantages of such technology will help to raise awareness among those who are unacquainted with its potential applications and benefits within their educational setting. ETP personnel can use this device for routine checking of the performance of different treatment units.

METHODOLOGY

Sample collection

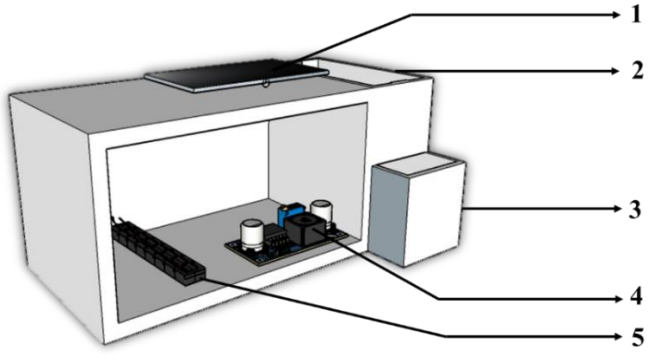
For this research, samples were collected from three types of source (Inland surface water, open drain wastewater, industrial wastewater) in Sylhet city area in Bangladesh. The parameters like conductivity, TDS, turbidity, COD and dissolved CO_2 were tested in the laboratory.

Standard method for wastewater parameters determination

The conductivity of wastewater was determined by a commercial conductivity meter (model: HI 9831-5). The TDS of wastewater was determined by a commercial device (model: TDS 5031). Turbidity of wastewater was determined by a commercial device (Lutron TU- 2016). Sample was digested by Hach DRB 200 digester at 150^0c for 120 minutes. After this, the absorbance of digested samples was measured by Hach DR 6000 with respect to blank at 600nm wavelength. Because, in the 600nm region chromic ion absorbs strongly, where the dichromate has nearly zero absorption ((Zhao *et al.*, 2004). Dissolved CO_2 was measured by analytical process means titration though NaOH

Device development

"**Waste Analyzer**" is a device (**Fig. 1**) which is used to determine the parameters by measuring voltage and resistance of wastewater. This machine was fabricated by using locally accessible materials and few factory-made equipment. The designed machine consists of four major parts:



[Fig. 1] Schematic diagram of the complete device "Waste Analyzer"
[1-Display unit, 2-Water chamber, 3-Disposal unit, 4-Microprocessor, 5-power adapter]

Wastewater chamber: Wastewater chamber is an important part of the device. This chamber is made of acrylic plastic. In this chamber, the wastewater sample is to be poured. There are two probes in this chamber which are used to determine the difference of voltage.

Disposal unit: This unit is placed just under the water chamber. After the sample is tested, the sample is disposed from water chamber to this disposal unit. Water chamber and disposal unit are linked with a silicon tube. It can be easily moved or carried to vacant the wastewater.

Voltage measuring unit: Voltage measuring unit is an electrical device consisting a circuit to measure the voltage difference between two probes. The input voltage is given from the ac current through an adapter. Output voltage can be measured by this unit. The output voltage is directly proportional to the input voltage and the ratio of resistance.

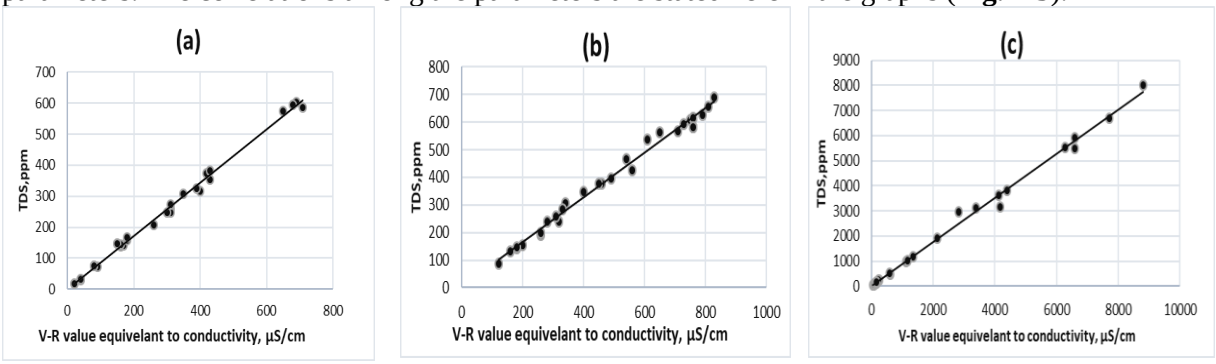
Display unit: Display unit is the part of this device where the measured values are shown. The display unit consists of a TFT Touch LCD Module.

Operation of the device: The following steps are generally followed to run a test sample using the "**Waste Analyzer**" in laboratory. First of all, the plug of the machine should be connected to socket. Calibration will not be required. As the AC current converted to DC current with voltage of 19, oxidation of the sample wouldn't be happened. Then wastewater is poured in the wastewater chamber. After this, the icon which was displayed on the monitor would be opened. Finally, the option in the monitor should be selected to determine the parameter.

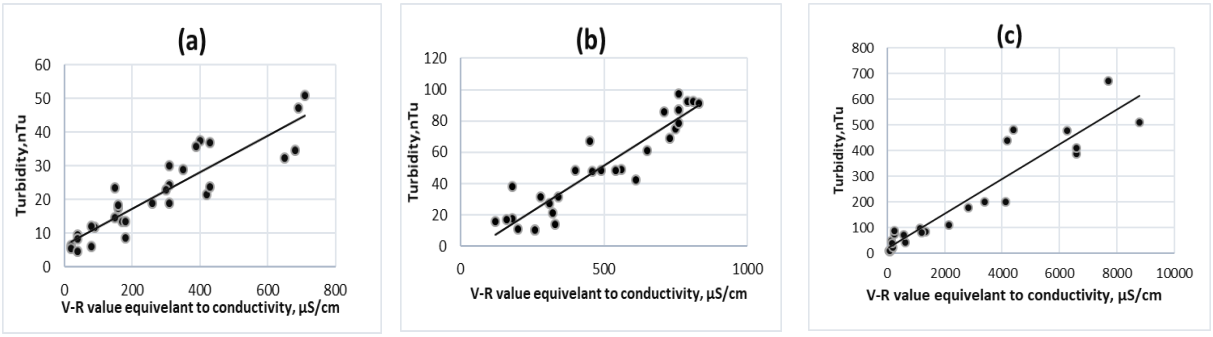
Software for device output: The "**Waste Analyzer**" software has been developed by the programming language of python to control the device and to determine the waste water parameter. When the sample has to be analyzed by device, operator should know the types of sample whether the sample is from industrial or municipal source. Then, the specific type of sample (inland surface wastewater, open drain wastewater, industrial wastewater) and the corresponding wastewater parameter has to be selected to analyze. After doing so, the device will measure the conductivity of wastewater sample and convert it to the desired parameter using the following equations. The result will appear on LCD touch display.

Indirect method for wastewater parameters determination

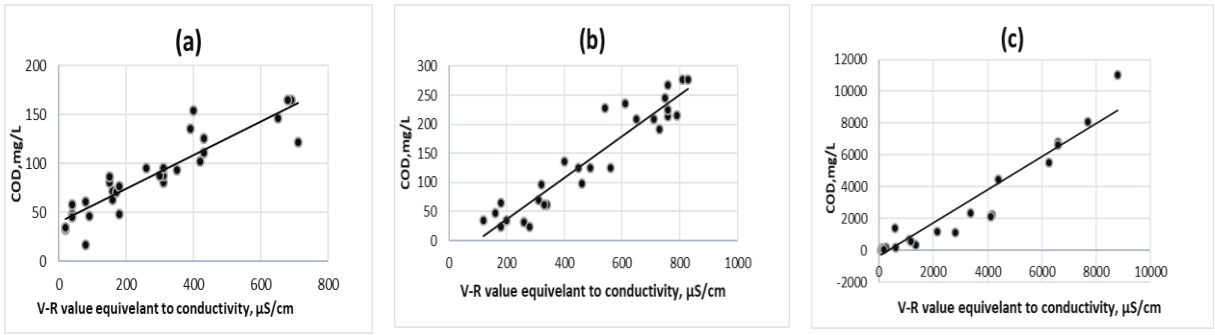
30 wastewater samples from each three different source (inland surface water, drain waste water, industrial waste water) were tested to develop correlation between waste analyzer V-R value and the other wastewater qualities. Such correlations can be frequently used to indirect measurement of these parameters. The correlations among the parameters are stated here in the graphs (**Fig. 2-5**):



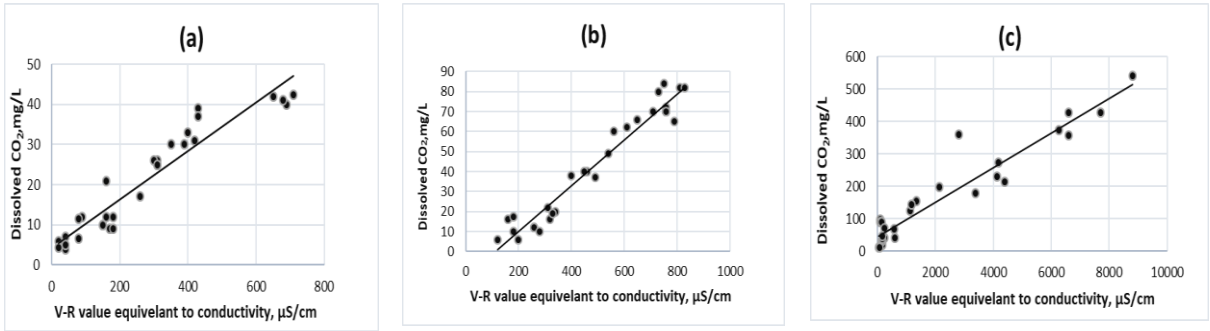
[Fig. 2] Relation between Waste Analyzer V-R Value Vs TDS for (a) inland surface water, (b) drain wastewater, (c) industrial wastewater



[Fig. 3] Relation between Waste Analyzer V-R Value Vs Turbidity for (a) inland surface water, (b) drain wastewater, (c) industrial wastewater



[Fig. 4] Relation between Waste Analyzer V-R Value Vs COD for (a) inland surface water, (b) drain wastewater, (c) industrial wastewater



[Fig. 5] Relation between Waste Analyzer V-R Value Vs Dissolved CO_2 for (a) inland surface water, (b) drain wastewater, (c) industrial wastewater

From the graphs, the estimated equation will be

TDS/Turbidity/COD/Dissolved CO_2= Waste Analyzer V-R value*C_1+C_2

C_1 and C_2 are constants that were got from the developed equations. They are enlisted in the **Table 1-4**.

Table 1: Data analysis and Regression Summary of Waste Analyzer V-R Value Vs TDS

Subject	Inland Surface water	Drain Wastewater	Industrial wastewater
R Square	0.99	0.98	0.99
NMRSE	0.05	0.04	0.08
C_1	0.8546	0.8065	0.8767
C_2	1.4314	3.6387	6.653

Table 2: Data analysis and Regression Summary of Waste Analyzer V-R Value Vs Turbidity

Subject	Inland Surface water	Drain Wastewater	Industrial wastewater
R Square	0.82	0.86	0.90
NMRSE	0.24	0.20	0.03
C_1	0.0543	0.1167	0.0676
C_2	6.4499	- 6.8858	17.8

Table 3: Data analysis and Regression Summary of Waste Analyzer V-R Value Vs COD

Subject	Inland Surface water	Drain Wastewater	Industrial wastewater
R Square	0.81	0.89	0.92
NMRSE	0.19	0.20	0.42
C_1	0.1725	0.3562	1.036
C_2	39.72	- 35.01	- 345.3

Table 4: Data analysis and Regression Summary of Waste Analyzer V-R Value Vs Dissolved CO_2

Subject	Inland Surface water	Drain Wastewater	Industrial wastewater
R Square	0.90	0.94	0.91
NMRSE	0.19	0.14	0.27
C_1	0.0602	0.1141	0.0535
C_2	4.3473	- 12.681	44.211

Table 1-4 shows that R^2 values are too much close (minimum: **0.81** and maximum: **0.99**) and the NRMSE values are also low (minimum: **0.03** and maximum: **0.42**). The **Table-5** enlists the results of five different wastewater samples tested by current "**Waste Analyzer**" and the commercial devices. However, the result found quite satisfactory and in all the cases the results showed by the low-cost device closely match the values as commercial instruments produced.

RESULTS AND DISCUSSIONS

After the method development activities as stated earlier where the relation between conductivity and other parameters were established, the testing performance of the present device was checked with some unknown samples. The equations which were established through experimental work installed in the device and then the device would display the result of the different expected parameters in its monitor. The following **Table 5** enlists the results of five different wastewater samples tested by current "**Waste Analyzer**" and the other commercial device. However, the result found quite satisfactory and in all the cases the results showed by the low-cost "**Waste Analyzer**" closely match the values as commercial instruments produced.

Table 5: Performance test of the present device with unknown samples

Sample Type	Output results	V-R value, mS/cm	V-R value, µs/cm	Turbidity, NTU	TDS, ppm	COD, mg/L	Dissolved CO_2, mg/L
Inland surface water	**Commercial device**	0.09	90	11.3369	78.345	55.245	9.7653
	Waste Analyzer	0.09	90	11.8	74	53	11
Industrial wastewater	**Commercial device**	1.64	1640	128.674	1444.4	1353.7	131.95
	Waste Analyzer	1.64	1640	102.32	1456	1337	128
Drain wastewater	**Commercial device**	0.82	820	73.24	725.54	504.22	88.08
	Waste Analyzer	0.82	820	69.24	731	537	92
Drain wastewater	**Commercial device**	0.91	910	79.32	804.45	597.46	92.89
	Waste Analyzer	0.91	910	73.47	809	625	95
Inland surface water	**Commercial device**	0.04	40	8.62	35.61	46.62	6.75
	Waste Analyzer	0.04	40	7.75	34	42	5

Traditional procedures for determining wastewater qualities are time consuming, tedious and expensive equipment are needed. On the other hand, by using the developed method wastewater qualities can be determined within short period. The cost is also less in comparison with other devices (**Table 6**).

Table 6: Price comparisons between "Waste Analyzer" and available commercial products

Device	Approximate cost/Market Price, BDT
"Waste Analyzer" (Current device)	10,000* (approx.)
Available commercial products	
***TDS meter**	8,000-10,000**
***Conductivity meter**	3,500-5,000**
***Resistivity meter**	12,000-16,000**
***COD reagent and spectrophotometer**	5,00,000**
***Dissolve Carbon Di Oxide Meter**	8,000-10,000**
***Turbidity Meter**	38,000-40,000**

*Material cost, **Market price

CONCLUSIONS

The electro-resistivity method can be a robust alternative of employing sophisticated, complicated and expensive laboratory investigations for predicting wastewater quality. It is also suitable for measuring purity of water. This developed method can offer the first screening test using very simple, cost-effective and time-consuming techniques, which is very important for the developing countries of the world. So, this could be a good monitoring device which could be used in the academic purposes as well as in industrial applications in developing countries. The device is named as "**Waste Analyzer**". The determined values of the instrument have been checked with repeatability test and the relative standard deviation for a set of observations which was found very little as only **7.56%** (maximum). For this proximity to actual results, it can be used in different relevant sectors.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
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CALOTROPIS GIGENTA LEAF FOR GOAT SKIN PRESERVATION: SUSTAINABLE CHLORIDE REDUCTION IN WASTEWATER

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ABSTRACT
The raw animal skins are preserved to resist bacterial putrefaction either destroying or controlling bacterial activity to allow transport and storage before starting the tanning process. The most common and popular preservation or curing method is using common salt (sodium chloride, NaCl), which is discharged along with the soaking liquor contributing a large amount of total dissolved solids (TDS) load in leather manufacturing. Thus, in spite of its popularity, reduction of this pollution load has become a great concern. In this proposed study, an investigation was made to preserve goat skin using plant leaf paste by less salt method. The method was analyzed base on different parameters e. g., shrinkage temperature (T_S), hair peeling, degradation, smell, the percentage of moisture content, extractable nitrogen value, bacterial count and contrasted with the traditional wet salting method. The physical characteristics, organoleptic properties and fibre structure of the leathers were assessed using a scanning electron microscope (SEM) to evaluate the preservation method. The results reveal that the leaf paste could be used as an alternative way to preserve goat skin for an interval of 30 days using less salt which reduced the pollution load e.g., chlorides and TDS in soaking operation by 52.04% and 46.5%, respectively.

Keywords: Preservation; Chloride; Total Dissolved Solids; Plant Leaf; Less Salt Method.

INTRODUCTION
Leather industry, an age-old industry has been serving society as an important consumer industry providing a wide range of leather goods. Hides and skins are the by-products of the meat industry that is the heart of the tanning process (Covington, 2011).

The main fractions of hides/skins consist of about 60-70% (w/w) of moisture and around 25-30% (w/w) protein which causes the substance prone to bacterial attack (Balada et al. 2008). The deterioration of hides/skins undertakes in short time (5-6 h) after the death of the animal if it remains unprocessed (Kanagaraj et al. 2005). The natural saprophytic bacteria present in the pelt of living animal produce of proteolytic enzymes which break down the protein to amino acids and to ammonia by further breaking down (Covington, 2011). The tanning process may ensure superior leather only when the collagen (protein) is intact. Thus, raw stock preservation must be started quickly and efficiently after flaying to protect temporarily against microorganisms during transport and storage before tanning process.

Preservation may be carried out by chemical, biocidal and physical methods. The ideal preservation method demands that it should be fully reversible without changing any properties and be environment-friendly. The wet salting preservation method is the most popular animal skin preservation method adopted globally due to its cost-effectiveness and availability (Kanagaraj et al. 2005). The action of salt is to dehydrate the animal skins presenting unfavourable conditions for bacterial growth and limit the growth through plasmolysis (Alagumuthu et al. 2015). However, the salt is discharged

during soaking of cured skins contributing to 70% of TDS generated in leather manufacturing (Kanagaraj et al. 2005) and 55% of chlorides in the composite tannery (Covington, 2011).
Much work has been done on alternative preservation techniques (Kanagaraj et al. 2015) - cooling and chilling (Babu et al. 2012a), vacuum (Gudro et al. 2014) and preservation by irradiation (Ross, 1997). Various salt-free chemicals have been used including the addition of silica gel (Kanagaraj et al. 2001), aryl alcohols (Venkatachalam et al. 1982), chlorites and hypochlorites (Margold and Heidemann, 1977) and sulphites (Vankar and Dwovedi, 2009) in low-salt skin preservation trials.
These methods are either associated with potentially hazardous substances or are economically unattractive or not practically feasible. Therefore, none of these is accepted and practised commercially. The physical preservation methods are energy intensive, economically unviable and the alternative chemical methods are either not practicable or have other environmental impacts (Alagumuthu et al. 2015). Organic plant and tree excerpts have also been tested for curing like the use of herbal plant *Rumex abyssinicus* with salt could also preserve the skin but it affects the leather quality (Shegaw et al. 2016). This study is approached to preserve raw goat skin with *Calotropis gigantea* plant leaf paste.
In this study, an investigation was made to preserve goat skin with a combination of *Calotropis gigantea* plant leaf paste with less or without common salt (NaCl). Different parameters like moisture content, hair failure, bacterial count, extractable nitrogen content, and hydrothermal stability were monitored for 30 days and contrasted with the typical wet salting preservation method to assess the process.

METHODOLOGY

Sample Collection

Fresh raw goat skin was collected from the slaughterhouse, Khulna, Bangladesh and then water washed for 30 minutes to remove adhering blood and other impurities and then finally drained. The collected *Calotropis gigantea* plant leaf was pasted utilizing a laboratory mortar to examine its possibility in the preservation of goat skin method.

Reagents and Chemicals

The biochemical and pollution parameters were determined using analytical grade reagents. For preservation, commercial NaCl was used and commercial pre-tanning and post-tanning auxiliaries were utilized to make shoe upper leather.

Preliminary Preservation Experiments

Four fresh samples (30 cm × 20 cm) were taken and then preserved with a different combination of curing agents at surroundings temperature (28±2°C) for 30 days. A small portion of goat skin samples were taken from the samples at fresh (raw), 1st, 2nd, 4th, 8th, 16th, 24th, and 30th day of preservation cycle and were carefully assessed determining the percentage of moisture content, shrinkage temperature, hair peeling, smell, bacterial count and extractable nitrogen content.

Inspection and Evaluation of Preservation Method

Determination of Moisture Content

Moisture content was determined using the Dean and Stark method (BIS, 1971).

Determination of Extractable Nitrogen and Bacterial Count

Around 5 g of preserved skin sample was cut and washed using distilled water, shaken well in an Erlenmeyer flask at 200 revolutions per minute (rpm) for 30 minutes. Then, it was filtered to separate the dissolved nitrogenous compounds using filter paper (Whatman No. 1) and the nitrogen content was determined according to the standard Kjeldahl method of APHA (APHA, 2012). In case of bacterial count, 1 mL of the collected liquor was then serial diluted (dilution factor = 10) with sterile water in a vial and shaken well. Then, the thinned solution was transferred into a cooling sterile nutrient agar Petri plate of about 0.1 mL volume and shaken gently clockwise and anticlockwise to get uniform distribution of the bacteria and then incubated at 37°C for 48 h. Finally, the number of colonies on the agar media was counted using a colony counter.

Determination of Hydrothermal Stability

Hydrothermal stability of the preserved goat skin was typically evaluated the shrinkage temperature. The shrinkage temperature (ºC) of the preserved goat skin was determined using a shrinkage tester (SATRA STD 114, UK) according to the ISO 3380 standard (SATRA, ISO 3380, 2015).

Leather Processing

Both the control and experimental goat skins were processed following the conventional chrome tanning method for shoe upper crust leathers after 30 days of preservation.

Generated Pollution Load in Soaking Process

Both the soaking liquor from control and experimental were analyzed for pollution loads following standard methods of APHA (APHA, 2012).

Physical Strength of Leather

The physical attributes of the leather were assessed following ISO 3379 (SATRA, ISO 3379, 2015).

Scanning Electron Microscope (SEM)

The effect of the proposed preservation method on fibre structure of leather was assessed using an SEM and compared with the control. The leather samples were collected from the same area and then placed on conducting carbon tape. After that, the samples were analyzed using SEM (JEOL JSM-6490, USA). The SEM was operated at an accelerating voltage of 20 kV with a magnification of 5000X to obtain the photographs of the grain surface.

RESULTS AND DISCUSSIONS

Optimization of Leaf Paste

Table 1 represents the different combination of curing agents based on their percentages (w/w) showing that the condition of preserved goat skin was unblemishedly confirmed by the hair peeling and smell.

Table 1 Leaf paste optimized in preservation method (22 days)

Sample No.	% of curing agents	Hair peeling	Smell	Physical feel
01	10% leaf paste	Nil	Nil	Hard
02	5% NaCl + 10% leaf paste	Nil	Nil	Medium hard
03	10% NaCl + 10% leaf paste	Nil	Nil	Flexible
04	15% NaCl + 10% leaf paste	Nil	Nil	Soft and flexible

Increasing the amount of salt gave the skin soft and flexible. Preserved hard skins are difficult to process with mechanical action as performed in the drum or paddle. Therefore, in this proposition, preservation with 10% leaf paste and 10% NaCl was considered as optimum to carry out the experiment.

Table 2 Shrinkage temperature and moisture content of preliminary experiment (22 days)

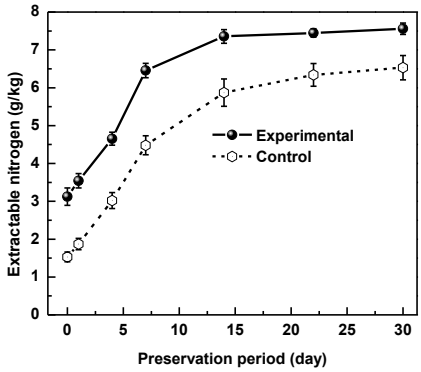
Duration	Sample 01		Sample 02		Sample 03		Sample 04	
	T_S	M_C	T_S	M_C	T_S	M_C	T_S	M_C
Fresh	63.5	72.37	64.1	66.66	65.1	73.71	63.9	66.85
1st Day	65.1	65.05	65.9	66.21	63.4	51.27	65.7	59.98
4th Day	65.9	64.89	66.2	62.99	63.9	54.14	66.1	50.21
7th Day	68.5	64.54	67.1	63.73	64.5	47.82	66.2	46.01
14th Day	65.6	62.21	66.9	62.98	64.3	41.69	65.9	44.05
22nd Day	65.3	57.31	66.4	55.32	64.2	43.08	64.7	40.09

Table 2 shows the shrinkage temperature (T_S) and moisture content (M_C) of the new approached preservation method showing that during this period, the change in shrinkage temperatures of the preserved goat skins with the various conditions was negligible. Moreover, during this period the moisture contents of the preserved goat skin decreased gradually. The moisture content of sample 03 was 43.08%, which was almost the same as the moisture content in the control method (43.1%).

Effectiveness of Preservation Method

Total Extractable Nitrogen

The bacterial attack on skin results in the breakdown of the polypeptide chain of the skin to peptide level and finally to the level of amino acids and ammonia that contributes to the extractable (volatile) nitrogen of soaking liquor (Alagumuthu et al. 2015).



[Fig. 1]. Extractable nitrogen content in preserved goat skin by control and experimental methods

The total extractable nitrogen produced in the experimental and control samples are shown in **Fig. 1**. In the raw untreated skin, extractable nitrogen was found at 1.5 g/kg and 3.1 g/kg for control and experimental, respectively. The nitrogen content was increased gradually for both samples but after 14th day the change remains negligible. Instead of higher nitrogen content, the experimental sample showed no hair peeling or smell during the physical assessment. So, it is clear that the proposed curing agent is able to control the bacterial action on the skin thus enabling better preservation up to 30 days.

Bacterial Count

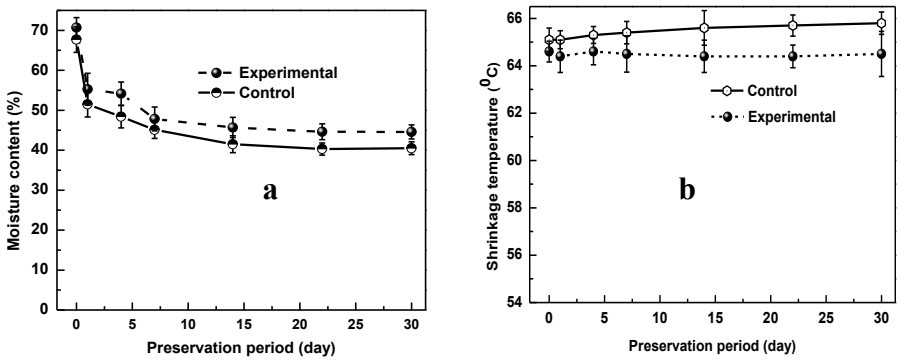
Table 3 shows the bacterial count of the raw goat skin for the control (50% NaCl) and experimental (10% NaCl + 10% leaf paste) was 1.2×10^5/g and 1.01×10^5/g, respectively.

Table 3 Bacterial count (CFU/g) in the preserved goat skins

Duration	Experimental	Control
Fresh	1.01×10^5	1.2×10^5
1st Day	1.08×10^5	8.4×10^9
4th Day	5.4×10^6	3.9×10^9
7th Day	10.4×10^6	2.1×10^7
14th Day	18.4×10^6	4.6×10^6
22nd day	13.2×10^6	1.7×10^6
30th day	14.7×10^6	5.1×10^5

The experimental sample showed a slow and gradual increase in bacterial count over time in comparison with the control and hair peeling, smell was absent in the proposed preservation system. The result is in agreement with the release of total extractable nitrogen content and thus confirms that the present approach has a good antibacterial agent.

Moisture Content



[Fig. 2]. Moisture content and shrinkage temperature of preserved goat skin control and experimental

The comparison of percentage (%) of moisture in the experimental and control sample method is shown in **Fig. 2a** for a period of 30 days indicating no significant variation.
It is clear that the reduction in the percentage of moisture content was almost similar for both cases in the first 24 hours but after that, the control sample showed less moisture content than experimental. However, there was no sign of putrefaction in an experimental sample, which may be due to the potential antibacterial aids of the *Calotropis gigantea* leaf paste against degrading microorganisms. After 8th day, there was a gradual diminution in moisture percentage in both methods which was found lower than the percentage of moisture content.

Hydrothermal Stability

Hydrothermal stability is the effect of wet heat on the integrity of the material. The value of this parameter is generally expressed in terms of shrinkage temperature which is routinely used to characterize collagen (Covington, 2011). It measures the disruption of different linkages and bonds as an indicator of existing interactions in collagen (Babu et al., 2012). **Fig. 2b** compares the hydrothermal stability of the experimental with the control for a period of 30 days showing greater thermal stability for the control sample after 4th day. However, on the 30th day, the shrinkage temperature for experimental and control was 64.5ºC and 65.8ºC, respectively. Therefore, it can be said that preserving based on *Calotropis gigantea* leaf paste has little effect for any variation in the collagen matrix.

Pollution Load in Discharged Soaking Liquor

The preserved sample and experimental skins were soaked and the pollution loads generated during this soaking operation were calculated in terms of Cl^-, TDS, BOD_5 and COD which are shown in Table 4. It seems that the proposed preservation method was reduced Cl^-, TDS, BOD and COD to a great extent 52.04%, 46.5%, 35.3% and 35.0%, respectively. Therefore, the present goat skin preservation method could be a viable and sustainable option to reduce pollution load in soaking operation.

Table 4 Pollution load generated in soaking of preserved goat skins

Sample	Cl^- (mg/L)	TDS (mg/L)	BOD_5 (mg/L)	COD (mg/L)
Control	18219 ± 173	42260 ± 57	1260 ± 36	5250 ± 63
Experimental	8737 ± 11	22620 ± 48	815 ± 11	3415 ± 15

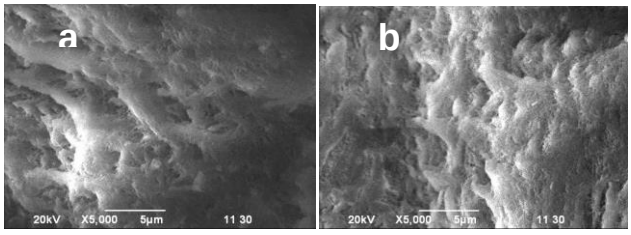
Physical Characteristics of Crust Leather

The organoleptic properties like softness, grain tightness, fullness, smoothness and physical strengths of the crust upper leather of experimental and control were assessed and tabulated in **Table 5**. It depicts that the experimental skin fulfilled the required values for the physical strengths. Thus, it is evident that *Calotropis gigantea* leaf paste does not pose any threat to weaken the collagen matrix by putrefaction.

Table 5 Physical properties of processed control and experimental leather

Parameters	Experimental	Control	Requirements (Kanagaraj et al. 2001)
Tensile strength (kg/cm^2)	237.33	244.2	200
Elongation at break (%)	43.5	39.6	40-65
Bursting strength:			
Distension at grain crack (mm)	8.8	8.3	7
Load at grain crack (kg)	42.0	43.0	20

SEM Analysis



[Fig. 3]. SEM photographs of crust leathers from preserved goat skin (a) control and (b) experimental

The SEM analysis for both the control and experimental preserved goat skin are shown in **Fig. 3**. It confirms no deterioration for the leather prepared from the experimental compared with the control. This exhibits that there was no noticeable change in the texture and quality of the goat skin preserved by the proposed method.

CONCLUSIONS

The present study reveals that goat skin could be preserved in combination *Calotropis gigantea* leaf paste and lower salt for a time scale of 30 days. The comparison with the conventional wet salting method assures its effectiveness. This lower salt method reduced significant pollution load like chloride and total dissolved solids by 52.04% and 46.5%, respectively. Thus, it could be concluded that *Calotropis gigantea* leaf paste has the possibility to emerge as a feasible less salt preservation method substituting the prevailing salt-based preservation with additional pollution load reduction during leather processing.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

MAPPING SPATIO-TEMPORAL PATTERN OF LAND SURFACE TEMPERATURE (LST) OF DHAKA METROPOLITAN REGION AND ITS IMPLICATION ON LAND USE CHANGE

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ABSTRACT
The relative skin temperature of land surface is Land Surface Temperature (LST) which is measured in the direction of the remote sensor. Knowledge of reliable estimates of LST is crucial because many applications such as evapotranspiration, climate change, hydrological cycle, vegetation monitoring, urban climate and environmental studies etc., rely on it. In our study, Dhaka Metropolitan Region (DMR) has been chosen as the study area. The objective of the study is to observe the spatio-temporal pattern of Land Use change within DMR and its associated change in land surface temperature pattern. Landsat 5 TM and Landsat 8 OLI/TIRS satellite images (path 137 and row 43 and 44) have been used dated November 2005 and November 2016 respectively. LSTs calculated from these two sensors provide the spatial distribution of surface temperature in two dates. By comparing these LSTs, the spatio-temporal change in land use can be explained during the study period. From the result, it is observed that the average temperature has been increased from 25.321 °C to 28.593 °C during the record 2005 to 2016 due to increase in the built-up area. The temperature of some areas has been decreased, which may be due to change in vegetation cover e.g. due to afforestation. Finally, the accuracy of the result is assessed with the help of Google Earth historical images.

Keywords: Environmental Monitoring; Land Surface Temperature (LST); Landsat Images; Urban Expansion; Remote Sensing.

1. INTRODUCTION

As the Land Cover (LC) and Land Use (LU) is changing the climate of the cities and built up areas are also changing. These changes may affect the environment by increased rate of sudden flood, excess pollution, health hazard, increasing surface temperature, evapotranspiration, heat storage, insubordination of wind and the state of the neighbouring surface ambience of the cities can be changed enormously. For example, LST of the rural area is lower than the urban area (Mallick et al., 2008). The capital of Bangladesh, Dhaka city is thickly populated with a population density of 23,234 people per square kilometer within a total area of 300 square kilometers (Oct 26, 2018) (worldpopulationreview .com) as a result the increasing population creates pressure on agricultural land, which is ultimately converted into urbanized area. The converted urban surfaces have higher thermal inertia. The purpose of this study is to investigate the effect of land use and land cover change on the land surface temperature of Dhaka Metropolitan Region and also the spatio-temporal change in land surface temperature and land use in the DMR between 2005 and 2016 by using the Landsat satellite images. LULC and LST change pattern for different areas has been studied by several researchers (Jalili, 2013). The land use/land cover changes in the southern China province of Guizhou from 1991 to 2001 has been examined by Xiao and Weng, (2007). Results showed that the land surface temperature increased in the urban areas and this is because of the rapid urban expansion that has occurred during the period between 1991 and 2001 (Zhou et al., 2010). Xian and Crane (2006), discovered similar characteristics in the valley of Las Vegas, south of Nevada. Utilized information from the systems of Landsat 5 and 7, the thermal characteristics of Tampa Bay, Florida and Las Vegas, Nevada were evaluated and results

showed that the Las Vegas urban surfaces had a daytime cooling effect, also known as an urban cool island or a heat-sink (Xian et al., 2006). Nikolaos and Peter (2013), examined the role of land use change in the recent warming of daily extreme temperatures. They examined changes in the warmest day (WD), warmest night (WN), coldest day (CD) and coldest night (CN) of the year during 1951-2003. They find that LU has led to a significant large-scale cooling of extremely warm days, consistent with the albedo increase that accompanies deforestation. They also found no significant influence from LU on cold extremes and the annual mean temperature (Christidis et al., 2013). Recent changes to vegetation cover are causing Earth's surface to heat up and activities like cutting down evergreen forests for agricultural expansion in the tropics create energy imbalances that lead to higher local surface temperatures and contribute to global warming. Detecting a temporal relationship between land use change and land surface temperature can be an important input to predict future land warming (Duveiller et al., 2018). The purpose of this study is to investigate the effect of land use and land cover change on the land surface temperature of DMR and also the spatio-temporal expansion of urban area and its associated change in land surface temperature and land use in the DMR between 2005 and 2016 by using the Landsat satellite images. Some specific objectives of this study are:

1. Implementation of geospatial technology for monitoring LST of Dhaka Metropolitan Region.
2. To examine the changes in the spatio-temporal pattern of LST in relation to land use conversions (Jalili, 2013).

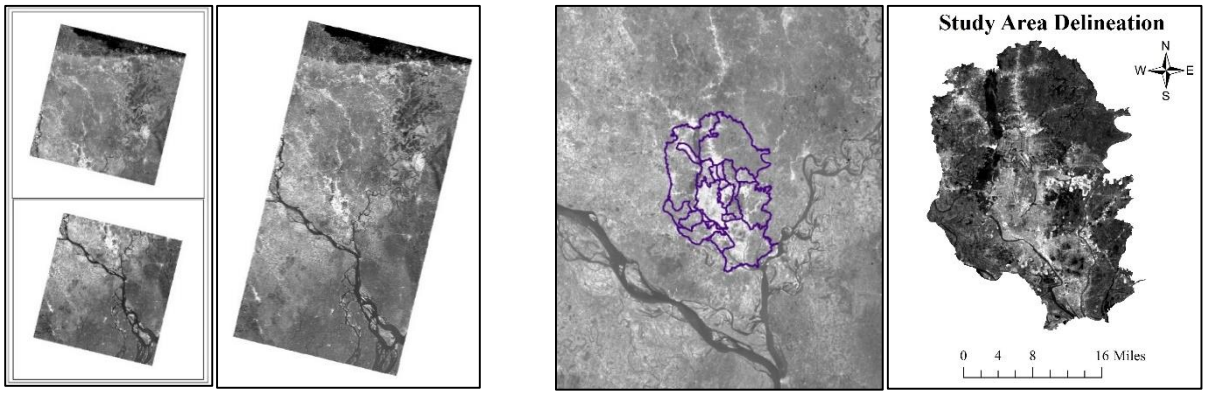
2. METHODOLOGY

2.1 Data Collection

Landsat 5 TM and Landsat 8 TIRS images have been used for our study purpose. Landsat images of November 2005 and November 2016 covering Dhaka Metropolitan Region (DMR) were downloaded from the United States Geological Survey website (https://earthexplorer.usgs.gov) (Debnath et al., 2018). For both Landsat images, scene size is 106 mi by 115 mi (https://landsat.usgs.gov) to cover the whole area of DMR Landsat scenes of different row (43 and 44) of the same path (137) were downloaded for each year mentioned above.

2.2 Landsat Image Pre-processing

Image pre-processing is a part of image processing techniques. In order to obtain the study area two Landsat images are stitched together by mosaicking technique. The mosaic images yet comprise areas out of the interest of this study, so they are also customized by clipping them with the shape file of the study area. The output of an image customization process is shown in [Fig. 1].



(a) (b)

Fig. 1: (a) Image mosaicking, (b) Study area delineation

2.3 Data Analysis

At this stage of work, the processed data are analyzed following some specific methods to obtain the desired output and results to accomplish the requirements of the objectives of this study.

2.3.1 Land Surface Temperature (LST) Calculation of Landsat 5 TM Image

To convert DN of Thermal Band to radiance the following formula "Eq. (1)" is used for Landsat 5 TM.

$$L_\lambda = \frac{(LMAX_\lambda - LMIN_\lambda)}{QCAL_{MAX} - QCAL_{MIN}} * (QCAL - QCAL_{MIN}) + LMIN_\lambda \qquad (1)$$

Here, L_λ indicates the cell value as radiance. For the thermal band, the digital number is denoted by QCAL. The minimum and maximum quantized calibrated pixel values are denoted by $QCAL_{MIN}$ and $QCAL_{MAX}$ respectively. The typical value of $QCAL_{MIN}$ and $QCAL_{MAX}$ are respectively 1 and 255. $LMIN_\lambda$ and $LMAX_\lambda$ represent spectral radiance scales to $QCAL_{MIN}$ and $QCAL_{MAX}$ respectively. The inverse Planck's law "Eq. (2)" is applied to compute the temperature of Landsat 5 TM:

$$LST = \frac{K2}{\ln(\frac{K1}{L_\lambda}+1)} - 273.15 \text{ (In Celsius)} \qquad (2)$$

Here, K1 and K2 are the thermal constant of Landsat 5 TM and L_λ is spectral radiance layer which is calculated by using "Eq. (1)". The value of K1 and K2 of the thermal band (band 6) is 607.76 and 1260.56 respectively. All these values are listed for each band in the metadata file (MTL) (Ahmed et al., 2017) (Giannini et al., 2015).

2.3.2 Land Surface Temperature (LST) Calculation of Landsat 8 TIRS Image

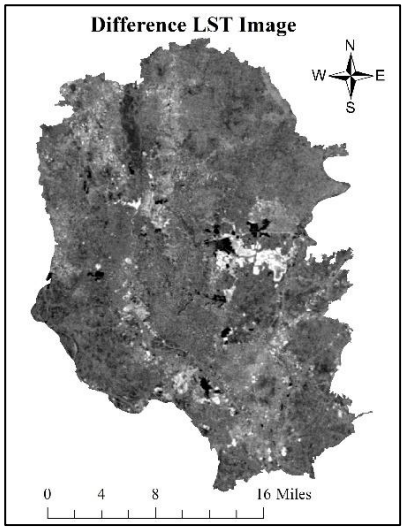
To convert DN of Thermal Band to radiance the following formula "Eq. (3)"is used for Landsat 8 TIRS:

$$L_\lambda = M_L QCAL + A_L \qquad (3)$$

Here, L_λ indicates the cell value as radiance. Band-specific multiplicative rescaling factor (radiance mult band x, where x is the band number) is denoted by M_L and band-specific additive rescaling factor (radiance add band x, where x is the band number) is denoted by A_L. For the thermal band the digital number is denoted by QCAL (described in 2.3.1).These values are taken from the MTL file of the Landsat images. Land surface temperature is calculated by using "Eq. (2)". Where K1 and K2 is the thermal constant of Landsat 8 TIRS which are 774.8853 and 1321.0789 respectively, for the thermal band (band 10). L_λ is spectral radiance layer which is calculated in the previous step. These values are also taken from the metadata file of the Landsat images (Ahmed et al., 2017) (Giannini et al., 2015).

2.3.3 Image Differencing and Reclassification

To find the spatio-temporal change in temperature between the years (2005-2016) the LST image of Landsat 5 TM is subtracted from Landsat 8 TIRS image. The output of image differencing result is shown in [Fig. 2(a)]. The subtracted LST layer is reclassified into three classes to know the temperature difference between the 11 years gap (2005-2016). The temperature classes are (-7.233 to 0), (0.1-5) and (5.1-11) degree Celsius, which indicates gradually increased temperature [Fig. 2 (b)].



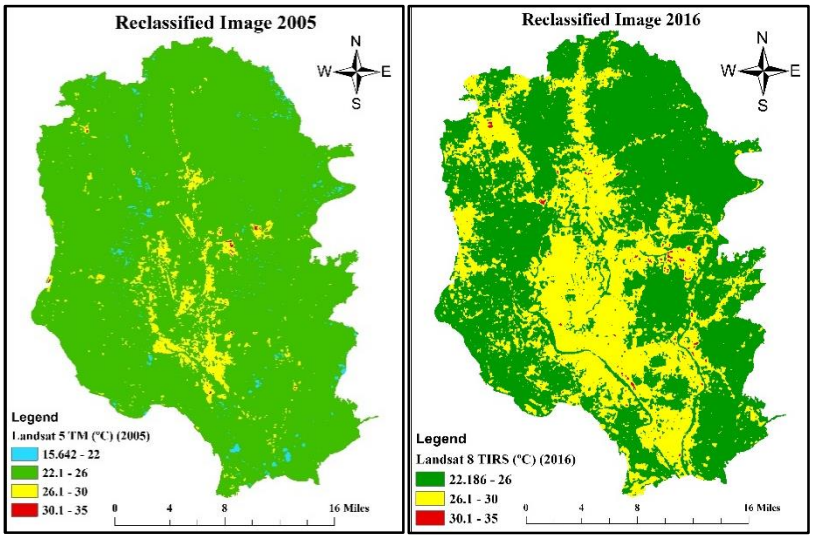
(a) (b)

Fig. 2: (a) Difference LST image; (b) Reclassified LST image

3. RESULTS AND DISCUSSIONS

3.1 Change in Land Surface Temperature:

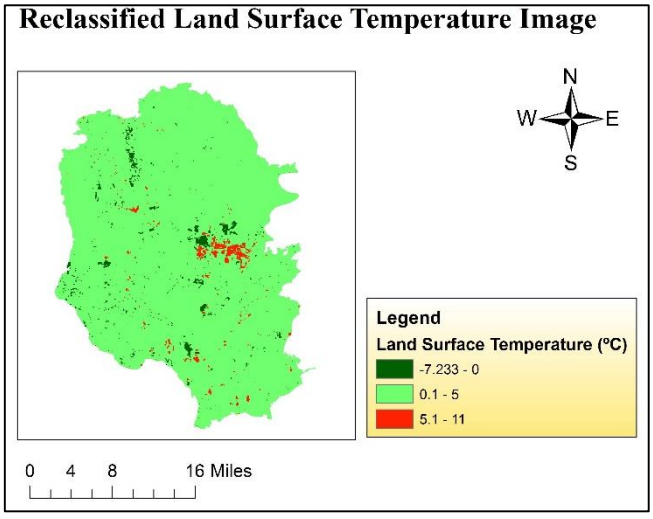
From the reclassified image of 2005 [Fig. 3. (a)] for Landsat 5 TM scene it can be observed that the temperature of some minor areas (denoted by light blue colour) is in between 15.642 to 22 degree Celsius which may be due to vegetation or water body. In some areas (denoted by yellow, red and green colour) the temperature difference is in between 22.1 to 35 degree Celsius which is comparatively higher than the light blue plotted area.



(a) (b)

Fig. 3: (a) Reclassified image 2005; (b) Reclassified image 2016

The increase in temperature was due to the conversion of the vegetated area into built-up area. From the reclassified image of 2016 [Fig. 3. (b)] for Landsat 8 TIRS scene, it can be observed that the temperature of some major areas (denoted by green colour) is in between 22.186 to 26 degree Celsius which may be due to vegetation or water body. In some small areas (denoted by yellow & red colour) the temperature difference is in between 26.1 to 35 degree Celsius which is comparatively higher than green plotted area (22.186 to 26 °C). The increase in temperature was due to the conversion of vegetated area into built-up area i.e. urbanization. With the help of Google Earth historical images it is found that, in 2005, the light blue coloured area which is 1376.73 hector was covered with wetland and vegetated area. But in 2016 this area was converted into bare land and also built-up area as the temperature increased. As the temperature of the light blue coloured area [Fig.3 (a)] was increased, the temperature range of 15.642 to 22 degree Celsius was absent in 2016 [Fig.3 (b)]. In some areas in 2016 there we also found some wetlands and vegetated area which is so minor compared to 2005 (light blue coloured area) that we can come up to a discussion and that is our lands are changing and day by day DMR is becoming a heat island. From the above analysis, it can be said that the temperature has been increased in the year 2016 compared to the year 2005 which may be due to urbanization.



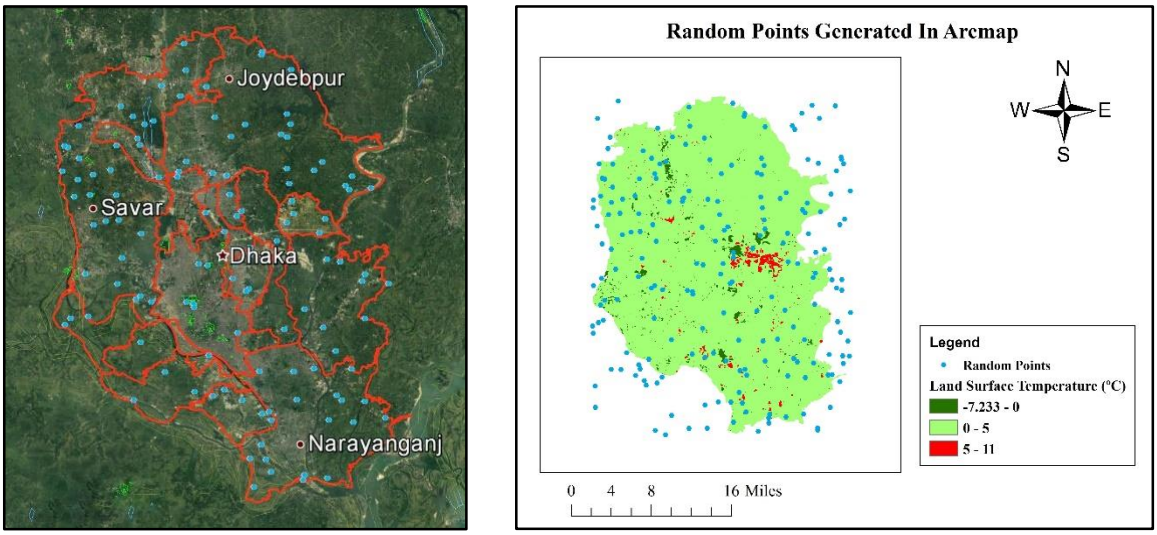
3.2 Analysis of Image Differencing:

From the reclassified LST image [Fig. 2(b)] the difference between 2005 and 2016 can be observed. The dark green & light green area indicates temperature ranges from (-7.233 to 0) and (0.1 to 5) degree Celsius respectively, which might indicate the vegetated area and water body. The temperature of the red marked area ranges from (5.1 to 11) degree Celsius, which might be due to built-up area i.e. urbanization.

3.3 Accuracy Assessment:

To determine how well the classification process is performed accuracy assessments are done on classified images. A random set of points is generated in the DMR study area. Then, using the Google Earth, the value for each point is identified. To identify each point's these random points are used to the known value in the classified image (Parece et al.). In this study, 200 random points were generated [Fig.4 (b)] in the study area to calculate accuracy. From this 200 points, 124 points were within the DMR study area [Fig.4 (a)]. So, 124 random points were taken to find the accuracy. With the help of Google Earth by using historical imagery, these points are identified by observing Landsat satellite images of the year 2005 and 2016. Landsat images were then compared with the reclassified LST image (Described in 2.3.3.).The accuracy of the reclassified image in discrimination with Landsat data was calculated by the following formula (Ahmed et al., 2017) "Eq. (4)".

Accuracy (%) = (Number of Points with Similar Value) / (Total Random Points) ×100 (4)



(a) (b)

Fig. 4: Random points (a) Explored in Google earth as .kml file; (b) Generated in Arc Map

3.3.1 Accuracy Assessment of Landsat Image

Accuracy of Landsat images between the years 2005 and 2016 were calculated by using "Eq. (4)". (Ahmed et al., 2017).

Accuracy (%) =106/124×100=85.4839%.

So the percentage of accuracy of Landsat image is 85.4839 %.

4. CONCLUSION:

This study introduces the spatiotemporal pattern of LST changes in Dhaka Metropolitan Region (DMR). In doing so, we assimilate LST of 2005 and 2016, in this 11 years comparisons, following conclusions was reached: (1) the environment of the Dhaka metropolitan will be severely affected due to the effect of global warming, (2) more Dhaka metropolitan areas are gradually shifting towards the high temperature zone if this process continues then DMR will be the next UHI, (3) future planning of DMR should focus on developing build up areas and ensuring more vegetation (Ferdous et al., 2018).

For further study different land cover indices can be used together and improve the model that presented here.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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GUAVA BARK CHARCOAL ADSORBENT FOR CHROMIUM REMOVAL FROM TANNERY DISPOSAL SITE

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ABSTRACT
In leather tanning, basic chromium sulphate is the mostly used tanning agent because of its substantial thermo-resistivity. Unfortunately, after chrome tanning, most of the tanneries in Bangladesh discharge the high chromium-containing wastewater to the environment without any treatment. In this paper, the efficiency of chromium removal of prepared charcoal adsorbent from the guava bark is described. The potentiality of the charcoal adsorbent of chromium ion removal was analysed investigating: charcoal dose, contact time, and relative pH. Under batch-wise analysis, 70 mL chromium containing disposal site was mixed with charcoal, stirred, settled, and chromium content was measured in the filtrate by the titrimetric method. Chromium levels in the raw disposal and after treatment of the filtrate were 3415.02 mg/L and 27.68 mg/L, respectively. The chromium removal was obtained by 99.2%. The use of low-cost guava bark charcoal adsorbent could be an alternative way of removing chromium from the tannery disposal site.

Keywords: Tannery disposal site, Chromium, Environment, Substituting system, Low-cost adsorbent

INTRODUCTION

The growing wastage due to anthropogenic activities has laid a massive impact on the environment. Many industries dispose of their industrial waste to the environment without treatment. Increasing industrialization enhances the deposition of mine tailings and metallurgical slags (Jacob and Otte, 2004; Ettler et al. 2004). Therefore, sediment/soil is contaminated with toxic metals especially heavy metals from where possible mobilization of metals into groundwater or transfer into the human food cycle.
The existence of these wastes in the natural environment can cause significant impacts on the ecosystem. In tanning process, mostly use basic chromium sulfate as tanning agent (Avindhan et al. 2004) where 60% chromium was absorbed by the pickle pelt and the residual 40% chromium remained as the solid and liquid disposal especially in the tannery disposal site (Fabiani et al. 1997). Anthropogenic activities e.g., tanning industries, electroplating, metal finishing, textile industries, and chromate preparation helps to enter chromium into the environment. Contamination of water, soil or sediment by the chromium is a significant concern for the environment. It can enter into human food chain from the water, soil or sediment. Even though chromium (III) plays a significant role as an essential trace element for the metabolism of a specific component of the human body (Kalidhasan et al. 2009) but a long lasting contact with Cr (III) has demonstrated allergic skin reactions and cancer (Eisler, 1986). On the contrary, chromium (VI) is suspected to be toxic and carcinogenic (Matos et al. 2009). Mostly, in the spent chrome liquor contain a high concentration of chromium.
According to reports, the chromium levels in tannery disposed effluent range from 2656-5420 mg/L (Hashem et al. 2015). In many countries, the level of chromium in the spent chrome liquor is strictly regulated. Several attempts were conducted to reduce chromium from industrial disposal with low-cost adsorbents e.g., wooden scraps (Shukla et al. 2002), cultivation by-products (Chuah et al. 2005),

ecological zeolite (Erdem et al. 2009), earth clay (Marquez et al. 2004), and eggshell and powered marble (Elabbas et al. 2016), unfortunately, all these attempts have become unworthy because of the less available nature of adsorbent.

Besides, chromium (III) another important type of contamination in wastewater is the presence of chloride ion. Drinking water standards in terms of chloride are 150-600 mg/L but the limit has been readjusted to 1000 mg/L for the coastal regions of Bangladesh (ECR, 1997).

Guava is a commonly grown fruit, which falls under the genus Psidium. Guava bark is popular for herbal remedies. Guava grows all over the tropics and subtropics. Lohani et al. (2008) used the guava bark as bioadsorbent for Hg(II) removal from aqueous solutions. So far, there is no available report using of guava bark charcoal for Cr(III) removal from tannery wastewater.

Here, guava plant (*Psidium guajava*) bark charcoal was used to remove chromium from the tannery disposal site. Chromium removal was determined to investigate different factors e.g., charcoal dose, contact time and relative pH. Additional investigations were performed on total dissolved solids (TDS), salinity, suspended solids, electrical conductivity and chloride content for optimization of process.

METHODOLOGY

Sampling

The chromium-containing disposed effluent was collected from the tannery at Khulna, Bangladesh. The disposed effluent containing chromium sample was collected in a plastic bottle, pre-washed with diluted nitric acid, and transported instantly to the laboratory for experimentation.

Charcoal preparation

The guava plant bark was collected from the guava plants available within the Territory of Khulna University of Engineering & Technology, at Khulna, Bangladesh. Then, it was oven-dried at 105^{O}C, burnt at 450-550°C in the absence of air in furnace and ground with mortar to make powder. Under an 80-mesh sieve, the ground charcoal was treated and preserved for analysis.

Reagents and Chemicals

The reagents and chemicals: nitric acid (Merck KGaA, Germany), sulphuric acid (Merck KGaA, Germany), perchloric acid (Merck, India), N-phenyl anthranilic acid (Loba Chemie, India), ammonium iron(II) sulphate hexahydrate (Merck, India), anti-bumping glass beads (Loba Chemie, India) and filter papers (Whatman No. 1) were procured from Khulna, Bangladesh.

Characterization of Wastewater

Chromium, pH, total dissolved solids (TDS), electrical conductivity (EC), salinity and chloride (Cl^-) levels were analyzed to justify the physicochemical properties of the tannery disposal site effluent.

Determination of chromium

Chromium level was measured in the untreated wastewater and after treatment in the filtrate by the titrimetric method, abiding by the official methods of analysis of Society of Leather Technologist and Chemists (SLC, 1996), official method of analysis (SLC 208). In a 500 mL conical flask, a 50 mL sample volume was taken where 20 mL concentrated nitric acid and 20 mL perchloric acid/sulphuric acid mixture was added. Then, the flask was slightly heated and boiled until the mixture had turned into a pure orange-red colour and boiling was continued for one minute. When ebullition had ceased, the flask was removed from the heating spirit. The flask was then cooled rapidly in the cold water bath. A 100 mL of distilled water was added carefully with a few glass beads and boiled for 10 minutes making free of chlorine. A 10 mL 30% (v/v) sulphuric acid was then added and cooled to room temperature. Then, the subjected solution was titrated with freshly prepared 0.1N ferrous ammonium sulfate solution with six drops of the *N*-phenyl anthranilic acid solution as an indicator. The final colour was indicated by a change in colour from violet to green.

Measurement of pH

pH of the wastewater and every stage of the experiment was measured by the digital pH meter (UPH-314, UNILAB, USA). The pH meter was calibrated in two points with the standard buffer solutions (4.01 and 7.0).

Determination of Parameters (TDS, EC, Salinity)

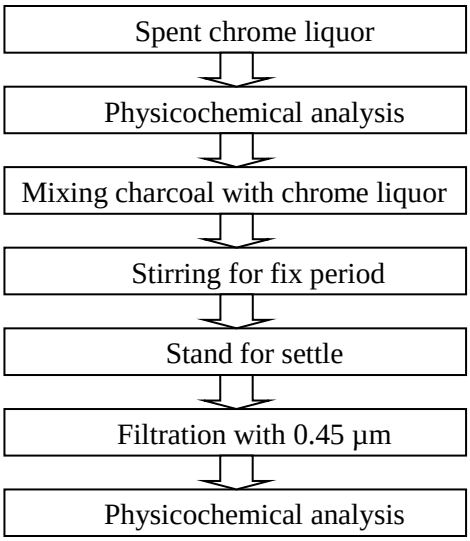
Measurements of TDS, EC and salinity were recorded using digital conductivity meter (CT-676, BOECO, Germany). The meter was calibrated with the standard solutions.

Determination of Chloride

Chloride content in the chrome tanning disposal site as well as after treatment of the filtrate was calculated using APHA standard argentometric method (APHA, 2012). A 100 mL water sample was placed in a conical flask and pH was limited within the range of 7 to 10. A 1.0 mL potassium chromate (K_2CrO_4) indicator was pipetted and the solution was titrated with silver nitrate as titrant (0.0141 N) to a pinkish yellow endpoint. Sodium chloride (0.0141 N) solution was used to standardize the titrant.

Treatment of chromium-containing wastewater

Chromium removal analysis was performed through batch-wise treatment. The schematic flow chart for the treatment of tannery disposal effluent is shown in **Fig. 1**.



[Fig. 1]. *Schematic flow chart for the chromium removal process*

Initially, the physicochemical parameters of the untreated chromium-containing industrially disposal effluent were analyzed and filtered through 0.45 µm pore size (Whatman No. 1) filter. Moving on, 70 mL disposal effluent was mixed with the prepared charcoal. The charcoal mixed sample was stirred over a constant period of time and the mixture was allowed to settle for a fixed duration. After settling, the mixture was filtrated through a 0.45 µm pore size filter once again. The chromium level and physicochemical parameters of the filtrate were determined. Total dissolved solids (TDS) were analyzed gravimetrically using the standard methods (APHA, 2012).

Process optimization

In the batch-wise examination, various parameters: charcoal dose, contact time and a relative was optimized. Through investigating the chromium removal rate the conditions were optimized.

Charcoal dose optimization

For charcoal dose optimization, varying dose levels were applied for each batch 1, 2, 3, 4, 5 and 6 g where other parameters were left unchanged, for instance, contact time (12 min) and initial pH (3.8).

Effect of contact time

Growing contact time enhanced chromium removal rate. When the contact time of the chromium ions and binding sites were elaborated, the adsorption rate became more effective. For optimization of contact time, differential stirring time was maintained for each batch 0, 4, 8, 12, 16, and 20 min respectively, while the other parameters remained constant.

RESULTS AND DISCUSSIONS

Properties of the used chromium solution

Table 1 shows the physicochemical properties of the tanning waste liquor. It seems that the waste tanning liquor obtained from the tannery had a large pollution load in terms of higher amount of pollutants e. g., concentration of chromium, TDS, acerbic (pH=3.8). The chrome tanning wastewater is potentially harmful to the environment. Therefore, it will be redundant to describe the importance of the chrome tanning waste liquor treatment for a healthy and sustainable environment.

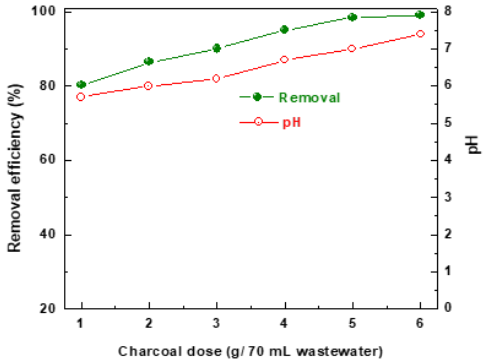
Table 1 Data comparison with Bangladesh standard

Parameters (Unit)	Collected sample	Treated sample	ECR, 1997
pH	3.8	7.0	6–9
TDS (g/L)	28.2	32.1	2.1
EC (mS)	65.4	73.6	1.20
Salinity (ppt)	3.97	40.3	–
Cr (mg/L)	3415.02	27.68	2.0
Chloride (mg/L)	15050	3430	600

It seems that after all stages of treatments, the physicochemical parameters were obtained pH, TDS, EC, salinity, chromium, chloride was 7.0, 32.1 g/L, 73.6 mS, 40.3 ppt, 27.68 mg/L, 3430 mg/L, sequentially. The maximum chromium removal was 99.2%. After the adsorption process, pH of the treated solution seemed within the limit of discharge although several parameters e.g., salinity, total dissolved solids, and electric conductivity were slightly increased. The chloride was reduced by 77.2%.

Optimal charcoal dose

The charcoal dose is extensively the most crucial factor in the adsorption process. The effect of charcoal dose on the performance of chromium removal from the chrome waste liquor is depicted in **Fig. 2**.

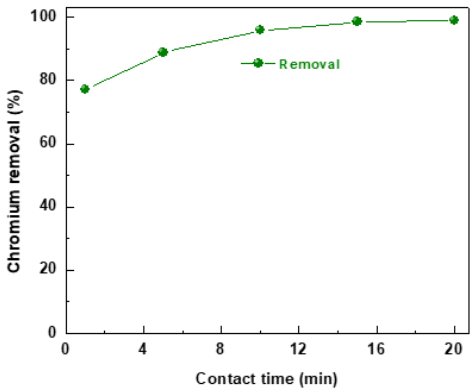


[Fig. 2]. *Effect of charcoal doses and pH of the solution on chromium removal.*

The chromium removal efficiencies for the charcoal doses 1 g, 2 g, 3 g and 4 g were 80.0%, 92.5%, 96.54% and 97.9% respectively. It is clear that with increasing the charcoal doses, the mixture pH also increased and simultaneously the chromium removal efficiency also increased. When the charcoal dose was 5 g or 6 g for each 70 mL wastewater, the chromium removal efficiencies were the same as 5 g/70 mL wastewater. Hence, it was estimated that the highest level of removal occurred with 5 g charcoal dose in 70 mL wastewater where pH was 7.0. It is obvious that pH plays a vital role in the charcoal adsorption of metallic particles because it is accountable in the protonation on the binding site of the metal ion. It establishes the adsorption of chromium by bark charcoal of the *Psidium guajava* as a function of the pH of the solution.

Optimum contact time

Contact time is an indispensable aspect in chromium removal from wastewater by adsorption. **Fig. 3** shows the chromium efficiency on contact period. It is clear from the above **Fig. 3** that the efficiency of chromium removal was increased gradually as the contact time was increased while keeping the adsorbent dose the same.



[Fig. 3]. *Effect of contact period in chromium removal.*

The chromium removal efficiency for 12 min, 16 min, and 20 min was 98.7%, 99.2%, and 99.2%, respectively and after that, the percentage of removal remained static. It denotes that the efficiency of chromium removal increases along with increases the contact time. The reason behind it could be that longer contact period allows metal ions (chromium) to bind on the charcoal adsorption sites. Also, it is clear that after a certain time period e.g., 12 min chromium adsorption was 99.2% and after that, there were no changes observed. Hence, it was decided that the optimal contact time to remove maximum chromium was 12 min.

Performance observation of the removal process

The percentage removal of chromium in this experiment at optimized condition is compared with the studies conducted previously in **Table 2**. An adsorbent dose of 5 g for 70 mL tanning wastewater with a 12 min contact time, the pH of the solution was 7.0. The chromium content was recorded in the wastewater before and after treatment were 3415.02 mg/L and 27.68 mg/L, respectively. Accordingly, the highest amount of chromium removal was obtained by 99.2%

Table 2 Comparison with the previous study

Chromium Removal (%)	Contact Time	References
90	30 min	Dahbi et al. 2002
83	6 hour	Aravindhan et al. 2004
99	840 min	Elabbas et al.2016
99	12 min	This study

A better chromium removal percentage was observed in this study than the previous researches conducted in this area. Chromium removal efficiency was obtained 99% at 12 minute contact time, whereas other studies recorded 90% removal in 30 minutes (Dahbi et al. 2002), 83% in 6 hours (Aravindhan et al. 2004) and 99% in 840 minutes (Elabbas et al. 2016).

CONCLUSIONS

This study reveals that *Psidium guajava* bark charcoal is quite effective to remove chrome particles from the chrome tanning tannery disposal site. The efficiency of chromium and chloride removal was obtained by 99% and 77%, respectively. The study signifies, prepared from *Psidium guajava* bark was an effective technique to wane toxic hazardous and carcinogenic substances, which can be an efficient

method to reduce the environmental pollution caused from the chrome liquor used in leather tanning and other contemporary industrial operations. The overall study could be useful for establishing a discharge system for industries using Desorption method to recover Chromium as well as to ensure the reusability of the water discharged.

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ASSESSMENT OF WATER QUALITY USING REMOTE SENSING TECHNIQUES -A CASE STUDY ON SYLHET METROPOLITAN AREA

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ABSTRACT
Supportable administration of water assets includes save maintaining, capable use, and distinction administration. However, exercises identifying with amount examination and administration as far as waterway release and water assets arranging are given consideration, water quality appraisal are as yet being done at particular areas of real concern. Utilizing otherworldly and spatial goals sensors and geospatial displaying strategies, water quality parameters, for example, chlorophyll-a, green growth sprout, turbidity and mineral substance in water bodies are being observed requiring little to no effort. Coordination of these advances with field checking have effectively helped in distinguishing proof of pollution zones and sources and for creating techniques for remediation. SYLHET" is one of the major urbanized territory in the Bangladesh which bowl zone encounters a fast change because of increment of the urbanized zone. There is incredible Impact of land utilize change because of quick populace and spontaneous urbanization. Unlawful lodging, superfluous enterprises and motorways are experiencing childhood with the water hold territory. These foundations going through the insurance zones of catchments territory which hampering water quality enormously. The examination is centred around the evaluation of urbanization in connection to arrive utilize and water quality utilizing RS and GIS strategies. To evaluate the water quality turbidity and Chlorophyll is estimated and results shows due to increase of heat island decrease of chlorophyll within 10 years is 15.37%.

Keywords: GIS; Water Quality; Land Use Change; Water Basin

INTRODUCTION

Bangladesh is a place where there are wetlands. In excess of 66% of the nation might be delegated wetlands as indicated by the definition articulated in the Ramsar Convention. Based on sorts, the wetlands of Bangladesh can be comprehensively characterized into the inland freshwater and tidal saline water wetlands. Floodplains, beels, haors and baors are the parts of the inland freshwater wetland's classification. The wetlands of Bangladesh bolster a wide assortment of flower and faunal decent variety, some of which are all inclusive and in addition privately imperilled. Be that as it may, these amphibian assets have been subjected to quick debasement because of the expanding populace weight, territory pulverization and other anthropogenic and regular causes (Choudhury, 2005). In the course of recent decades' biodiversity has turned into the issue of worldwide worry for its fast decrease around the world. Bangladesh is no exemption. Wetlands are considered as the world's most gainful environments as they give an extensive variety of monetary, societal and natural advantages. Wetlands and floodplains assume an imperative job in the lives of a large number of needy individuals worldwide by giving subsistence jobs (Nishat, 2002) despite the fact that wetlands have many known attributes that are vital to the vocations of nearby occupants, they are corrupted and lost because of a great deal of activating elements. Wetland preservation and relief can be an inescapable technique for the eventual fate of the Bangladesh. Bangladesh is an incredible agent of tropical districts rich with gigantic organic

decent variety. The wetlands of north-eastern locale of Bangladesh have incredible environmental, business and financial significance. The dynamic connection of earthbound and oceanic frameworks makes these wetlands very profitable naturally. The wetlands are perceived as containing extremely rich segments of biodiversity of nearby, provincial and national hugeness (Nishat, 2002). The assets in the hoar region have no appropriate preservation and administration strategy, for which those are declining steadily. Regardless of a developing familiarity with the requirement for ensuring nature, debasement has happened quickly amid the most recent three decades. Subsequently, nation's nature has been harmed, backwoods exhausted, wetlands decimated.

The aim of the study is to evaluate the quality of the changing of wetland during the period of 2005 to 2016 in Sylhet Metropolitan Area (SMA). To achieve the aim of the study, following objectives are adopted (1) To find out the changes of wetland area in SMA during the period of 2005 to 2016 using supervised classification (2) To measure the quality of wetland according to remote sensing techniques of chlorophyll, turbidity and temperature in SMA.

METHODOLOGY

Sylhet, is a noteworthy city in north-eastern Bangladesh. It is the capital of Sylhet Division and Sylhet Region, and was conceded metropolitan city status in Walk 2009 (Choudhury, 2014 It is one of the biggest urban areas in Bangladesh. The Sylhet locale is outstanding for its tea gardens and tropical timberlands, the city anyway is right now known for its business blast — being one of the most extravagant urban communities in Bangladesh, with new ventures of inns, shopping centers and extravagance lodging bequests, and so forth. For carrying study, a consecutive methodology has been adopted. For the study TM of Landsat imagery is collected for three different years 2005, 2010, 2013 and 2016 and the cloud cover of the data is less than 4%. After data collection data is processed in several steps for further analysis. Image order alludes to gathering picture pixels into classifications or classes to create a topical portrayal. For surveying the land cover change at first regulated characterization used to decide the land utilize example of the examination zone and exactness appraisal is done to evaluate the precision of the order. The overall accuracy of the classification is about 79%.

Table 1: Details of the Landsat Satellite Images

Satellite	Sensor	Date	Resolution	P/R
Landsat 5	TM	06 September, 2005	30m	136/43
Landsat 5	TM	25 August, 2010	30 m	136/43
Landsat 8	OLI-TIRS	12 September, 2013	30m	136/43
Landsat 8	OLI_TIRS	03 July, 2016	30 m	136/43

Table 2: Accuracy Assessment Matrix

Classification	Waterbody	Vegetation	Others	Row total	Error of commission	User accuracy
Waterbody	2155	35	50	2240	12.12	87.89
Vegetation	3	3278	14	3279	18.39	81.60
Others	318	289	199	806	22.57	77.43
Total column	2436	3849	263			
Error of omission	13.18	14.84	24.33			
Procedure accuracy	86.82	85.16	75.67			
Overall accuracy 79.85%						

The one of the most important stage of the study to estimate the temperature from the prepared satellite image. Then the radiance is converted into temperature in Kelvin unit. Then temperature is again converted Kelvin to Degree Celsius. For Landsat TM image digital numbers DNs of thermal band (band 6) of were converted into radiance using the following Eq. (1)

$$R_{TM6}=V/255\ (R_{max}- R_{min}) + R_{min}$$

Where V represents the DN of band 6 and

$R_{Max} = 1.898(\mathrm{mW} * cm^{-2} * \mathrm{sr}^{-1}), \mathrm{R_{MIN}} = 0.1534(\mathrm{mW} * cm^{-2} * \mathrm{sr}^{-1})$

And the second step, conversion of radiance into temperature in Kelvin T(K) was done by the following Eq. (2)

$$T = \frac{K1}{\ln(K2/(R_{TM6}/b) + 1)}$$

Where, K_1=1260.56K and K_2= $607.66(\mathrm{mW} * \mathrm{cm}^{-2} * \mathrm{sr}^{-1} * \mu\mathrm{m}^{-1})$, b represents the effective spectral range and b=1.239(μm)

For Landsat OLI_TRS, at first, OLI and TRS band data can be converted to TOA using the following Eq. (3)

$$L_\lambda = M_L W Q_{cal} + A_L$$

Where; L= TOA spectral radiance $(\mathrm{Watts/m^2} * \mathrm{srad} * \mu\mathrm{m})$, M_L= Band specific multiplicative rescaling factor from the metadata, A_L= Band specific z rescaling factor from the metadata. Q_{cal}= Quantized and calibrated standard product pixel values (DN)

For converting spectral radiance to temperature following Eq. (3) is used

$$T = \frac{K2}{\ln(K1/L_\lambda + 1)}$$

Where ;T= At satellite brightness temperature (K), L_λ= TOA spectral radiance $(\mathrm{Watts/m^2} * \mathrm{srad} * \mu\mathrm{m})$, K_1= Band-specific thermal conversion constant from the metadata (K_1_CONSTANT_BAND_x, where x is the band number, 10 or 11) , K_2= Band-specific thermal conversion constant from the metadata (K_1_CONSTANT_BAND_x, where x is the band number, 10 or 11); Temperature are derived in 'Kelvin (A)' which were converted into 'Degree Celsius (B)' using the following equation

B= A-273.15

For assessing turbidity and total suspended matters are considered as important variables in many studies due to their linkage with incoming sunlight that in turn affects photosynthesis for growth of algae and plankton. These parameters are also directly associated with Secchi disk depth.

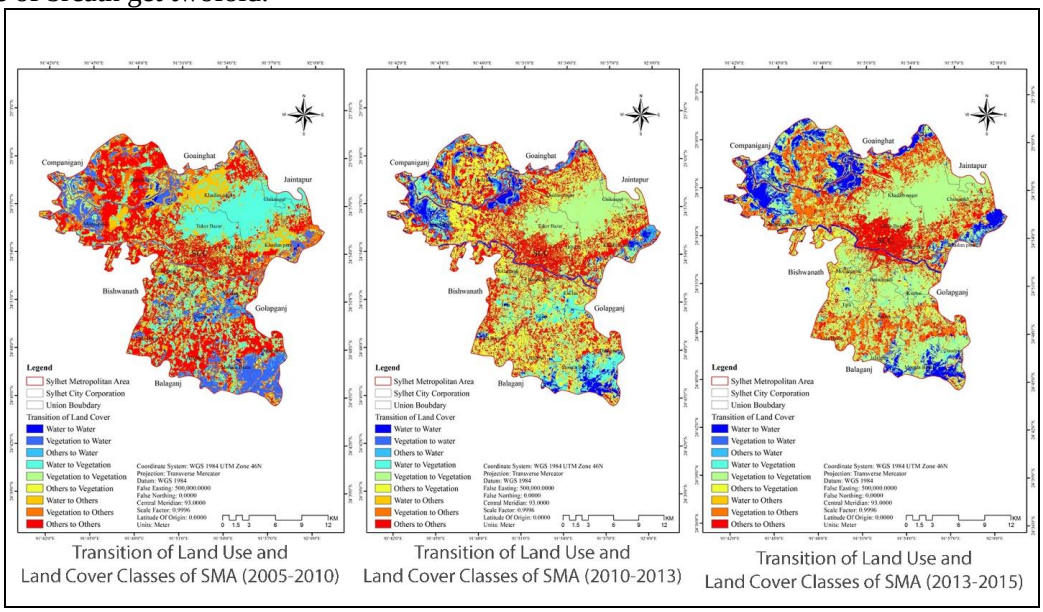
$$T = 6.7 + \left(0.62 \times \frac{RED}{NIR}\right) - \left(0.882 \times \frac{NIR}{BLUE}\right) - \left(3.22 \times \frac{GREEN}{BLUE}\right)$$

For retrieval of Chlorophyll band ratios is used to select two spectral bands that are representative of absorption/scattering features of chlorophyll-a (Gin et al. 2002). The past examinations have additionally demonstrated that the wavelength run for portraying chlorophyll-an is somewhere in the range of 400nm and 900nm. Along these lines, the four groups which are generally connected with chlorophyll-an are the blue, green, red and NIR groups. The last phase of the investigation is the estimation of connection between the surveyed parameters to decide the water quality.

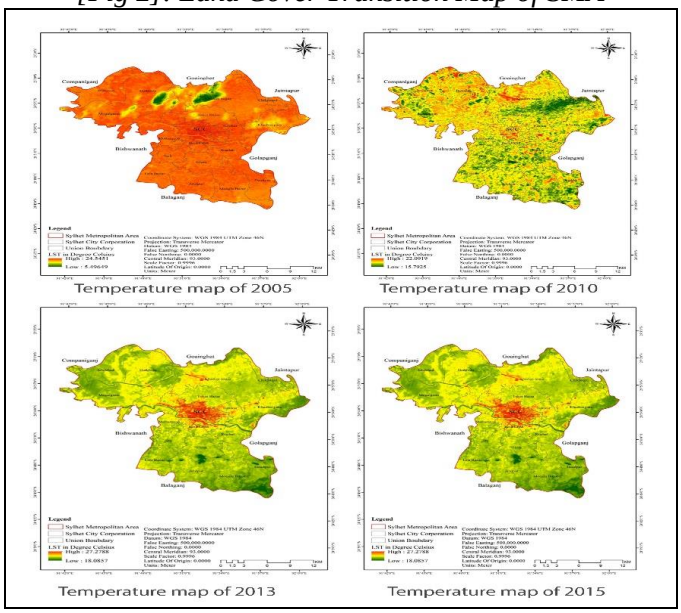
RESULTS AND DISCUSSIONS

Figure 2 demonstrates the change of land cover in the Sylhet Metropolitan Territory (SMA) for the four eras considered in this exploration. Two patterns are unmistakably discernable from the figure: (a) vegetation expanded steadily over the periods; and (b) water body declined step by step over the periods. All the more particularly vegetation expanded by 33.14% and water body diminished by 20.54% in the previous 11 years, from 2005 to 2016. Be that as it may, two things are not reasonable from Figure 6. To start with, it is misty whether the developed territories were just the beneficiary of grounds from different kinds or contributors too to different sorts (e.g., changed over from developed to water body). Second, the examples of transformations like the degree of change from one class to the others). With the end goal to comprehend these connections, additionally examinations were led. In this examination band no 6 from Landsat TM satellite picture was utilized to assess surface temperature and NDVI. Remote detecting is a compelling apparatus for order of land cover and NDVI. The LST circulation of 2005, 2010, 2013 and 2016 present in figure 3. High temperatures are mostly found in urban focuses, that is the warmth island impact. The base, greatest and normal temperature were 14.50°C, 24.55°C and 19.52°C of every 2005 and 15.79°C, 22.09°C and 18.94°C out of 2010 and

19.84°C, 25.73°C and 22.78°C of every 2013 and in conclusion, 18.09°C, 27.28°C and 22.68°C out of 2016. Over the eleven years (2005 to 2016) the normal temperature expanded 3.16°C and the greatest and least temperature expanded separately 2.73° C and 5.34°C. The outcome shows that the warmth island impact is expanding step by step. Since, the temperature is rising step by step, rate of breath in the plants is affected by temperature and inside certain breaking point of 10°C increment in temperature, the rate of breath get twofold.



[Fig 2]: Land Cover Transition Map of SMA



[Fig 3]: Temperature Map of SMA

Table 3**:** LST (°C) values for 2005, 2010, 2013 and 2016

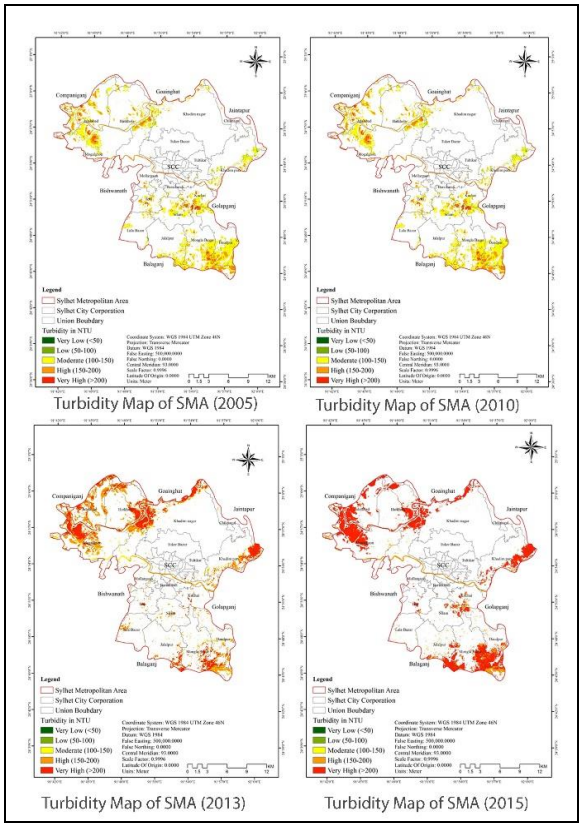
Year	High	Low	Mean
2005	24.55	14.50	19.52
2010	22.09	15.79	18.94
2013	25.73	19.84	22.78
2016	27.28	18.09	22.68

From the above table Chlorophyll describes High (150-200) and Very High (>200) decreases during the period from 2005 to 2016. The Figure 6.1 demonstrates the measure of chlorophyll in the individual years. Above figure delineates that there was an extraordinary misfortune in chlorophyll-an in ongoing

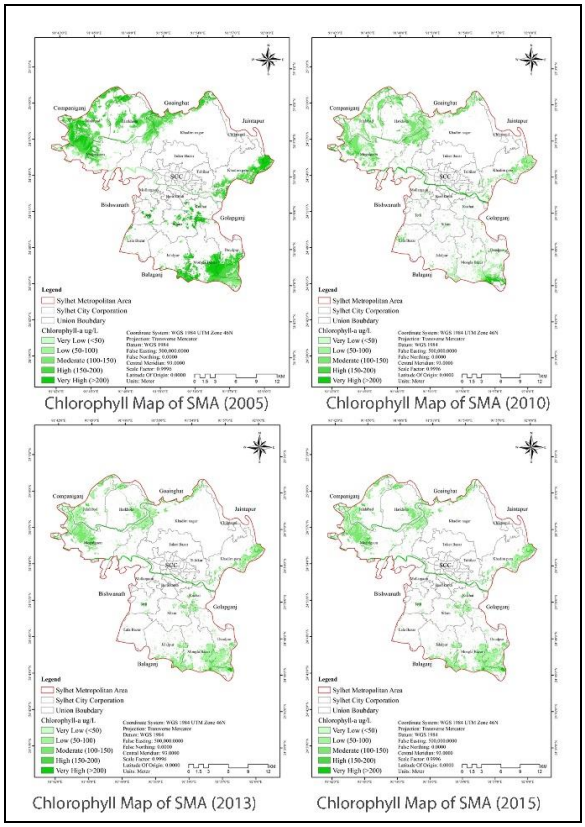
eras (e.g., 2010-2013, and 2013-2016). This implies a few sections of the beforehand very immersed phytoplankton were changed over into some other land cover classes.

Table 4: Chlorophyll-a Percentage for 2005, 2010, 2013 and 2016

Quantity	Percentage of Chlorophyll-a			
	2005	2010	2013	2016
Very Low (<50)	3.83	7.24	10.45	8.32
Low (50-100)	11.10	43.77	26.90	36.79
Moderate (100-150)	18.45	33.57	48.85	44.30
High (150-200)	44.71	10.54	9.28	4.77
Very High (>200)	21.91	4.88	4.53	5.82



[Fig 4]: Turbidity Map of SMA



[Fig 5] Chlorophyll *Map of SMA*

CONCLUSIONS

The water percentage in Sylhet Metropolitan area is 35.21%, 13.96%, 12.33%, 14.67% consecutively in the year 2005, 2010, 2013 & 2016 respectively. It is seen after 2005 land use change in water percentage is gradually decreasing in alarming rate. Focusing on transition of LULC it is seen that water to water land use change 1.12% whereas water to other percentage 12.01%, water to vegetation 22%. But on reverse point vegetation to water transition land use is only 10.34% & other to water is 2.52%. From the above data it is seen water body is gradually diminishing to other land use among them maximum vegetation area. If this condition persists then the water reservoir of the Sylhet city would be nonfunctional with respect to catchment basin area. The maximum temperature in 2005 is 24.55^{o}, in 2010 is 22.09^{o}, in 2013 is 25.73^{o} & in 2016 is 27.28^{o}. Over eleven years 2005 to 2016 the average temperature increases 13.60 & maximum temperature increases 5.53^{o}. The result indicates that heat island is increasing day by day. Since the temperature rising respiration in the plant is influenced by the temperature. Due to this reason the growth of the plant increases which is one of the reasons for transition of water to vegetation (22%) become the second highest of transition land use in 2005 to 2016. Studying turbidity analysis, we can see in 2005 the highest chlorophyll percentage in water body was 21.19%, in 2010 chlorophyll percentage was 4.88%, in 2013 was 4.53%, and in 2016 was 5.82%.

The chlorophyll percentage decreasing in alarming rate day by day. This indicates that the amount of chlorophyll has a great loss in the time period 2005 to 2013. This means that some part of previously highly saturated phytoplankton was converted into other land use. If this condition persists then hazard like water logging and flood will take place as there will be outflow through the catchment area.

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19 –21 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

FACTORS AFFECTING ACTIVATED SLUDGE TREATMENT PROCESS

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ABSTRACT
This research deals with the comparative study of different operational parameters in a specific volume of sewage, sludge aged and maintaining an optimum range of F/M ratio into the waste environment. Separate aeration tanks of same sizes, pH range 6 – 9 has been maintained during the experiment. Results reveals that the recommended ECR limit has been achieved with in 2.6hours and 5.5hours of aeration period achieving around 87% and 75% of COD reduction using different volume of sewage. Variation of F/M ratio concludes optimum dosing range of sludge. However, in the case of EC and TDS an increasing trend of complete reverse situation has observed. This paper also slightly introduce the effect of Sludge aged on pH. The obtained Optimum range for microorganism will help to provide accurate prediction and their feasibility in waste water treatment. The lag time of various measurement Parameters in the process will help for various domestic waste water treatment applications and several promising areas to explore in the future.

Keywords: Activated Sludge, parameters, microorganism, application, explore.

INTRODUCTION
A promising long-term and sustainable solution to the growing scarcity of water worldwide is to recycle and reuse wastewater. People require a supply of clean water, meanwhile at the same time they generate huge amounts of wastewater that is contaminated with various toxic compounds, becoming a burgeoning problem in the developing world too. In other words, Magnitude of water pollution from disposing of domestic wastewater has already been taken considerable dimension to threaten public health and the environment. Immediate intervention is required to reduce the magnitude of water pollution through proper treatment of biological waste before disposal. Biological treatment of domestic wastewater is evaluated as a suitable treatment method for domestic wastes. Treatment of wastes with bacteria involves the stabilization of waste by decomposing into harmless inorganic solids either by aerobic or anaerobic process. In aerobic process, the decomposition rate is more rapid and it is not accompanied by unpleasant odor, whereas in anaerobic process, longer detention period is required and gives unpleasant odor. Among the other biological methods, Activated Sludge process where naturally growing bacterial cultural used for bio-degradation of organic matter. The use of Activated Sludge in biological treatment is mostly common where greater flexibility of treatment, permitting a control over the quality of effluent desired. The effluent produced is clear, sparking and non-putrescible. BOD removal 80% - 95% and bacterial removal 90% - 95% (Metcalf et al., 1995). However, the efficiency

of microorganism depends on many factors, including the chemical nature and the concentration of pollutants, their availability to microorganisms, and the physicochemical characteristics of the environment (Saı¨d El Fantroussi et al., 2005; G. Durai et al., 2011). The use of activated sludge was observed in a sequential batch process and the factors affecting the domestic wastewater treatment process were analyzed for the period of one year.

This study was undertaken to assess the characteristics of domestic wastewater, determine the potentiality of activated sludge to break down waste organics under various cyclic condition and determine the optimum F/M ratio and detention time for treatment of domestic wastewater. Varying volume of sewage and F/M ratio, it has been tried to determine the optimum values of operational parameters. Limited numbers of batches have been studied for both budget and time restriction. Due to this, not much is being done to improvise the study.

METHODOLGY

Collection of Wastewater

The Sample was collected from nearby domestic backyard manhole. The obtained raw sample has vary COD values. The sample was collected during peak flow time around 8-10 am.

Test procedure for Wastewater Characterization

In this study, BOD, COD, DO, pH, turbidity, EC, MLSS, MLVSS, and F/M were determined following the standard methods (American Water Works Association, 1998) for raw sample.

Experimental Setup

The setup of conventional batch process for the treatment of domestic wastewater using activated sludge is shown below;

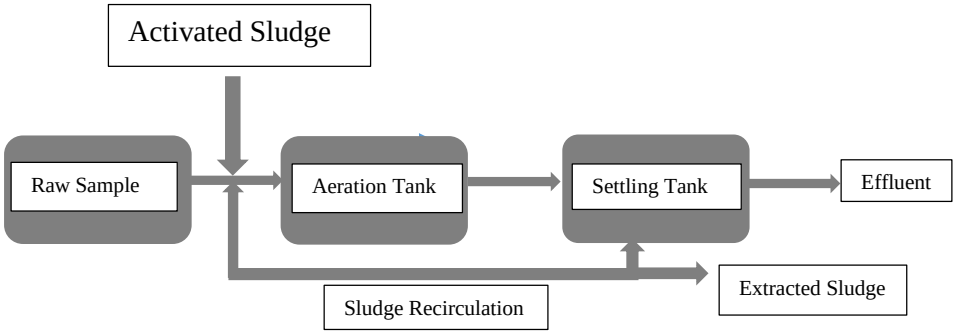

Fig. 1: *Setup*

Procedures

Seeding of Sludge was done separately for more than 2 weeks. Nutrients and extra diffusers were added at the initial phase to increase the process of seeding. Sampling of Raw water was done using 10L of gallons each. We found the COD and EC of raw sample above 500mg/L and 1200 micro simen/cm each time. The experiment was done with a continue aeration for 8hours at a constant room temperature.

RESULTS AND DISCUSSION

Effect of volume of sewage on COD reduction

In the experiment, different volume of waste water have been used to determine the best reduction rate of COD. Using small volume of sewage, maintaining the ratio (diameter: depth) of around 1:1, various problems like, poor floc formation, Dispersed growth problem and filamentous bulking of sludge under natural environmental conditions etc. have been encountered (Michael Richard et al., 2003). Using large

volume of sewage by maintaining the ratio of around 2:1 have shown better performance.

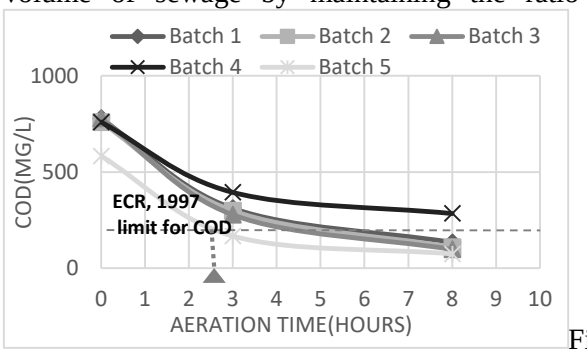

Fig. 2: *Variation of COD with Aeration Time*

According to the graph plotted, the optimum limit has been achieved within 2.6 hours (The Environment Conservation Rules, 1997). We can conclude that by maintaining the ratio 2:1 (diameter: depth), the distance between the wall of tank and aerator (centered) was sufficient to avoid the hydraulic effect. This decreases the chances of collision between reactor wall and flocs, reduce the settleability of flocs and obtains the better performance.

Effect of F: M ratio on COD reduction

The reduction of COD has been observed in the laboratory with varying F/M ratios in sequential batch process using Activated sludge. For a conventional plug flow the F: M ratio should be 0.2 – 0.4. (Source: Typical design parameter for Activated Sludge). As, due to sludge thickening, the F: M ratio was found to be low that cause removal rate of COD a bit low to some extent.

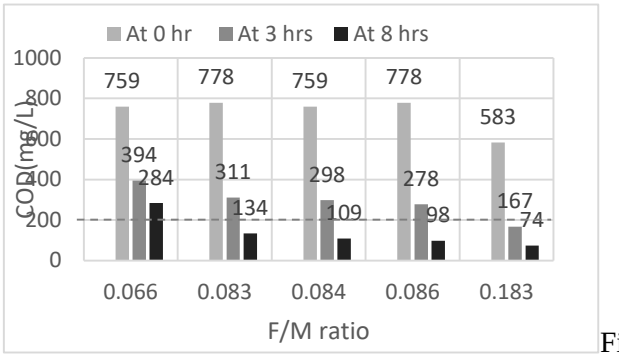

Fig. 3: *Variation of COD with F/M ratio*

The bar graph showed, COD removal at F/M ratio 0.083, 0.084 and 0.086 has achieved the standard limit but sludge thickening has taken place making the F/M ratio (0.066) smaller than general. In this case we can say that, autolysis might occur into the process. F/ M ratio 0.183 has achieved the recommended ECR limit with in short time i.e. least COD value. We can conclude that, micro-organism might not enter the starvation phase in this case as they are actively involved in the process.

Effect of Sludge age

The pH affects biological growth of bacteria. Below pH 6.0 fungi starts to growth and above pH 9.0, the retardation of metabolism will occur (Rahman et al., 1988). Diversion a certain portion of the settled sludge or recirculation, increase the opportunity of growing new bacteria in the system. The variation of pH showed increase alkalinity and concentration of NH_3 in the experiment which concludes the existence of nitrifying bacteria. Since, significant nitrifying bacteria have been observed that cause

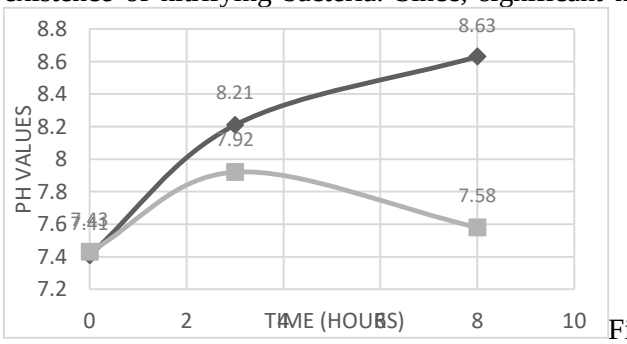

Fig. 4: *Variation of pH with Aeration Time*

the reduction of COD removal performance. Thus, we can conclude due to increase of pH, it might affect the bio-oxidation process of bacteria and might function slowly. However, the study needs further investigation.

Variation of EC and TDS with aeration time

An increasing trend of Electrical Conductivity has been observed with the aeration time using diffuser aeration process. An increasing trend of complete reverse situation has been observed.

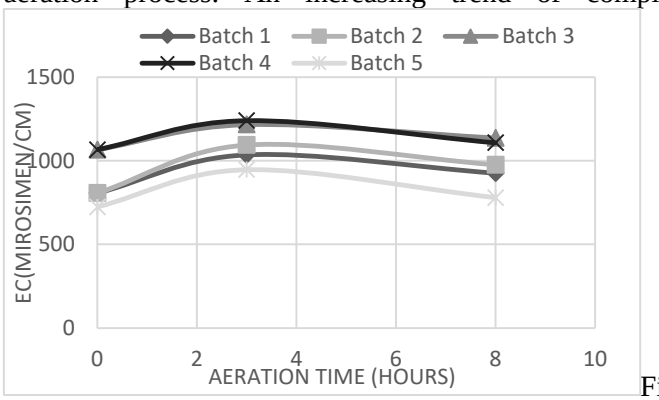

Fig. 5: *Variation of EC with Aeration Time*

Results reveals that around 24% of increase in EC has been observed after the addition of activated sludge. The tremendous increased of EC is due to ion dispersion as; there might be some inorganic ions that release from the organic compound. When EC increases, TDS (26%) and ion concentration of water also increase, which might not favorable for local redox reaction and also effect the solubility of water.

CONCLUSION

Compared to other biological treatment methods, activated sludge process would be more efficient for COD reduction. COD reduction rate for first 3 hours was very effective compared to last hours as microorganism are seems to be active in first hours. Increasing trend of EC and TDS with time reveals the increase of ion concentration in waste environment. In addition, the sludge utilization processes have advantages of easy control, stable performance and high operation flexibility. The relatively low operation cost and eco-friendliness of this systems increases application in treatment practice.

ACKNOWLEDGEMENT

At first, the authors recalls the gratefulness to almighty GOD. Then expresses their sincere gratitude and deep indebtedness to their supervisor Prof. Dr. Farooque Ahmed, Professor of Civil Engineering Department (Environmental Engineering Division), BUET, Dhaka under whose expert guidance and constant inspiration, this thesis work was successfully completed. His careful reading of the draft, valuable comments, criticism and constructive suggestions immensely contributed to the improvement of the thesis. The authors expresses their sincere thanks to the Civil Engineering Department, BUET for providing all the facilities and equipment, which enabled them to carry the research work. Thanks and appreciations are due to Mr. Ehosan Habib (Asst. Experimental Engineer, for his tireless support in the Environmental Laboratory of the Civil Engineering Department). The authors wishes to give cordial thanks to Mr. Mahbub, Mr. Mithu, Mr. Anwar, Mr. Najmul and all other support staffs of environmental lab for their services in many ways.

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APPENDIX

Sl No.	Parameter	Unit	Industrial Effluent Quality Standard at Discharge Point		
			Inland Surface Water	Public Sewerage System Connected to Treatment at Second Stage	Irrigated Land
1	Ammonical Nitrogen (as elementary N)	mg/l	50	75	75
2	Ammonia (as free ammonia)	mg/l	5	5	15
3	Arsenic	mg/l	.20	.05	.20
4	BOD_5 at 20°C	mg/l	50	250	100
5	Boron	mg/l	2	2	2
6	Cadmium (as Cd)	mg/l	.50	.05	.05
7	Chloride	mg/l	600	600	600
8	Chromium (as total Chromium)	mg/l	.50	1.0	1.0
9	COD	mg/l	200	400	400
10	Chromium (as hexavalent Chromium)	mg/l	.10	1.0	1.0
11	Copper (as Cu)	mg/l	0.5	3.0	3.0
12	Dissolved Oxygen	mg/l	4.5 - 8	4.5 - 8	4.5 - 8
13	Electro-conductivity	micro mho/cm	1200	1200	1200
14	Total Dissolved Solids	mg/l	2100	2100	2100
15	Fluoride (as F)	mg/l	2	15	10
16	Sulphide (as S)	mg/l	1	2	2
17	Iron (as Fe)	mg/l	2	2	2
18	Total Kjendahl Nitrogen (as N)	mg/l	100	100	100
19	Lead (as Pb)	mg/l	0.1	1.0	0.1
20	Manganese (as Mn)	mg/l	5	5	5
21	Mercury (as Hg)	mg/l	.01	.01	.01
22	Nickel (as Ni)	mg/l	1	2	1
23	Nitrate (as elementary N)	mg/l	10	Not Yet Fixed	10
24	Oil and Grease	mg/l	10	20	10
25	Phenolic Compounds	mg/l	1	5	1
26	Dissolved Phosphorus (as p)	mg/l	8	8	15
27	Radioactive Substances	To be Specified by Bangladesh Atomic Energy Commission			
28	pH		6 - 9	6 - 9	6 - 9
29	Selenium (as Se)	mg/l	.05	.05	.05
30	Zinc (as Zn)	mg/l	5	10	10
31	Temperature	°C	40 Summer 45 Winter	40 Summer 45 Winter	40 Summer 45 Winter
32	Suspended Solids	mg/l	150	500	200
33	Cyanide (as Cn)	mg/l	0.1	2.0	0.2

Table 1: Standards for wastewater (ECR, 1997)

Typical design parameters for commonly used activated-sludge processes[a]

Process Name	Type of Reactor	SRT, days	F:M kg BOD/kg MLVSS-d	Volumetric Loading		MLSS, mg/L	Hydraulic detention time, hrs	RAS % of Influent[e]
				lb BOD/1000 ft^3-d	kg BOD/m^3-d			
High-rate aeration	Plug flow	0.5 - 2	1.5 - 2.0	75 - 150	1.2 - 2.4	200 - 1000	1.5 - 3	100 - 150
Contact stabilization	Plug flow	5 - 10	0.2 - 0.6	60 - 75	1.0 - 1.3	1000 - 3000[b] 6000 - 10000[c]	0.5 - 1[b] 2 - 4[c]	50 - 150
High-purity oxygen	Plug flow	1 - 4	0.5 - 1.0	80 - 200	1.3 - 3.2	2000 - 5000	1 - 3	25 - 50
Conventional plug flow	Plug flow	3 - 15	0.2 - 0.4	20 - 40	0.3 - 0.7	1000 - 3000	4 - 8	25 - 75[f]
Step feed	Plug flow	3 - 15	0.2 - 0.4	40 - 60	0.7 - 1.0	1500 - 4000	3 - 5	25 - 75
Complete mix	CMAS	3 - 15	0.2 - 0.6	20 - 100	0.3 - 1.6	1500 - 4000	3 - 5	25 - 100[f]
Extended aeration	Plug flow	20 -40	0.04 - 0.10	5 - 15	0.1 - 0.3	2000 - 5000	20 - 30	50 -150
Oxidation ditch	Plug flow	15 - 30	0.04 - 0.10	5 - 15	0.1 - 0.3	3000 - 5000	15 - 30	75 - 150
Batch decant	Batch	12 - 25	0.04 - 0.10	5 - 15	0.1 - 0.3	2000 - 5000[d]	20 - 40	NA
Sequencing batch reactor	Batch	10 - 30	0.04 - 0.10	5 - 15	0.1 - 0.3	2000 - 5000[d]	15 - 40	NA
Countercurrent aeration system (CCAS)	Plug flow	10 - 30	0.04 - 0.10	5 - 10	0.1 - 0.3	2000 - 4000	15 - 40	25 - 75[f]

[a]Adapted from WEF (1998); Crites and Tchobanoglous (1998)
[b]MLSS and detention time in contact basin
[c]MLSS and detention time in stabilization basin
[d]Also used at intermediate SRTs
[e]Based on average flow
[f]For nitrification, rates may be increased by 25 to 50%
NA = not applicable

Table 2: Typical design parameters for Activated Sludge Processes.

4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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MUNICIPAL SOLID WASTE MANAGEMENT IN DHAKA CITY: AN EVALUATION BASED ON LIFE CYCLE ASSESSMENT (LCA)

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ABSTRACT
Municipal solid waste management (MSWM) has turned out to be perplexing for Dhaka City Corporation more than ever because of inadequate means and inappropriate waste management practices. The objective of this investigation was to utilize life cycle assessment (LCA) tool to quantitatively determine the comparative contribution of various waste management scenarios thus finding out the least impactful management scenario for Dhaka city. Utilization of different functional elements or steps in the waste management practice were altered in the two modelled scenarios which were then compared with the present practice. The present scenario (Denoted as S_1) practices 60% waste collection efficiency with 40% open dumping, 6.20% composting, 15% recycling, 2% open burning and 36.80% unsanitary landfill without energy recovery. Assumed scenarios S_2 and S_3 practice 90% and 100% waste collection efficiency, 10% and 0% open dumping, 40% and 60% composting, 20% and 25% recycling, 2% and 0% open burning with 28% and 15% in unsanitary and sanitary landfill respectively. In consideration of the functional unit for the study area Dhaka city, one ton of municipal solid waste was chosen during one-year period. The analysis indicated that the present management scenario poses the most impact on human health and climate change whereas model scenario S_3 contributes the least (<10% of total) because of elimination of open dumping and open burning options. However, increased collection efficiency and infrastructure for sanitary landfill in S_3 resulted to elevated contribution towards consumption of non-renewable resources.

Keywords: Life cycle assessment (LCA); Municipal solid waste (MSW); Dhaka city; Impact categories

INTRODUCTION
Proper Municipal solid waste management (MSWM) is a complex and a challenging issue in developing countries like Bangladesh. The capital city, Dhaka is expanding day by day with an extensive growth rate of population and thereby the pollution potential is equally elevating. Due to accelerated metropolitan population increase, rapid industrialization, rising urbanization and movement of people to the capital for quality education and income perspective, there has been an alarming rise in the municipal solid waste (MSW) generation in Dhaka city. The amount and types of this waste increased rapidly with the intensive growth rate of the city population. The waste generation rate in the Dhaka city is 4,634.52 tons/day and waste generation rate is 0.56 kg/capita/day (Bahauddin & Uddin, 2012). According to Waste concern (2009), the average percentage of compostable content of MSW in Dhaka city is 67.65% with the residual 32.35% being recyclable. The capacity of Bulta composting plant has been reported as 130 tons/day and the daily recycled rate of the total generated waste as reported amounts to 15% in Dhaka city (mainly inorganic) which is estimated to be 475 tons/day (Enayetullah et al., 2006). Besides, waste concern introduced a project in 2006 on a barrel composting

plant for small community in several slum areas to reduce health problems of the slum people. The poor management of municipal solid waste management contributes to the degradation of environment and overall risk on public health. The uncollected waste on roads and government places clogs the sewerage path and pollutes the water resources. The collection and disposal efficiency of waste is not increasing with the increase in the generation rate of municipal solid waste in Dhaka city. In Bangladesh, the most common waste disposal practices are unregulated open dumping, exposed burning, recycling, composting and unacceptable landfilling practices. Establishment of proper disposal option for MSW exerting minimum environmental impact remains one of the biggest developmental challenges for Bangladesh. Life cycle assessment (LCA) is a methodology which is used to evaluate the environmental impact of a specific product or service from cradle to grave throughout the whole life period of this product or service (Lin et al., 2013). Existing MSW management plans and framework can be evaluated through Life cycle assessment (LCA) concepts and techniques to provide the solid waste planners and decision makers with the option to choose the most acceptable one (Obersteiner et al., 2007). A number of LCA studies have been conducted on MSW management systems in developed and developing countries such as Iran, India, Pakistan, Srilanka, Nepal, Nigeria, Italy, Turkey, China, Malaysia, Indonesia, Singapore, Russia, Spain, Greece, Austria etc. (Miliute and Kazimieras, 2010; Yadav & Samadder, 2018). Rajaeifar et al., (2017) conducted an LCA study in Iran by Impact 2002+ method, in which five scenarios including anaerobic digestion; landfilling with composting; incineration; incineration with composting; anaerobic digestion with incineration were compared and the option of anaerobic digestion combined with incineration option was found to exert the least environmental impact compared to other scenarios. Abduli et al. (2011); Tarantini et al; (2009); Hong et al. (2010) also reported studies of LCA on MSWM. In Nigeria, Ogundipe and Jimoh (2015) reported that composting and recycling together has a minimal environmental impact compared to other waste management options. In Turkey, Banar et al. (2009) conducted an LCA study on MSW fraction basis for Eskisehir city and compared five scenarios. The aim of present study is to use LCA as a tool to compare and assess the environmental burdens of varying municipal solid waste management scenarios and to find out the least impactful solid waste management option in Dhaka city. The outcomes of the current investigation could be useful and applied to the other municipalities of Bangladesh.

METHODOLOGY

The waste management elements that were considered in this study for impact assessment in Dhaka city were collection and transportation, open dumping, exposed burning, recycling, composting and unsanitary landfilling of waste. As functional unit, one ton of municipal solid waste was considered for comparing and evaluating the results. For collection and transportation of the waste, total number of trucks, dustbins, secondary transfer station and gaseous emission into the air from diesel oil for transportation of waste (Kebin et al., 2010; Babu et al., 2014) were considered agreeing to DCC survey data. Environmental impact for open dumping and burning were considered from previous literature (EPA 1997; EPA 1995; Yadav and Samadder, 2018). The quantity of electricity and diesel required for machinery operation to accomplish recycling of waste were assumed to be 3.2 kWh and 3.21 L/ton of waste (Rajaeifar et al., 2015) respectively. Barrel composting (Moqsud et al., 2011) and bulta composting plant data were considered for the impact of the composting process. For landfilling of waste, the number of trucks and emission into the air from diesel oil for compacting of waste was also considered. Emissions of the landfill through air and soil have been considered from previous literature (Mboowa et al. 2017; Babu et al., 2014). Emission of leachate into water was also considered (Hossain et al., 2016). Afterwards, three scenarios were chosen based on the utilization of different proportions of waste collection and waste treatment options. The present waste management scenario was chosen as the baseline scenario in this study area. Utilization of different functional elements or steps in the waste management practice were altered in the two modelled scenarios which were then compared also with the present practice. The present scenario (Denoted as S1) was considered to practice 60% waste collection efficiency with 40% of waste in open dumping, 6.20% waste in composting, 15% in recycling, 2% in open burning and 36.80% unsanitary landfill without energy recovery. The second scenario was assumed based on reducing of organic and recycling fraction of waste. Assumed scenario denoted as S2 was considered to practice 90 % waste collection efficiency, 10 % waste in open dumping, 40% in composting, 20% in recycling, 2% in open burning and 28% in the unsanitary landfill. The third scenario was attempted with a vision to minimize the pollution potential through disposal by increasing

the rate of composting and recycling of waste and removing open burning process. Assumed scenario denoted as S3 was considered to practice 100% waste collection efficiency with 60% waste in composting, 25% in recycling and 15% in the sanitary landfill. After composting, residues of recycling waste, construction waste were disposed of in the sanitary landfill by covering with proper soil. Accordingly, the consequential assumption was that the emissions from the sanitary landfill in this scenario would be zero. The inventory data of waste management practices were chosen from Eco-invent 3.4 data of SimaPro 8.5.2 software libraries. In this study, the Impact 2002 + method was chosen to analyse the data which is the most widely used and acceptable method in LCA analysis of MSWM (Rajaeifar et al., 2015). The Impact 2002+ method analyses the impacts through consideration of 15 mid-points impact categories that ultimately leads to four endpoint damage categories of Human Health, Climate Change, Ecosystem Quality and Resource. The outcomes are expected to provide comparative scenario based information to the decision-makers which would eventually enable them to select the most eco-friendly municipal solid waste management option in Dhaka city.

RESULTS AND DISCUSSIONS

Comparative Impact Assessment among waste management scenarios

The comparative analysis results of fifteen midpoint categories of solid wastes management scenarios are shown in [Fig. 1] based on characterization result. The characterization result shows that scenarios-1 has the environmental contribution on global warming, aquatic eutrophication, aquatic acidification, terrestrial acidification, respiratory organics, respiratory inorganics, carcinogens, and non-carcinogens. However, scenario-2 and scenario-3 exhibit comparatively lower impact. It is important to mention that, scenario-3 has significant impact on non-renewable energy and land occupation as the composting and recycling fractions were higher in this scenario. Overall, scenario-3 was found to be the eco-friendliest among waste management scenarios based on fifteen categories impact assessment result.

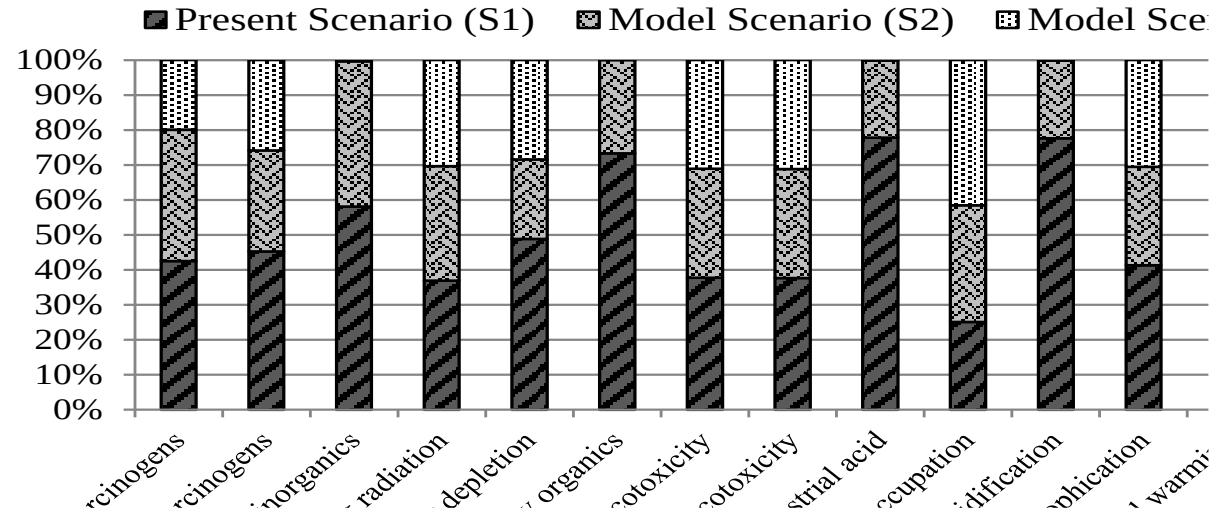

Fig. 1: Fifteen Midpoint impact categories for the solid waste management scenarios based on Characterization result

Overall assessment of damage on the environment for solid waste management

The analysis result of four damage categories is shown comprehensively in [Fig. 2]. These four damage categories are significantly important to assess the overall effect on the environment due to the requirement to manage the huge quantity of solid waste. The results are discussed below:

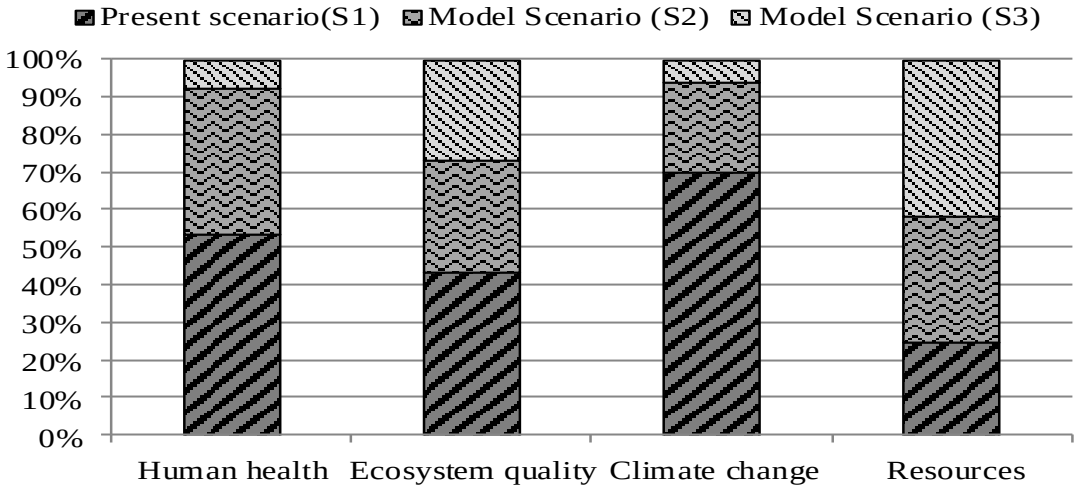

Fig. 2: Plots of the overall damage categories for the solid waste management scenarios

Human Health

[Fig. 2] shows that present scenario S-1 led to the maximum adverse impact (about 53%) on the Human Health category compared to the others scenarios. Model scenario S-3 seems to exert lesser impact (only 8%) and the model scenario S-2 exerts about 39% environmental impact on human health. Hong et al., (2010) also found the landfilling scenario to be the worst scenario with respect to the Human Health category. The scenario S-3 in the current study was found to exert less environmental impact that might have been caused by the sanitary option for landfilling in this study in addition to the elevated proportion of the options of composting and recycling of waste. Moreover, the model scenario S-3 was found to be better than the present scenario S-1 which can be explained by the fact that the open dumping process is included as one of the practices in the present scenario S-1. Open disposal option contributed the incremental damage on the Human Health category. Increasing percentage of the option of composting waste in scenario S-3 would contribute towards reducing the negative impacts of human health. As a result, S-3 was found to be more eco-friendly scenario based on human health damage assessment result.

Ecosystem quality

Based on [Fig. 2], all scenarios under consideration had a significant contribution to the "Ecosystem Quality" category. It can be observed that the scenarios S-1 and S-2 contribute about 42% and 31% impact on the ecosystem damage category while scenario S-3 has a lesser impact (26%) on ecosystem. Precisely similar to the findings on Human Health category, the landfilling process was found as the main cause of adverse impact on the Ecosystem Quality. Recycling and composting were seemed to be the options that significantly reduced the impacts on Ecosystem as significant level of emissions could be avoided through these processes.

Climate change

Climate change is an important factor in making a decision on MSWM issue. According to [Fig. 2], the present scenario S-1 exerts the maximum adverse impact on the Climate Change, while the model scenarios exert a favorable impact on climate. It should be mentioned that landfill gas could create a strong impact on the climate change. Methane recovery on landfilling contributes lesser impact on Climate change. As methane is a Green House Gas (GHG), it should be noted that GHGs cause global warming through trapping of heat and warming the earth's surface. In fact, emissions of CH_4, CO_2 and to a lesser extent N_2O which are the three main Greenhouse Gases (GHGs) can be potentially emitted from a landfill thereby contributing towards climate change. Model scenario S-3 has less impact on climate change because of the elevated proportions utilized in composting (50%) and recycling (25%) of waste. Besides, sanitary option for landfilling was considered in this system. As a result, the impact on climate change from scenario-3 is comparatively very low.

Resources

As shown in [Fig. 2], all scenarios under consideration seem to exert certain impact on the "Resources". Among the studied scenarios, model scenario S-3 exerts the maximum impact on resources. Higher proportions of collection efficiency, composting and recycling were considered in scenario-3 that might have caused the elevated level of impact on resources. Among all, the present scenario S-1 seems to exert the minimum impact on resources as it consumes the least.

Comparing environmental impact of three scenarios based on single score

Single score results help in understanding the magnitude of the impact and relative importance of the same that are relevant for the scenarios under consideration. Impact 2002+ method enables comparing all scenarios under consideration based on single score. The resulted plot as shown in [Fig. 3] details that present scenario S1 and model scenario S2 exhibit worst and moderate negative impacts respectively while model scenario S3 exert environmental benefits. The main benefits of model scenario S3 are production of fertilizer and recyclable products. Besides, Model scenario S2 exerts moderate environmental impact compared to present scenario (S1). Model scenario S3 will help in the reduction of landfill gases and various other negative impacts on environment. At the end [Fig. 3] sensitivity analysis result of single score indicates that increasing composting and recycling rate will help in terms of environmental benefits. So, Model scenario (S3) would be preferred for waste management in Dhaka city.

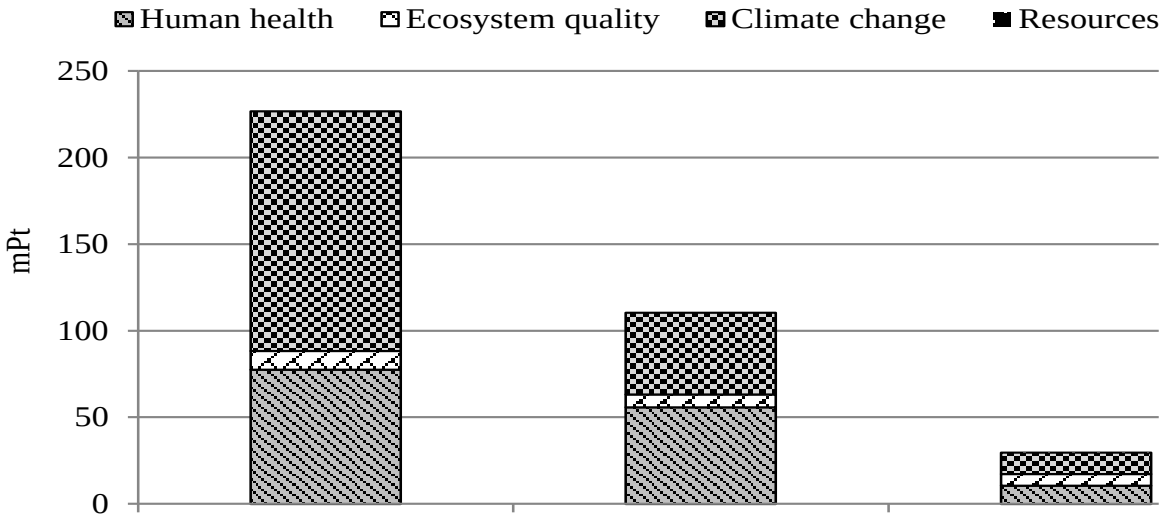

Fig. 3: Comparing environmental impacts of three waste management scenarios based on single score

CONCLUSIONS

This paper evaluates the environmental burden of present scenario of municipal solid waste management in Dhaka city. In addition, two model scenarios were formulated and compared with the present scenario of Dhaka city. Life Cycle Assessment (LCA) was utilized as a tool to assess the emissions to air, water and environment from waste management processes such as waste collection & transportation, open disposal, exposed burning, recycling, composting and landfilling of solid waste. The scenarios with open disposal exposed burning and unsanitary landfilling options with lesser collection frequency evidently exerted more negative impacts on the environment, health and ecosystem. However, resource consumption was also evident for the most environmental friendly option that involved efficient and increased collection frequency, no dumping or burning option and sanitary landfilling. These comparative analyses will serve as a decision support tool to develop an efficient and eco-friendly waste management system in Dhaka city.

ACKNOWLEDGMENTS

The authors are grateful to the Instituted of Energy, Environment, Research and Development (IEERD) at University of Asia Pacific (UAP) for providing research fund.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
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REMOVAL OF AMMONIA NITROGEN AND HYDROGEN SULFIDE FROM TANNERY WASTEWATER USING DRIED TANNERY SLUDGE AND FERRIC HYDROXIDE SUSPENSION

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ABSTRACT

The removal of medium-low NH_3-N and H_2S from tannery wastewater is done by the combi- nation of aeration and adsorption via dry activated sludge and ferric hydroxide suspension. Batch studies were conducted as a function of pH, concentration of modifier, contact time, and initial concentration. The study showed that best removal of NH_3-N and H_2S was done at a pH of 8 and contact time of 120 minutes. The adsorption study indicated that ferric hydroxide suspension had a higher adsorption capacity for NH_3-N than dried activated sludge. After aeration the mechanism of removal of NH_3-N and H_2S by dry activated sludge and ferric hydroxide suspension was coexistence of adsorption and cat-ion exchange. Initial NH_3-N concentration being 353 mg/l in tannery wastewater was reduced to 30 mg/l and H_2S was reduced from 253 mg/l to 0.04 mg/l after the aeration adsorption treatment.

Keywords: Activated sludge, aeration, adsorption, cat-ion exchange.

INTRODUCTION

Leather industry is a major industry in Bangladesh and the Government of Bangladesh has declared it as a priority sector. The effluent emanating from tannery industry contains high concentration of ammonia nitrogen and sulfide ions. Since these effluents are toxic to aquatic environment, it is essential to neutralize them and bring the discharge levels of these species to below the toxic limit.

Great efforts have been aimed at the removal of N-NH_3 and sulfide from wastewater. Some traditional methods are air stripping [3], chemical precipitation [4], biological denitrification [5], dry-ice [6] and so on.

Activated sludge is the by-product of sewage treated by the activated sludge process. Every year a large amount of activated sludge is produced from sewage treatment plants situated in the tannery industrial area. In this study, activated sludge was used as the bio-adsorbents to remove medium-low N-NH_3 and sulfide from tannery wastewater. Because of its sorptional nature, ferric compounds were mixed with the sludge to modify it increasing its adsorption efficiency. Tannery effluent were also passed through these ferric compounds to investigate its adsorption capacity. Aeration, coagulation and adsorption were subsequently done to mimic the treatment process in real life and to maximize the removal efficiency.

METHODOLOGY (SECTIONS)

Adsorbate

Tannery effluent from tannery industrial village in Savar, Dhaka, Bangladesh was used as the source of ammonia nitrogen and sulfide.

Adsorbent

The activated sludge was obtained from a sewage treatment plant of tannery industrial village situated in Savar, Dhaka, Bangladesh.
The sludge was dried at 110°C for 24 hours and sieved through a 300μm sieve and stored dry until use, labelled as Original Activated Sludge (OAS).
Adding NaOH solution to a certain concentration (0.05~0.30 mol/l) of ferric chloride solution, ferric hydroxide suspension was produced. With the ratio of 1 g OAS to 10 ml ferric hydroxide, suspensions were mixed uniformly and placed in an oven at 60°C for 12 h. The filtered solid was dried at 110°C and stored for dry until use and labeled as activated sludge modified by ferric hydroxide (FHMAS).

Removal Procedures

The removal of N-NH_3 and H_2S was performed simultaneously. The removal methods were in turns aeration-coagulation and flocculation-adsorption via OAS/FHAMS-adsorption via ferric hydroxide ($Fe(OH)_3$) solution. Amount of N-NH_3 and H_2S were also determined after every removal process.

Aeration

The first step of tannery effluent treatment was initiated by the aeration process using different bacteria doses and different aeration times. From the whole aeration process 24 hours aeration time with 100mg/L activated sludge dose was selected for further proceedings..

Coagulation and flocculation

The coagulant used for this process was ferrous sulphate ($FeSO_4$). 500ml effluent was taken in several glass jars and the coagulant was added. Then the coagulation process was continued for 10 minutes in slow mixing and 20 minute in rapid mixing. After the mixing the sample was left still for about 15 minutes for the flocculation and settlement process.

Adsorption via OAS/FHAMS (Shaking with OAS/FHAMS)

Adsorption via OAS and FHAMS were done separately. OAS is modified by mixing ferric hydroxide and FHAMS was created. The separate adsorption process was done to assess the effectiveness of the modification. The effluent was the remainder from the aeration process. After aeration,100mL of effluent was taken by this way in a glass jar. 0.3 g FHMAS or OAS was suspended in 100 ml wastewater containing N-NH_3 and H_2S. The mixture was agitated on a gyratory shaker at 250 rpm by 20 min. At the end of the experiment the suspension liquid was decanted and the supernatant was analysed.

Adsorption via Ferric Hydroxide ($Fe(OH)_3$) Solution (Filtering through ($Fe(OH)_3$) solution)

After the adsorption via OAS and FHAMS, as the final stage of this removal process adsorption via ferric hydroxide (FeOH) solution was done. 1L of distilled water was taken in two glass jar. 1 mole of ferric chloride ($FeCl_3$) was added in one jar and 3 moles of sodium hydroxide (NaOH) was added in other. Then these two solutions were mixed in another jar to make the suspension of ferric hydroxide ($Fe(OH)_3$). Then this suspension was placed on a filter to remove all the water. After removing the majority portion of the water, the remaining effluent from the previous process was passed through the suspension. The treated effluent after this process had very little colour and odour in it. Again the amount of N-NH_3 and H_2S in the effluent were measured at the end of this final process.

ANALYSIS AND MEASUREMENT

Both N-NH_3 and H_2S was measured by Portable Data-logging Spectrophotometer HACH DR/2010. Polyvinyl Alcohol Dispersing Agent, Mineral Stabilizer and Nessler Reagent were used for N-NH_3 measurement. Sulfide 1 Reagent (Cat. 181632) and Sulfide 2 Reagent (Cat. 181732) were used for H_2S measurement. PH was measured by pH meter.

REMOVAL MECHANISM

The removal of both H_2S and NH_3-N are highly pH dependent. In aqueous solution H_2S dissociates into its ions HS^- (bisulfide) and S^{2-} (sulfide) as pH increases. This is the reason we see almost 100% S^{2-} removal at all pH level. In case of NH3-N removal, at pH 7 of the waste water, ammonia nitrogen exists mainly in the form of NH_4^+, while more than 90% is free ammonia when the pH is over 11. This why removal of NH_3-N increases as pH increases.

$$NH_4^+ + OH^- \leftrightharpoons NH_3 + H_2O$$

In the aeration process sulfide oxidizing bacteria such as Beggiatoa and Thiobacillus play an important part in sulfur removal. Beggiatoa obtains the energy necessary for their growth by oxidizing the sulfide ion to colloidal sulfur. The removal of NH_3-N occurs by the nitrification process which requires the mediation of two distinct groups: bacteria that convert ammonia to nitrites (Nitrosomonas) and bacteria that convert nitrites to nitrates (Nitrobacter).As majority of the S_2- is removed by aeration, adsorption is mainly prevalent in NH_3-N removal.After the experimental process, the analyzed Fe^{3+} concentration in solution showed that the content of Fe^{3+} increased with the removal efficiency of NH_3-N , but Fe^{3+} concentration was almost zero by Ferric Hydroxide suspension. Analysis of the data showed that the number of removed NH_3-N was more than that of Fe^{3+} in solution, which meant that cation exchange and adsorption are taking place at the same time.

RESULTS AND DISCUSSIONS

To assess the effectiveness of each abovementioned steps in removing N-NH_3 and H_2S, each steps were performed individually and as a part of the combined process. Coagulation and flocculation was only done individually. In the case of other steps, removal efficiency was consistent in both individual and combined process.

Aeration: The dual effect of bacteria dose and aeration time was analysed on the same sample. The different doses used for this observation were 50ml/L,100ml/L,150ml/L and 200ml/L and the observation times were 0 hour,2 hour, 4 hour, 6 hour and 24 hour.

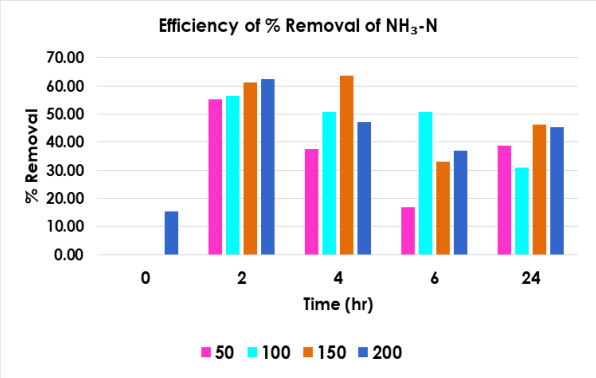

Fig. 1(a)

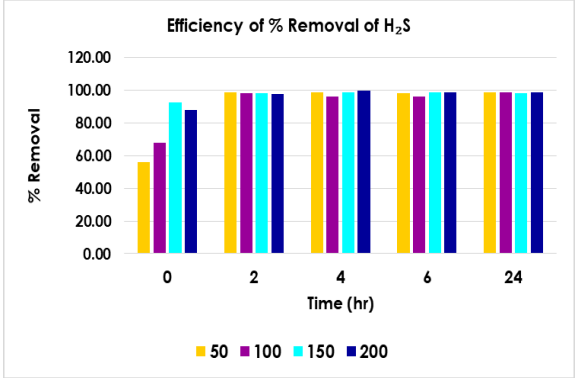

Fig. 1(b)

Fig. 1(a) Effect of bacteria dose and aeration time on the efficiency of % N-NH_3 removal
1(b) Effect of bacteria dose and aeration time on the efficiency of % H_2S removal

Coagulation:

Five samples having $FeSO_4$ doses of 0.5, 1, 1.5, 2, 2.5 g/L were taken for turbidity measurement. After plotting the corresponding turbidity vs dose of $FeSO_4$, the optimum dose was found 2g/L.

According to the optimum dose 2g/L, test doses were selected as 2g/L,1.5g/L and 2.5g/L. For these three doses the removal rate of NH3-N, H2S and NO3 were observed.

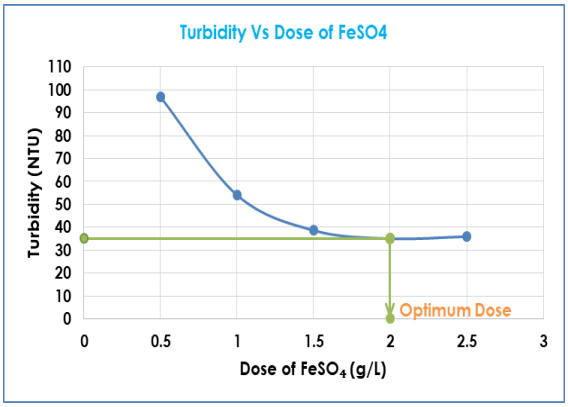

Fig. 2 Determination of optimum dose for

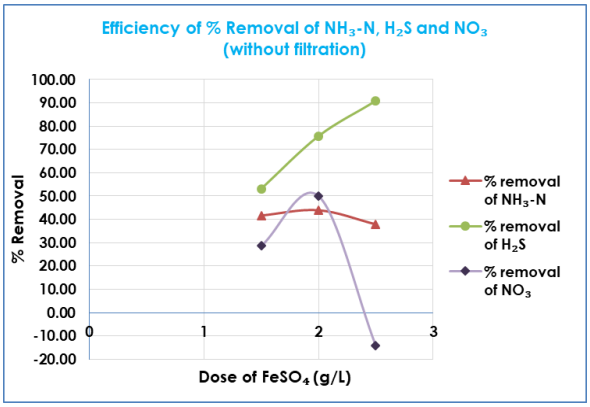

Fig. 3 Effect of selected coagulation doses on

Coagulation with FeSO4	NH3-N, NO3 and H2S removal. Contact time was 10 min for rapid mixing and 20 min for slow mixing.

Adsorption of NH_3-N and H_2S on OAS and FHMAS:

0.3g OAS and 0.3g FHMAS were mixed in 2 different 100ml samples. The result was almost same for both of the cases. No filtration was performed in this case. So for this particular tannery waste water sample the efficiency of NH_3-N and H_2S removal using OAS and FHMAS is almost same.

Then the two samples were passed through a filter paper and it was noticed that the removal rete was increased for NH_3-N. But the removal rates were same for OAS and FHMAS even after using filtration.

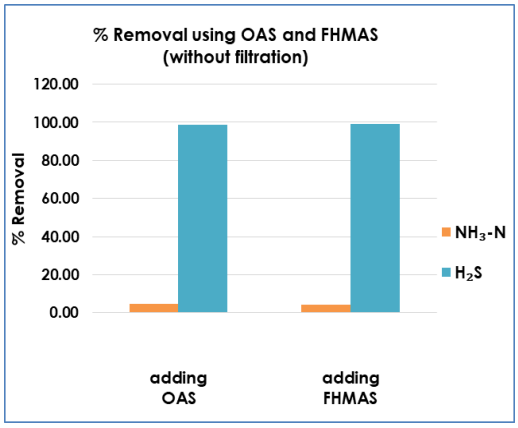

Fig. 3(a)

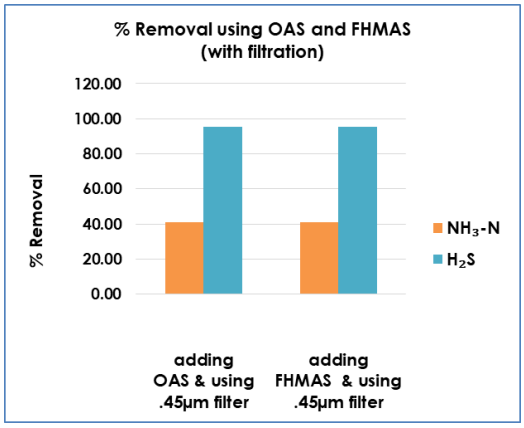

Fig. 3(b)

Fig. 3(a) Effect of OAS and FHMAS on NH_3-N and H_2S removal. Initial concentrations were 110 mg/L and 21.15 mg/L respectively, pH 8 and adsorbent dose 3 g/L. No filtration was used.

Fig. 3(b) Effect of OAS and FHMAS on NH_3-N and H_2S removal. Initial concentrations were 110 mg/L and 57.3 mg/L respectively, pH 8 and adsorbent dose 3 g/L. 0.45 µm sieve was used.

Effect of combination of methods using the same sample:

After the individual removal via each process, all these process were done in sequence to mimic the real life treatment process. Aeration, adsorption via OAS/FHAMS and adsorption via Ferric Hydroxide was done subsequently.

Table. 1 pH and concentrations of NH_3-N and H_2S after consecutive application of aeration, shaking with OAS and filtration through $Fe(OH)_3$

	Raw	Aerated	Aeration + Shaker	Aeration + Shaker + Filter
NH_3-N (mg/L)	352.5	150	107.5	30
H_2S (mg/L)	252.5	0.15	0.75	0.04
pH	8.5	9.3	8.9	14.3

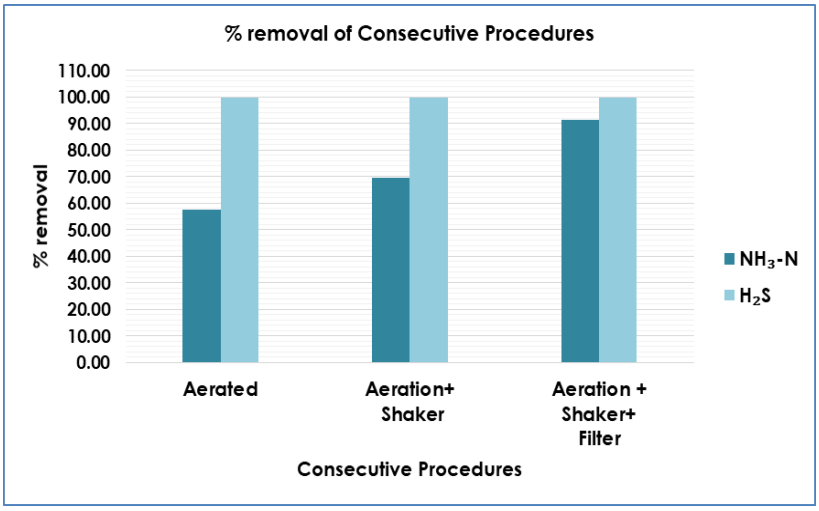

Fig. 4 Effect of consecutive application of aeration, shaking with OAS and filtration through $Fe(OH)_3$ suspensions on the removal of the same samples of NH_3-N and H_2S.
From the graph below it can be seen that performance of each step in this combined process mirrored their performance in their individual removal process. Total removal of N-NH_3 was 91.489% of its initial concentration and 99.984% H2S was removed by this combined process.

Effect of individual steps in combined method:
N-NH3 removal was 91.48% in total, where as total H_2S removal was 99.98%. If the total removal is taken as 100% for both, in case of N-NH_3 removal majority (63%) was done alone in aeration process, where as 99.94% of total H_2S removal was removed via aeration, making aeration process the most effective one. Filtering through Ferric Hydroxide is the 2nd most effective process, removing 24% of remaining N-NH_3. Shaking with OAS/FHAMS removed 13% of N-NH_3 but it increased the amount of H_2S present.

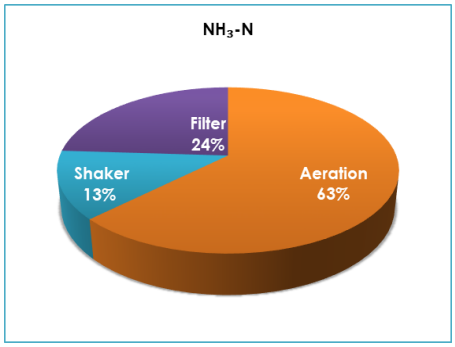

Fig. 5(a)

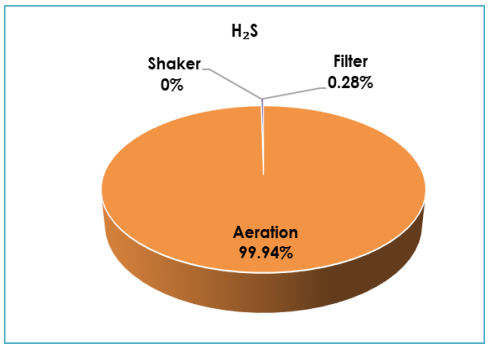

Fig. 5(b)

Fig. 5(a) Effect of individual steps (aeration, shaking with OAS and filtration through $Fe(OH)_3$ in their combined application on NH_3-N removal
Fig. 5(b) Effect of individual steps (aeration, shaking with OAS and filtration through $Fe(OH)_3$ in their combined application on H_2S removal

Effect of pH on the removal rate of NH_3-N and H_2S in combined method:
This combined method is done under various pH level. Data shows the best result in removal of N-NH_3, was in pH 8 around 92% removal while almost all the H_2S was removed under every pH level. The graph of N-NH_3 removal shows that around 90 percent removal is done in pH 6, then is suddenly drops at pH 7. Then again it starts to rise reaching its peak at pH level 8 after which the removal efficiency starts to fall again. But in the case of H_2S removal, the curves stays near the top at almost all pH level, showing there is apparently no effect of pH in the removal of H2S. Such is the case due to fact that, almost all the H_2S present in the effluent was successfully removed in the aeration process leaving almost nothing for the adsorption via OAS/FHAMS.

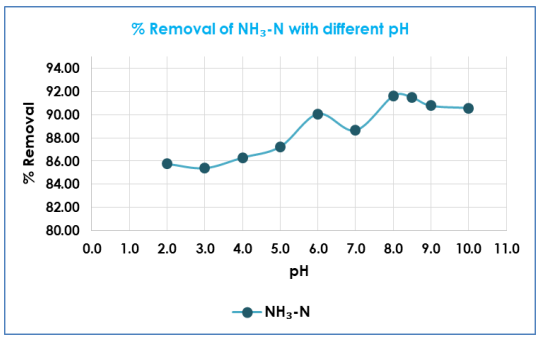

Fig. 6(a)

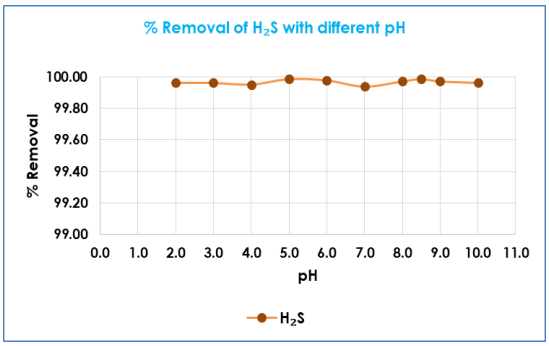

Fig. 6(b)

Fig. 6(a) Effect of pH on NH_3-N removal through the of consecutive application of aeration, shaking with OAS and filtration through $Fe(OH)_3$. Initial concentration of NH_3-N was 352.5 mg/L.
Fig. 6(b) Effect of pH on H_2S removal through the of consecutive application of aeration, shaking with OAS and filtration through $Fe(OH)_3$. Initial concentration of H_2S was 252.5 mg/L.

Effect of contact time on the removal rate of NH_3-N and H_2S in combined method:
As a part of combined process, effect of contact time with OAS/FHAMS in gyratory shaker was measured. Optimum removal was reached just at 5 minutes (shown in the table) but for the full removal we had to wait 2 hours.

Table: 2 concentrations of NH3-N and H2S after different contact times with OAS

Time (min)	Raw	0	5	10	15	20	30	50	80	100	120
NH_3-N (mg/L)	170	15	12.5	15	15	30	20	80	2.5	32.5	0
H_2S (mg/L)	4	0.05	0.09	0.03	0.05	0.07	0.19	0.15	0.38	0.1	0.01

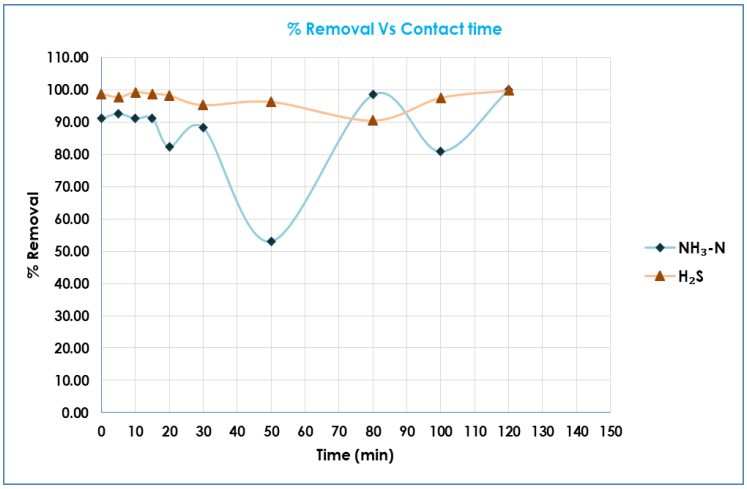

Fig. 7 Effect of contact times on NH_3-N and H_2S removal

CONCLUSIONS

The presented research was carried out to use tannery sewage for treating the tannery effluent. A huge amount of tannery sewage is generated everyday which will be put on a good use treating tannery effluent. Some modification is done and some extra steps were added effectively remove majority of N-NH_3 and H_2S. The research shows that majority of (99.94%) of H_2S is removed by aeration process alone. N-NH_3 removal was tricky and the whole combined process removed around 91.5% of initial amount bringing it lower than the permissible limit of 50 mg/L. Final pH value after the process was 14.3. Further studies are being conducted to reduce the final pH value and to evaluate the effectiveness of this combined process in removing other harmful substances from tannery effluent.

ACKNOWLEDGMENTS

The authors gratefully thank our thesis supervisor Dr. Md. Delwar Hossain for providing us with his kind supervision and wise direction while conducting this research. We would also love to thank the Department of Civil Engineering, BUET for providing us with all the supports to conduct this research.

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EXPLORING THE RELATIONSHIP BETWEEN URBAN VEGETATION LOSS AND LAND SURFACE TEMPERATURE RISE USING GIS AND RS

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ABSTRACT
Urban vegetation plays a significant role in moderating Land Surface Temperature (LST) across urban area. Huge demand on residential and commercial space in urban area results in loss of urban vegetation. The aim of this study is to identify the amount of urban vegetation loss and LST rise in Khulna City Corporation (KCC) area during 20 years (1998-2018). Thermal band of Landsat satellite image has been used as LST data for 20 years, Geographic Information System (GIS) with Remote Sensing (RS) techniques have been used to find the loss of vegetation area, and LST calculation. The result shows that in February 1998, total vegetation area was 22.3011 square kilometres and that was 43.06% of total land cover, that times the highest LST was 27.93 degree Celsius, but in February 2018 total vegetation area reduced to 16.9407 square kilometres, and only cover 32.71% of KCC area therefore highest Land Surface Temperature rise to 29.80 degree Celsius .The result shows near 2 degree Celsius temperature rise in 20 years in KCC area. Therefore proper planning needs to conserve urban vegetation area; otherwise this effect will result in increasing UHI area.

Keywords: Khulna City Corporation (KCC); Remote Sensing (RS); Land Surface Temperature (LST)

INTRODUCTION
The growth of urban areas has a significant impact on land use by replacing areas of vegetation with residential and commercial areas and their related infrastructure; this escalates the land surface temperature (Ibrahim, 2017). An increase in urban growth with a related decrease in vegetation, which resulted in an alteration of urban microclimates (Buyadi et al., 2013).Urban climate has gained a significant focus due to global mean surface temperature increase since the late 19th century and the climate within the urban areas have changed due to Land Use/Land Cover change (Islam & Islam, 2013) therefore in recent years common phenomenon in urban or metropolitan area is rise of temperature higher than the surrounding rural areas. The amount of humidity in the air is greatly affected by the change of natural land surfaces to built-up areas as vegetation is a major source of humidity (Abdullah, 2012). Ibrahim as cited in (Quattrochi & Luvall, 1999; Weng et al., 2004) argues that higher thermal capability for releasing daytime heat at night and greater solar radiation absorption are usually caused in urban areas by replacing vegetative areas with paved surfaces such as buildings, parking lots, roads, etc., thus causing 'urban heat islands' which is the contrast of temperature between the warmer urban areas and the colder surrounding rural areas often resulting from this process. In developing countries, urbanization and industrialization often take place rapidly without any sustainable planning and guiding policies (Ferdous and Rahman, 2018).Khulna City Corporation (KCC) area, Bangladesh is not on exception. In this regard Geographic Information System (GIS) with Remote Sensing (RS) data has been used to detect Land Surface Temperature (LST) change in accordance with vegetation cover loss across KCC area.

METHODOLOGY

The primary objective of this research is to associating Land Surface Temperature (LST) rise in accordance with vegetation cover loss. To access the objective of the study some set of procedure have been followed. Khulna City Corporation (KCC) area 50.61 sq. km (BBS, 2011) has been selected as study area that is located 22°50´30´´north latitude and 89°30´00´´east longitude. KCC is an urban area of a developing country where rapid urbanization and industrialization often take place with lack of sustainable planning and policies therefore excessive loss of vegetation area results in change of LST over the decade. Supervised image classification method has been used to classify the total KCC area into four classes as water body, vegetation, built-up area, and bare soil: from that classification vegetation cover is extracted to identify the loss of vegetation area for the year of 1998, 2008, 2018 with Remote Sensing (RS) data and Geographic Information System (GIS). LST is known as radiative skin temperature of land surface, therefore thermal band of Landsat satellite image for the year of 1998, 2008 and 2018 has been used to calculate the LST by the calibration of spectral radiance and emissivity correction. In this regard thermal band 6 of Landsat 4-5 (TM) for the year of 1998, 2008 and thermal bands 10 and 11 of Landsat (8 OLI) for the year of 2018 has been used as data. To avoid the seasonal variation of temperature one specific month of the year is selected as RS data.

Table 1: Details of Landsat satellite images.

Respective Year	Path and Row	Date Acquired	Sensor
1998	Path 138, Row 044	14 February 1998	Landsat 4–5 Thematic Mapper (TM)
2008	Path 138, Row 044	17 February 2008	Landsat 4–5 Thematic Mapper (TM)
2018	Path 138, Row 044	21 February 2018	Landsat 8 Operational Land Imager (OLI)

Source: US Geological Survey, 2018.

To calculate LST firstly the Digital Number (DN) value of thermal bands of satellite images has been converted to radiance (Lλ) value by following equations.

For Landsat 4-5, Radiance (Lλ) = (QCAL/255) *((LMAX-LMIN) + LMIN (1)
For Landsat 8, Radiance (Lλ) = ML* QCAL+AL (2)

Where, QCAL=Digital Number (DN) of the thermal band. QCALMIN=Minimum DN value, QCALMAX=Maximum DN value, LMAX=Maximum spectral radiances, LMIN=Minimum spectral radiances, ML= Band-specific multiplicative rescaling factor from the metadata, AL=Band-specific additive rescaling factor from the metadata.

The next step of calculating LST is to converted radiance value into Satellite Brightness Temperature. Satellite Brightness temperature can be derived from spectral radiance by the following formula.

$$T_B = \frac{K_2}{\ln(\frac{K_1}{L_\lambda}+1)} - 273.15 \quad (3)$$

Where, TB= Satellite Brightness Temperature Lλ = Spectral Radiance
K1 and K2 = Calibrated constant depending on the sensor of TM and ETM

Table 2: Data of LST Calculation.

Year	LMAX	LMIN	QCALMAX	QCALMIN	K1	K2
1998 & 2008	15.303	1.238	255	1	607.76	1260.56
2018	22.00180	0.10033	65535	1	774.8853 & 480.8883	1321.0789 & 1201.1442

Source: US Geological Survey, 2018.

Finally LST can be derived using several emissivity correction formulas. The following formula can be used to emissivity correction (Weng, 2001).

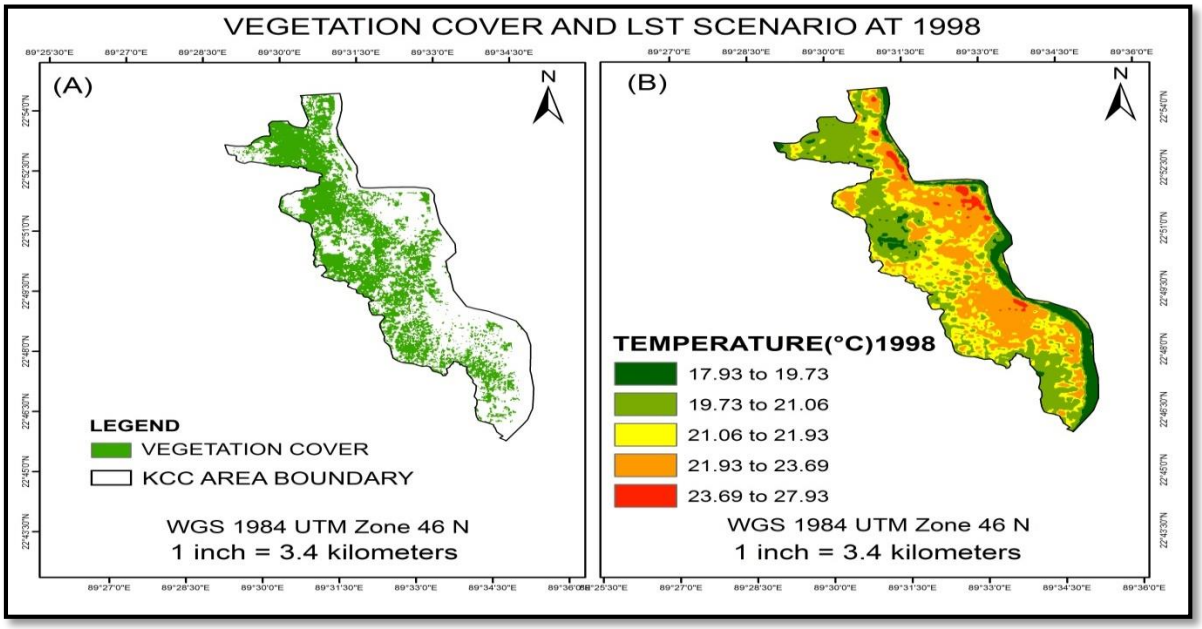
$$LST = \frac{T_B}{1+\left(\frac{T_B*\lambda}{\rho}\right)*\ln \varepsilon} \quad (4)$$

Where, λ= Wavelength of emitted radiance P= Constant 1.438× 10-2 mK and ε = Emissivity

RESULTS AND DISCUSSIONS

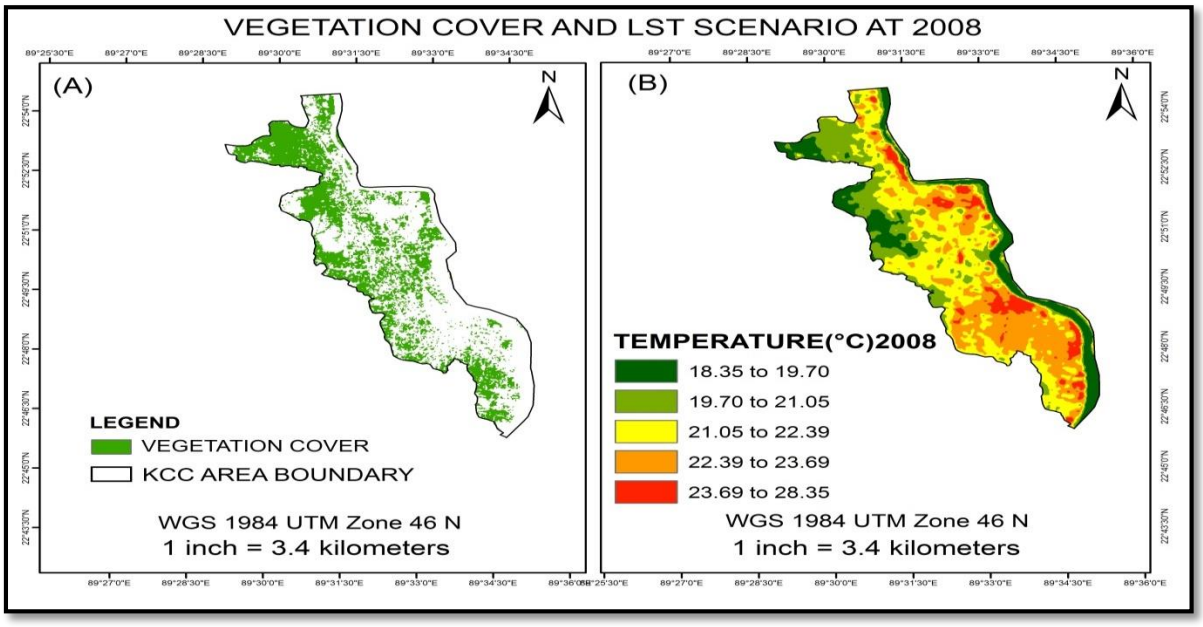
Vegetation Cover and LST Scenario at Different Period

Vegetation is the major source of humidity of KCC area because it covers highest portion of the land across KCC area other than any land cover types in 1998; therefore in KCC area vegetation is the key component of environment to keep the nature cool.



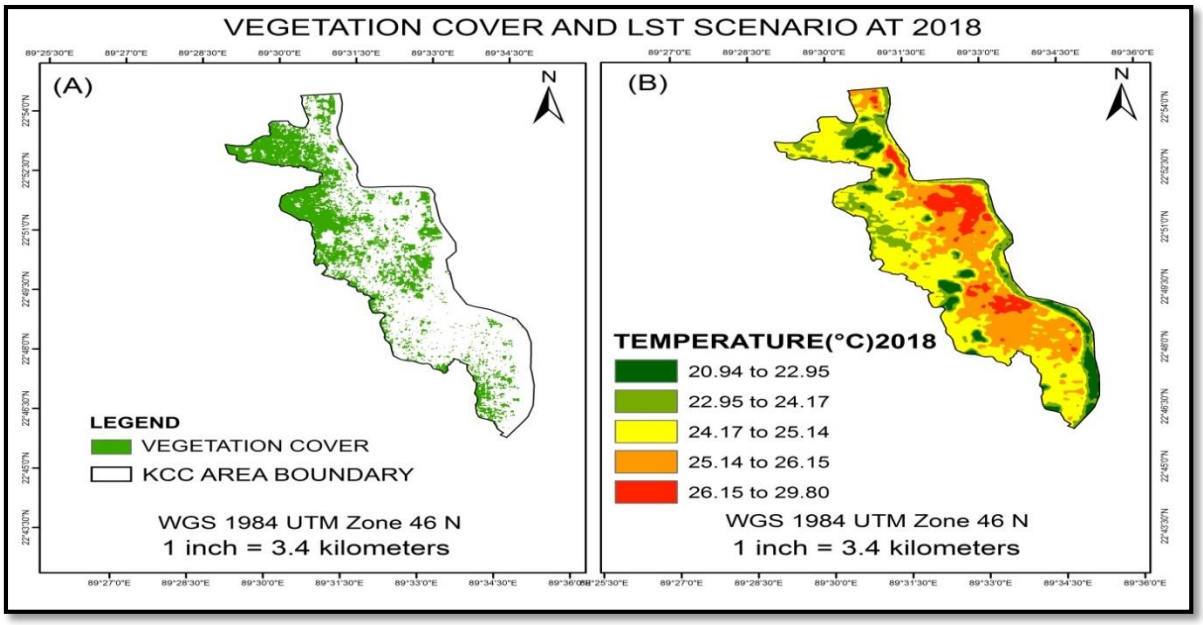
[Fig. 1]: Vegetation cover (A) and LST (B) scenario at 1998

According to supervised classification of land cover of KCC area vegetation covers 43.06%, 37.75% and 32.71% of land cover in the year of 1998, 2008 and 2018. Fig. 1 and Fig. 2 represent the vegetation cover and LST scenario at 1998 and 2008. The analysis results show that the total vegetation cover at 1998 and 2008 was 22.3011 square kilometres and 19.5516 square kilometres. As vegetation covers decrease from 43.06% to 37.75% therefore highest LST varies from 27.93 Degree Celsius to 28.35 Degree Celsius in the year of 1998 to 2008. The results also show that lowest LST varies from 17.93 Degree Celsius to 18.35 Degree Celsius.



[Fig. 2]: Vegetation cover (A) and LST (B) scenario at 2008

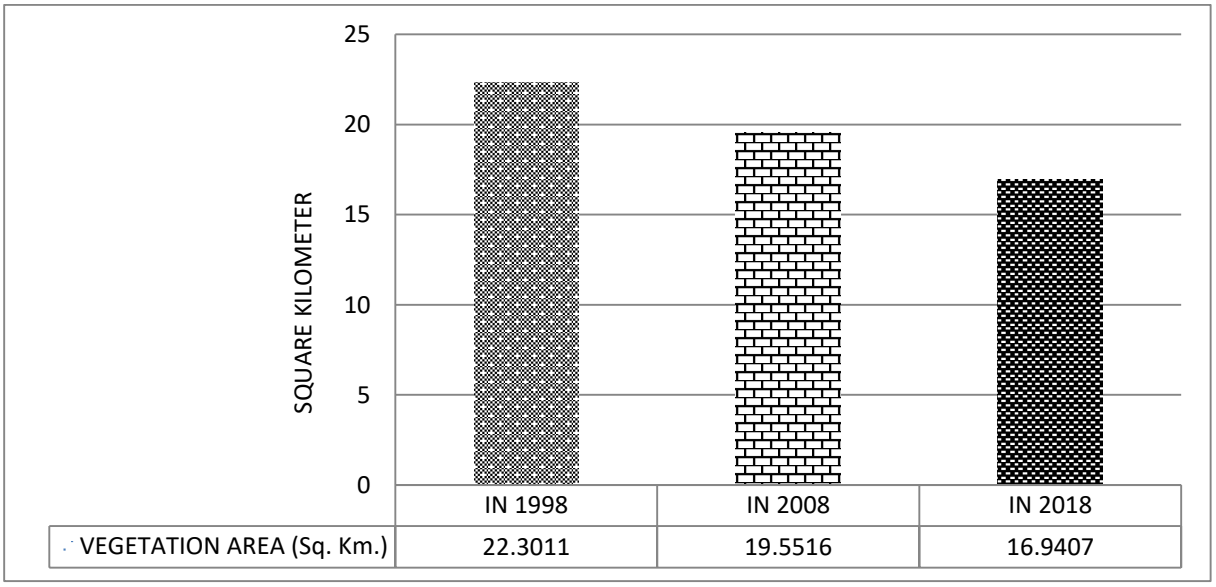
The loss of vegetation cover and rise of LST at 1 Degree Celsius temperature in ten year interval indicates not only LST rise but also significant environmental imbalance across KCC area. Following Fig. 3 represents vegetation cover and LST scenario in 2018.



[Fig. 3]: Vegetation cover (A) and LST (B) scenario at 2018

According to Fig. 3 the total vegetation cover in 2018 is 16.9407 square kilometers and that covers only 32.71% of KCC area. In this regard 2.6109 square kilometers vegetation covers loss from 2008 to 2018 therefore LST also varies. The results show that variation of highest LST from 2008 to 2018 is 1.45 Degree Celsius as highest LST in 2018 is 29.80 Degree Celsius. As significant vegetation cover loss from 1998 to 2018 at a higher rate therefore that the lowest LST in 2018 that is 20.94 Degree Celsius is much higher than the lowest LST from 1998 and 2008.

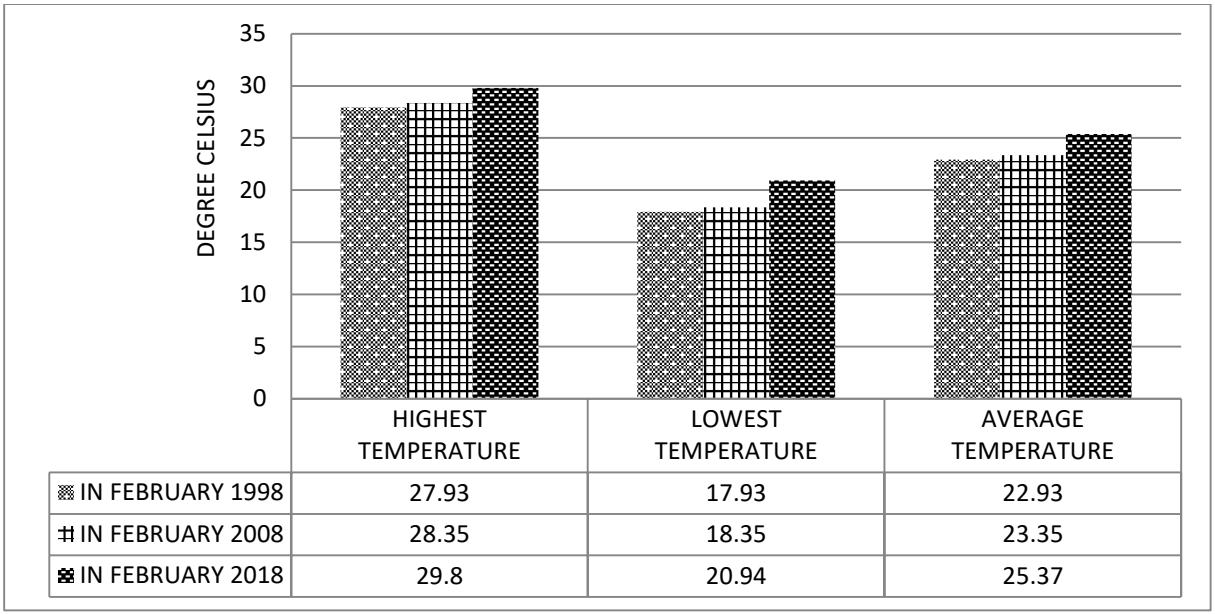
As Khulna city is known as industrialized city with rapid urbanization therefore mass vegetation area has been removed to get the urban space. Following Fig. 4 represent the vegetation cover for the year of 1998, 2008, 2018 in KCC area with high rate of loss of vegetation area from 22.3011 square kilometers to 16.9407 square kilometers.



[Fig. 4]: Vegetation covers at 1998, 2008, 2018 in KCC area

Scenario of Twenty Years Variation of LST

Rise in urbanization with mass industrialization is one of the major reasons of climate changes and one of the major reasons for climate change is LST rise in urban area across the world. Following Fig. 5 represents the scenario of LST across KCC area, Bangladesh in accordance with the February month of the year. The result shows both highest lowest and average temperature rise from 1998 to 2018 therefore near 2 Degree Celsius temperature rise in twenty years. Highest lowest and average temperature rise in twenty years indicates the Khulna city is going face the effect of climate change.



[Fig. 5]: LST scenario at 1998, 2008, 2018 in KCC area

Statistical relationship among amount of vegetation cover and LST

Following Table 2. represent the relationship among twenty years land surface temperature change with the vegetation cover across KCC area. In 1998 the much amount of vegetation cover significantly affect to keep LST cool and that period the temperature ranges from 17.93 to 27.93 Degree Celsius but in the year of 2018 much amount of vegetation cover loss affect in rising land surface temperature at the range of 20.94 to 29.8 Degree Celsius.

Table 3: Vegetation cover with LST range.

1998		2008		2018	
Vegetation cover	Highest to lowest temperature range	Vegetation cover	Highest to lowest temperature range	Vegetation cover	Highest and lowest temperature range
22.3011 Square kilometers	17.93 to 27.93 Degree Celsius	19.5516 Square kilometers	18.35 to 28.35 Degree Celsius	16.9407 Square kilometers	20.94 to 29.8 Degree Celsius

CONCLUSIONS

In present time the most common problem in urban areas is increasing surface temperature as vegetation cover is replace by concrete non-evaporating, non-transpiring surface. Land surface temperature needs to be minimized to control the physical biological and chemical processes of the earth systems. High rate of urban vegetation loss result in high LST across urban area. Vegetation it the key component of environment to keep the environment cool with moderate LST. In this regard vegetation cover needs to preserve for better living environment.

ACKNOWLEDGMENT

First and foremost, we would like to thanks United State Geological Survey (USGS) for free Landsat satellite data. Then we would like to express special thanks to Md. Rashidul Hasan (Assistant Professor Department of Urban and Regional Planning, CUET) for his great inspirations to us.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
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EFFECT OF TANNERY WATER ON PHYSICOCHEMICAL QUALITY OF RIVER WATER

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ABSTRACT
Effluents from leather processing, a major industry are one of the main source of continuous input of pollutants in river water which hampers the aquatic ecosystem. In this study we made an investigation on the effect of tannery effluents on Dhaleshwari river water near Savar, Dhaka. As the river water continuously polluted by tannery effluents so concentration of tannery effluents in river water is getting high day by day. So, the effluents were mixed with Dhaleshwari water at concentration of 5%, 25%, 50%, 75%, 90% and analyzed along with the river water and effluent. Then physicochemical properties like pH, Conductivity, Total Dissolved Solid(TDS), Total Alkalinity(TA), Total Hardness(TH), Dissolved Oxygen(DO), Biological Oxygen Demand(BOD), Chemical Oxygen Demand(COD), Sulfate, Chloride and Chromium are analyzed for all the samples and the results show that with the increasing effluent concentration water quality getting worse day by day. If this continues, will pose a serious threat to aquatic ecosystem, agriculture and human life.

Keywords: Tannery effluents; River water; Concentration; Physicochemical.

INTRODUCTION
Leather industry plays an important role in Bangladesh Economy due to its large potential for employment, growth and export (Tinni et al, 2014). At the same time, it poses serious environmental threats by discharging liquid effluents and solid wastes directly into surrounding low lying areas (Tinni et al, 2014). Savar is a major industrial area of Dhaka city and now a major part of Leather industry of our country relocated there. The CEPT in Savar has the capacity to treat, if properly functional, 2500 cubic meters of waste, but the tannery industries produce more than double that during this large religious festival (Lynne, 2018). Finally, not all the tanneries go through the CETP .That's why we selected Dhaleshwari River near Savar, Dhaka. Physicochemical and microbiological characteristics may describe the quality of water, therefore an analysis of physicochemical parameters of River water was made by many workers (Sinha, 1986; Trivedi et al, 2009; Sinha et al, 2000; Richa et al, 2011; Vinod et al, 2003; Yadav et al, 2011). Industrial effluents from leather tanneries discharged higher amount of metal especially chromium (Vinay et al, 2014). These effluents released on river or canal as well as dump into ground water and lead to contamination of chromium due to accumulation (Vinay et al, 2014). Tanneries caused environmental problem very much. Survey results showed that the most environmental effect was bad smell to the surrounding area, indicated by respondents of 45% and the secondly scarcity of fresh water was 32% among the respondents (Tinni et al, 2014). The waste water were fall in the nearby river and the slums people use these water which causes various diseases to them. Over 8,000 workers in the tanneries suffer from gastrointestinal, dermatological, and other diseases, and 90% of this population dies before the age of 50 (Human Rights Watch, 2012). Major

problems are due to waste water containing heavy metals, toxic chemicals, chlorides, lime with high dissolved and suspended salts and other pollutants (Uberai, 2003). Tanneries generate waste water in the range of 30-35 L/Kg skin/hide processed with variable pH and high concentration of suspended solids, BOD, COD, tannins including chromium (Nandy et al, 1999). The present work is focused to see the modulatory effect of tannery effluents on physicochemical parameters like pH, temperature, conductivity, TH, TA, TDS, DO, COD, BOD, SO4, Cr *etc.* of Dhaleshwari River water. The Water quality of Dhaleshwari River can be estimated after addition of % tannery effluents in laboratory condition to predict the future status of river water (Vinay et al, 2014). This is why we run this study. The observed values of various physicochemical parameters of water samples were compared with standard values recommended by world health organization (W.H.O, 1993).

METHODOLOGY

Water sample was collected from Dhaleshwari River 3km upstream from tannery village and treated and untreated tannery effluents was collected from Common Effluent Treatment Plant (CETPs) Savar, Dhaka. At 1st we collected the river water, tannery influent and effluent from CETP in the month of November and run the study. Then we also collected the river water in the month of June and run the test with influent and effluent collected from (CETPs) Savar, Dhaka. That's how we also get a seasonal variation of the river water. The percent of effluents viz. 5%, 25%, 50%, 75%, 90% v/v were made in the collected river water sample and these concentrations were used for physicochemical analysis. The samples were kept in room temperature. The pH of samples (river water, 5%, 25%, 50%, 75%, 90% effluent, 100% effluent) was determined using a digital pH meter. Conductivity of samples was determined using EC meter. Temperature and Dissolve Oxygen (DO) were determined by digital DO meter. TDS was determined by standard method. Total Hardness (TH), Total Alkalinity (TA) were determined by titration. 5 days incubation method was used to test BOD and Chemical Oxygen Demand (C.O.D.) was measured by open reflux method. Sulphate and Chloride were determined by direct Spectrophotometric method. Trace metal Cr was determined by digesting the sample with concentrated HNO_2 and H_2SO_4 made up to 50 ml volume and analysed by atomic absorption spectrometer.

RESULTS AND DISCUSSIONS

The observed values of the samples water quality parameters of the study are given in Table 1 & 2 for different samples. The effluents were collected in the month of November'2017 and influents were collected in the month of June'2018 respectively.

The Dhaleshwari river water quality is seriously affected by tannery waste. The observed values of the samples water quality parameters of the present study are given in table 1. The treated effluent was rich in TDS, deficit in DO, high BOD and COD. The pH value ranging from 7.4 to 8.5 is an essential factor in formation of algal blooms (Palharyal et al, 1993). Low or high pH value makes the water unfit for irrigation and soil becomes alkaline resulting in poor crop growth and yield (Vinay et al, 2014). pH values for Dhaleshwari water are 7.8 in winter and 7.4 in wet season, shows that Dhaleshwari water sample is alkaline in nature. We found that pH value does not exceed 8.5 for both tannery effluents and influents. The pH was found slightly alkaline for sample of tannery waste water. Other workers also reported alkaline tannery waste water (Deepali et al, 2009; Kadam et al, 1990).

The EC of Dhaleshwari water sample was found 0.65 mS/cm in winter and 0.35mS/cm in wet season. EC was found in increasing order for both tannery effluents and influents with increasing concentration of tannery wastewater. The EC were found from 1.16 mS/cm to 12.4 mS/cm for 5% to 100% tannery effluents modulated sample and 1.56 mS/cm to 13.33mS/cm for 5% to 100% tannery influents modulated sample. Increase in EC values indicates the presence of higher concentration of ions (Vinay et al, 2014).

Furthermore, TA of River water was found 113 mg/L in winter and 238 mg/L in wet season. TA was found 286 mg/L to 1732 mg/L for different effluents percentage concentration of water samples from 5% to 100%, while TA was found 178 to 2028 mg/L for 5% to 100% influent modulation for water sample. 260 mg/L is even beyond the highest desirable limit prescribed by WHO standard for drinking water.

Table 1. Effect of different concentration of tannery effluent on physicochemical properties of the Dhaleshwari River water.

Parameters	Units	River Water	5%	25%	50%	75%	90%	Influent
Temperature	◦C	23	23	23	23	23	23	23
pH		7.8	8	8.2	8.3	8.3	8.4	8.5
Conductivity	mS/cm	0.65	1.16	3.64	6.62	9.46	11.35	12.4
TDS	mg/L	400	690	2090	3850	5560	6740	7410
TA	mg/L	238	286	565	894	1246	1494	1732
TH	mg/L	204	216	320	370	430	490	510
DO	mg/L	3.99	1.22	0.05	0.04	0.04	0.03	0.03
COD	mg/L	12	23	235	587	779	1002	1228
BOD	mg/L	4.8	20.8	50.4	82.4	102.4	160	240
Sulphate	mg/L	60	130	450	925	1025	1400	1850
Chloride	mg/L	40	160	1100	1900	2900	3700	3800
Chromium	mg/L	0.014	0.267	1.837	3.779	6.132	7.569	8.197

Table 2. Effect of different concentration of tannery influents on physicochemical properties of the Dhaleshwari River water.

Parameters	Units	River Water	5%	25%	50%	75%	90%	Influent
Temperature	◦C	29.5	29.5	29.5	29.5	29.5	29.5	29.5
pH		7.4	7.8	8.2	8.4	8.4	8.4	8.5
Conductivity	mS/cm	0.35	1.56	3.88	7.55	10.02	12.25	13.33
TDS	mg/L	270	780	3037	4630	6810	8245	9280
TA	mg/L	113	178	602	963	1454	1613	2028
TH	mg/L	179	213	343	412	507	578	602
DO	mg/L	4.41	1.8	0.11	0.04	0.04	0.03	0.02
COD	mg/L	9	24	347	713	967	1403	2314
BOD	mg/L	2.8	43	132	203	390	476	730
Sulphate	mg/L	18	200	525	1050	1200	1550	1900
Chloride	mg/L	24	120	1300	2400	3400	4300	4500
Chromium	mg/L	0.01	3.013	28.267	57.014	113.569	133.029	147.257

TH value of Dhaleshwari river water was found 204 mg/L in winter and 179 in wet season. TH was found 216 mg/L to 510 mg/L for different concentration of water samples from 5% to 100%, while TH was found 213 to 602 mg/L for 5% to 100% influent modulation for water sample. 180 mg/L is the highest desirable limit prescribed by WHO standard for drinking water. The presence of calcium, magnesium and bicarbonates in excess makes water unfit for irrigation since its application increase problem of soil salinity and its permeability detrimental to crop plants (Srinivas, 1984) .

TDS values were found in increasing order for both tannery effluents and influents. The TDS were found from 690 mg/L to 7410 mg/L for 5% to 100% tannery effluents modulated sample and 780 mg/L to 9280 mg/L for 5% to 100% tannery influents modulated sample. In winter the river water's TDS was 400 mg/L and 270 mg/L in wet season.

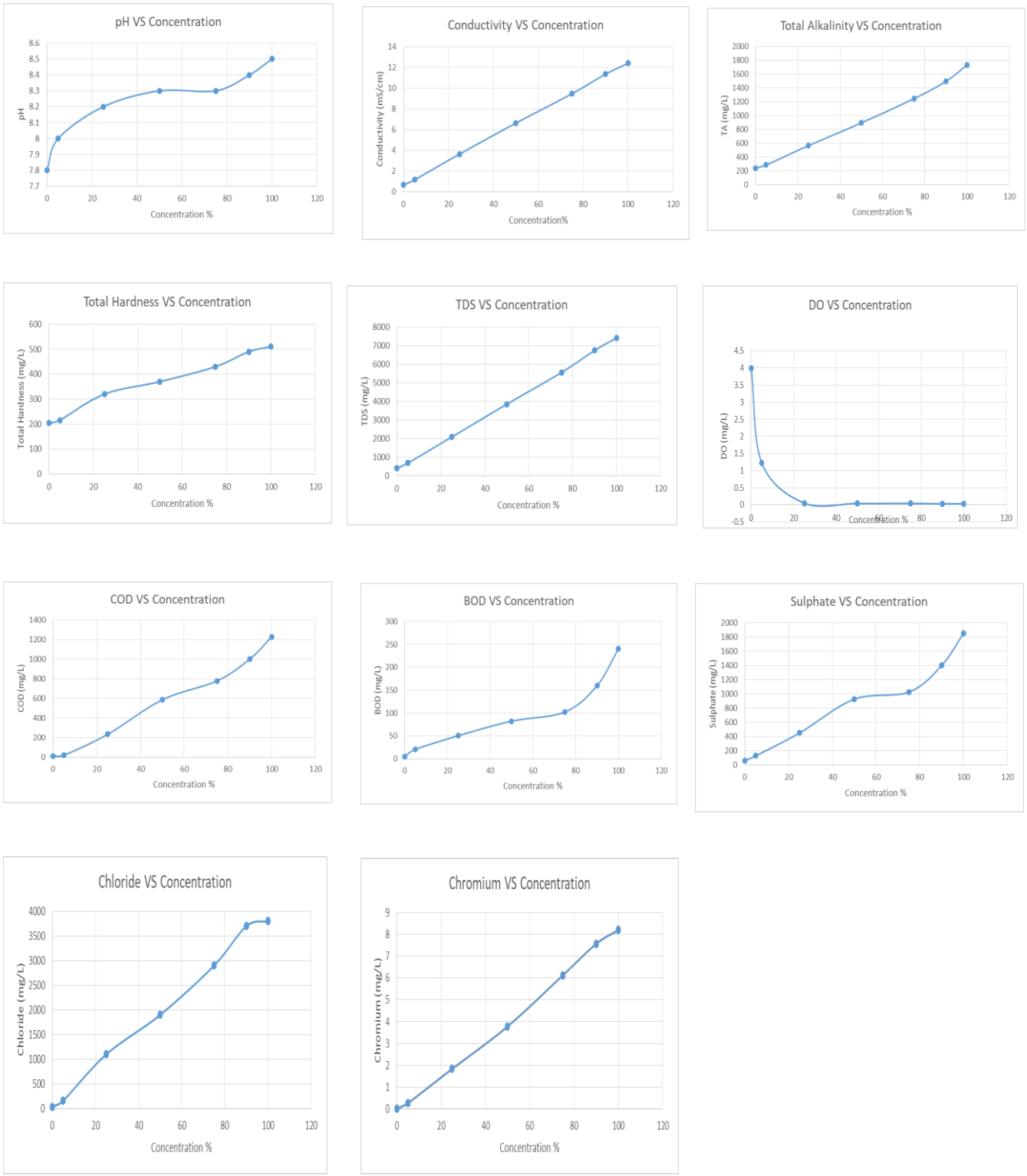

Figure 1. Effect of tannery effluents on physicochemical properties of the Dhaleshwari River water.

Dissolve Oxygen (DO), is an important factor for water (Vinay et al, 2014). Here we can see that for both the influents and effluents the value of DO is very low. For the river water we found DO value 3.99 mg/L in winter and 4.41 in wet season which are also very low. For different percentage of sample with

tannery waste water, COD value was found in increasing order for both tannery effluents and influents. The COD were found from 23 mg/L to 1228 mg/L for 5% to 100% tannery effluents modulated sample and 24 mg/L to 2314 mg/L for 5% to 100% tannery influents modulated sample. In winter the river water's COD was 12 mg/L and 9 mg/L in wet season. High COD and BOD value indicate the pollution strength of the waste water (Vinay et al, 2014). For different percentage of sample with tannery waste water, BOD was also found in increasing order for both tannery effluents and influents. The BOD values were found from 20.8 mg/L to 40 mg/L for 5% to 100% tannery effluents modulated sample and 43 mg/L to 730 mg/L for 5% to 100% tannery influents modulated sample. In winter the river water's BOD was 4.8 mg/L and 2.8 mg/L in wet season. Sulfate was found in increasing order for both tannery effluents and influents with increasing effluent percentage. We found Sulfate from 130 mg/L to 1850 mg/L for 5% to 100% tannery effluents modulated sample and 200 mg/L to 1900 mg/L for 5% to 100% tannery influents modulated sample. In winter the river water's Sulfate was 60 mg/L and 18 mg/L in wet season. The WHO limit for Sulfate in drinking water is 630 mg/L (WHO). Chloride amount in samples also increased with the increasing concentration of tannery waste water. The Chloride were found from 160 mg/L to 3800 mg/L for 5% to 100% tannery effluents modulated sample and 120 mg/L to 4500 mg/L for 5% to 100% tannery influents modulated sample. In winter the river water's Chloride was 40 mg/L and 24 mg/L in wet season. Chromium and its compounds are toxic, which are being mixed with natural water from a variety of industrial effluents (Siraj et al, 2012). Tannery is a major source of Chromium as waste in water. It leads to liver damage, pulmonary congestion and causes skin irritation as well as results in ulcer formation (Raji, 1998). In winter we found 0.014 mg/L Chromium and in wet season 0.01 mg/L Chromium in Dhaleshwari river water. The Chromium were found from 0.267 mg/L to 8.197 mg/L for 5% to 100% tannery effluents modulated sample and 3.013 mg/L to 147.257 mg/L for 5% to 100% tannery influents modulated sample which is higher than WHO permissible limit for Chromium in drinking water.

CONCLUSIONS

From the study we can see that the water quality of Dhaleshwari River is getting damaged at a great extent. After adding only 25% tannery effluent all the WHO limits were crossed. As mixing of tannery effluent is a continuous process, then that day is not so far when Dhaleshwari will turn into new Buriganga. The CETP isn't working at that limit as it need to be. Therefore, regular monitoring of Dhaleshwari river water quality is necessary so that appropriate preventive measures can be taken. Other than that serious environmental quality deterioration could take place in a few years which will be serious threat for human and aquatic life. We also get the idea that water quality is varies with temperature and seasons. The situation will be even more catastrophic if the effluents are directly discharged into the river without using the CETP. So all the tanneries in Savar should discharge their waste water at first into the CETP and for that necessary steps should be taken as soon as possible. Other than that the situation will be horrible.

ACKNOWLEDGEMENT

The authors would like to acknowledge Department of Civil Engineering for the lab facilities, the lab assistants of Environment lab, BUET for their help. Also like to acknowledge stuff of CETPs for their help.

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DESIGN AND OPERATION OF A BENCH SCALE WASTEWATER TREATMENT PLANT FOR SHRIMP PROCESSING INDUSTRIES

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ABSTRACT
The shrimp sector is the central important for Bangladesh particularly in the context of export earnings. The shrimp sector is supporting over 1 million people and 3.5 million dependents. In 2016-17 fiscal year, frozen shrimp and fish has been exported 150.27 million pounds and earns 4211.60 million crore BDT. About 80% of the shrimp processing industries are situated in southwestern region and the southeastern part of the country. Most of these industries do not have wastewater treatment plant (WWTP). Conventional WWTP is physico-chemical type and takes higher cost in operation. The principal objective of this research to find the best possible cost effective biological effluent treatment plant for shrimp processing industries. Firstly, study area and an industry has been selected to characterize of wastewater. Based on the characterization, bench scale plant has been designed and operated. Several parameters have tested to analyzed and control the operation of the plant. It is shown the bench scale plant has removed remarkable organic load from wastewater. The BOD_5 and COD reduction rate has been found 76% and 68% respectively. The all parameters have met the national standard. The designed criteria can be effectively used in shrimp processed wastewater treatment.

Keywords: Shrimp wastewater; Treatment; Activated Sludge Process

INTRODUCTION
It is the great concern in Bangladesh to discharging of liquid and other wastes without any treatment. Most of the shrimp industries in Bangladesh do not follow the environmental compliance for effluent treatment plant (ETP) in their factories and discharge effluent direct to the environment. Shrimp culture in Bangladesh made its initial beginning in the coastal district of Satkhira in 1960s. Gradually, shrimp culture expanded to the coastal belts of Khulna, Bagerhat, Cox's Bazar and Chittagong (Naureen et al., 2006*)*. In 1973, the export earnings were only US$ 3.17 million, which stands at US$ 420 million in 2004-05 and US$ 526.45 million in 2016-17 fiscal year (BFFEA, 2006). There are handsome numbers of seafood processing industries in Bangladesh. There are 162 fish processing plants in the country of which 96 plants are GOB licensed (Kabir, 2014). One ground survey has found the shrimp processing industries are installed on the road side, nearby agricultural lands and surrounded by rivers and others water body. Estimated effluents 47500L/day/plant generated are directly released in the environment (Billah, 2016). Shrimp process wastewater contains high amount of biodegradable organic loading. From literature it has been found, BOD_5 value varies from 560 mg/L to 1226.6 mg/L, COD ranges from 1666 mg/L to 3666 mg/L (Thomas et al., 2015). According to Billah (2016), COD is approximately 790 ppm, BOD_5-490 ppm, Dissolved Oxygen 0.15 – 1.82 ppm, SS-780 ppm, Total Dissolved Solids-1320-2350 ppm, Total Organic Carbon-220 ppm, Oil & Grease 65 ppm, Salt-11mg/L etc. Conventional design of Effluent Treatment Plant may be take exorbitant cost for design, installation and operation.

In Bangladesh, recently good practice has started in readymade garment (RMG), knitting and washing industries. The same design of WWTP used in RMG may be not appropriate for shrimp processing industries. Therefore, an appropriate WWTP design need for these circumstances which will be cost effective. Therefore, to determine the initial characteristics of a sea food processing (shrimp processing) industrial wastewater, to perform different bench scale treatment for wastewater of a sea food processing industry and to design the best possible biological wastewater treatment plant for a sea food processing industry are the main goal of the study.

METHODOLOGY

Firstly, a shrimp processing industry has been selected by help of DoE Khulna. Then samples were collected from the selected industry according to standard sampling method. Samples were preserved into the refrigerator of laboratory where it was needed. The samples were tested in environmental engineering laboratory for characterizing and analyzing. Selected parameters were Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Dissolved Solids, Total Suspended Solids, pH etc were measured to characterization and analysis of performance of designed bench scale plant. Based on the characterization, the treatment method and unit processes were selected and volume of reactors were calculated. Regular monitoring were maintained and parameters were measured in laboratory. The research methodologies are given in figure 1.

Figure 1: Flow Diagram for Research Methodology

Figure 2: The bench scale project

Sampling points were selected for design and operation of the bench scale plant as following:

- Receiving shrimps and initial washing
- Initial icing (or IQF)
- Deheading and
- Dewatering or soaking or production room
- Common drain (for regular feed in the bench scale plant)

Sample collection and preservation has attained according to standard method. Samples were randomly collected in plastic bottles of 500 mL, 1000 mL and 5 L to cover most of the investigated area during study period. The bottles were completely filled with effluents in a way so that no air remains above the surface. Each bottle was cleaned thoroughly by rinsing with tap water followed by washing with distilled water to remove undesirable solids and suspended materials before chemical analysis.

The chemical analyses of effluents were performed as quickly as possible. The result of typical raw wastewater and design basis is given in the following tables.

Table 1: Results of raw wastewater test

Parameters/points	Receiving shrimps and initial washing Mg/L	Initial icing (or IQF) Mg/L	Deheading Mg/L	Dewatering or soaking or production room Mg/L	Common Drain Mg/L
Dissolved Oxygen (DO)	1.39	1.26	1.83	1.46	1.5
Biochemical Oxygen Demand ($\mathbf{BOD_5}$)	270	234	489	362	330
Chemical Oxygen Demand (COD)	756	655	1370	1013	256
Total Solids (TS)	2430	3380	2430	4000	2780
Total Suspended Solids (TSS)	640	80	50	480	140
Total Dissolved Solids (TDS)	2380	3380	2380	2900	2640
pH	7.5	7.51	7.61	7.66	8

Table 2: Range of values that considered to design of the bench scale plant

pH	DO (Mg/L)	$\mathbf{BOD_5}$ (Mg/L)	COD (Mg/L)	TS (Mg/L)	TDS (Mg/L)	TSS (Mg/L)
7 – 9.5	1 – 2	250 – 450	450 – 650	2500 – 4500	1500 – 3500	≤ 600

Based on the above value the bench scale plant has been designed. The flow were kept 20 ml/min. Suspended solids and BOD_5 removal capacity were assumed 50% and 30% respectively after primary clarification. The circular type clarifier were used that made of High Density Polyethylene (HDPE) plastic and 1.2 L volume. The Retention time was 1hr and 10 cm in diameter with 15 cm liquid depth. On the other hand, a rectangular type aeration basin were used which volume was near 8L and HRT was 6.25hrs. Length and width was 32 cm & 18 cm made of same plastic. There were 3L air was supplied by diffuse aeration system as continues and completely mix system.

The collected data and results from the study were tabulated and compiled as well as presented in appropriate form. The MS Excel office program was used to data representation and tabulation of the study.

RESULT AND DISCUSSIONS

There were twelve different parameters were tested to cover this study. Not all parameters were checked equal numbers of sample. Few parameters likes color, chloride, nitrogen nitrate etc were tested only four or five samples. But maximum parameters such as BOD_5, COD, Solids etc were tested significant numbers of sample. Consistently the parameters found from this study has discussed below as well as performance basis deliberation in following texts.

Biochemical Oxygen Demand

The higher value of wastewater was found 354 mg/L and the lower one was 75 mg/L. The average value of BOD_5 noted 177 mg/L noted for raw wastewater. The BOD_5 value has shown 500-1550 mg/L by Steven (1996) and BOD_5 was found 560-1226.6 mg/L in Kerala by Sherly (2015). The primary clarifier has reduced BOD_5 5.64%. In aeration basin bacteria degrade biodegradable matter as convert

waste to energy and body cell. But microorganism still in aeration basin as living or dead cell. Then clarifier settles these all organic waste as well as inorganic waste and then leave out the waste part as sludge. The designed bench scale plant has also performed well. The average value was noted 41.3 mg/L for effluent. This meet the maximum permissible value (50mg/L) of ECR 1997, Bangladesh. The average reduction rate was measure 77%.

Chemical Oxygen Demand

Previous some research in home and abroad has found typical COD value in shrimp processing wastewater is 1300-3250 mg/L (Steven, 1981). Michael (1980), has shown 790 mg/L COD value in shrimp processing wastewater. Saha (2001), has reported in a paper 232 mg/L COD value of shrimp processing area in adjacent of Rupsha River. The typical value of COD was found of this study is 160 mg/L to 948 mg/L. The arithmetic mean value was calculated 355 mg/L for inlet wastewater.

In aeration basin significantly removed COD from wastewater. Almost half of the value reduced in the aeration basin. In the final stage, secondary clarifier has taken the final action and reduced COD significantly. The higher value was found 170 mg/L and the lower one was 34 mg/L of effluent. Arithmetic mean value was found 117 mg/L whereas national standard is 200 mg/L. There were 15 samples tested from effluent. The average rate of COD removal was found 67%.

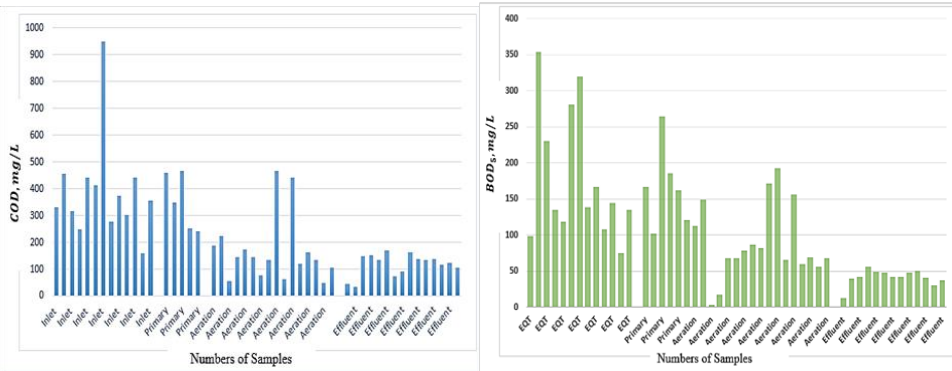

Figure 3: BOD_5 and COD value of different unit operations of the designed bench scale plant

Solids removal

All types of solids like biodegradable, non-biodegradable, filterable, non-filterable, suspended, dissolved, organic, inorganic are called total solids (TS) in word. But total solids not consist with volatile solids. The main two portion of total solids are dissolved solids and suspended solids. The substances present in wastewater in the form of suspended are may be called suspended solids or total suspended solids (SS or TSS). Dissolved or total dissolved solids (DS or TDS) represent all organic and inorganic constituents present in water in dissolved form. TDS also represents the total salt of water. In shrimp process industries effluent contains 100-800 mg/L of TSS (Carawan, 1991). Billah (2016) shown 543 (+/- 187) mg/L in exactly shrimp processed wastewater in Khulna region. The standard value of TSS for inland discharging is 150 mg/L and 200 mg/L for irrigation for Bangladesh. This study has found TSS 383 mg/L as average value of inlet wastewater. The highest value of TSS was recorded 960 mg/L and lowest one was 127 mg/L. The arithmetic mean value was noted 137 mg/L. Effluent water contain less than the standard level when the wastewater leaving from the bench scale plant. There were 13 samples from effluent of designed bench scale plant has been taken under test and the arithmetic mean value was found 137 mg/L.

This study recorded up to 4720 mg/L dissolved solids. Billah (2016) noted TDS value 1777 (+/-553) mg/L in shrimp processed wastewater in southwestern region. Significantly separated total dissolved solids from the wastewater in both primary and secondary clarifier of the designed treatment plant. Thus the final effluents contain mentionable less amount than the inlet wastewater. Final TDS of effluents value was measured 1805 mg/L. The removal percentage for SS was 64% and 37% for TDS.

pH & DO

Sherly (2015) has also found pH level of 7.5 and 7.4 in different two sources of shrimp process wastewater. There was thirteen raw samples were measured of this study for pH and average arithmetic mean value was found 8.03. Finally, treated wastewater leaves through secondary clarifier. Here final settlement as occurred and mainly biological sludge settled out. pH variation was state of being more or less 7 to 8. Arithmetic mean value was noted 7.73 for effluent of the designed treatment plant.

There are almost 15 samples were measured for influent Dissolved Oxygen (DO). Sometimes initially checked the DO value in laboratory after receiving the sample from industry or site. The arithmetic average value of DO of raw wastewater was found 2.7 mg/L. Billah (2016) has noted the DO value is 1.7 (+/- 0 .12). After final clarifier of the study, samples were measured and found DO level is above 4.5 mg/L. The higher one found 6.3 mg/L and lower one was 1.3 mg/L. The arithmetic mean value was noted 4.68 mg/L.

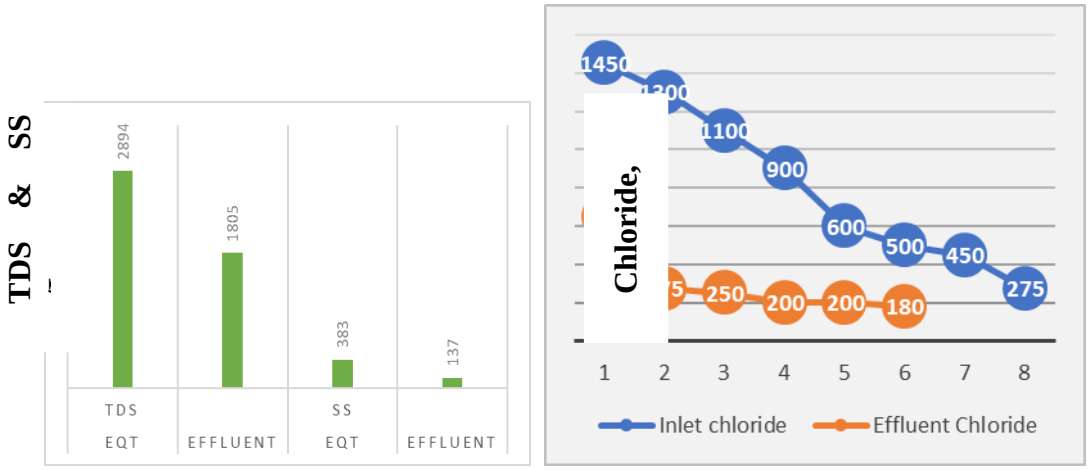

Figure 4: Mean value of TDS & SS and Chloride of inlet & outlet of Bench scale project

Chloride & EC

Chloride is inorganic anions that major contribute in effluents characteristics. Generally, found the concentration of chloride in shrimp process wastewater was high. Excess content of brine solution like NaCl, KCL etc may be responsible to higher chloride in wastewater. The chloride concentration in the river Rupsa located in the adjacent area of shrimp processing industries was measured 432 mg/L and 611 mg/L during low and high tide respectively by Begum (2006). The national guideline of wastewater discharge in Bangladesh represents 600 mg/L. This study was found as higher one is 1475 mg/L and lower one 275 mg/L. After the treatment through the designed bench scale plant plant effluent wastewater contain average 292 mg/L of chloride concentration.

EC is indicator of salinity problem in soil and water. The effluent of shrimp processing industries is basic in reaction and it has high value for electrical conductivity (Saeed et al., 2003). This study has found maximum 8.57 mS/cm that is 8577 µS/cm. The arithmetic mean value was recorded 4.51 mS/cm. The output wastewater contain EC was almost half of the inlet wastewater. The arithmetic mean was found 2.51mS/cm.

Nitrate- Nitrogen

Raw sample contain less amount of nitrogen. Maximum value was recorded 3.8 mg/L. Next aeration process add air in water and microbes take part to degrade biodegradable wastes. Here, the concentration of NO_3-N has gone long or higher than inlet wastewater 2.9 mg/L was found as lower concentration and higher was 13.4 mg/L. As the average value was found 6.57 mg/L of NO_3-N. So, it can be said that effluent will not be responsible for eutrophication.

CONCLUSION

It was the first study about wastewater treatment of shrimp process industries in Khulna using local treatment setup so far. It is clear from the study, no chemical coagulation is required. From the study of

the bench scale plant, it has shown that treatment level was moderate in practical, when continuous treatment will be run with large amount of wastewater the efficiency of treatment will be increased.

ACKNOWLEDGEMENT

I reveal to my gratefulness to Subinoy Biswas Nayan, post graduate student, who helped by working in laboratory. I also show my gratitude to Mr. Sayed Ahsan Ali, Technical officer and Mr. Sarder Shahidul Alam, Principal Assistant, Environmental Engineering lab, KUET, who helped in laboratory facilities.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
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AN ANALYSIS FOR DECONSTRUCTION AND DEMOLITION OF RESIDENTIAL BUILDINGS IN DHAKA CITY

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ABSTRACT
Building demolition and deconstruction is a standout amongst the most well-known activities at the end of building service life in the construction industry. The construction industry is a major waste generator. Solid waste management is a challenging task as population in Dhaka city is increasing gradually. Municipal solid waste (MSW) age in Dhaka city is 4634.52 tons/day, with a for every capita age 0.41 kg/day. And Construction and Demolition waste is a major part of MSW. The goal of this research is to investigate the act of private building deconstruction with the act of demolition in the Dhaka city in terms of different socio-economic parameters. This study was conducted with the help of some demolition and deconstruction contractors who have years of experience in this field. The similar investigation is created by efficiently breaking down two separate private deconstruction and demolition extends and increasing with avant-garde cost information for some selected areas (Dhanmondi, Bonani, Uttara) in Dhaka city. Some study shows that deconstruction costs and time duration could be 20-30% higher than demolition costs and time duration. This analysis manifests a methodology for contrivers of waste administration projects to assess and create techniques for advancing C&D waste diminution.

Keywords: Deconstruction, Demolition waste, Waste reduction, Waste management, Dhaka city.

INTRODUCTION
Solid waste management has challenged urban areas and governments all through the world. The foremost part of non-civil solid waste comprises of waste string generated from Construction and Demolition (C&D) activities. As per one statistics, around 136 million tons of building-related C&D flotsam and jetsam was created in the United States in 1996. In the Commonwealth of Massachusetts, it is assessed that 95% of non-city solid waste is C&D garbage. In 2004– 05 C&D squander age in Australia was 15.1 million tons. Construction and Demolition waste was evaluated at 40% of the volume of overall landfill waste (Crowther, P. 2000). Dhaka, the capital of Bangladesh has been predicted to be the 6th largest megacity in the world by 2030 with about 10 million additional people compared to current population (Rehnuma P. 2016). This rapid urbanization will be accompanied by a fast growing demand of building construction and renovation. Which will result in producing more construction and demolition waste. There are around 2034146 household in Dhaka metropolitan area (District Statistics 2011, Dhaka). Most of the buildings in Dhaka city is old and unplanned. So there is growing demand of building demolition in the purpose of development. Despite the fact that C&D waste is for the most part idle, and subsequently, may not represent an ecological risk as incredible as

risky waste or run of the mill metropolitan solid waste, still its huge volume results in a noteworthy issue for some communities because of the reducing transfer limit. The best methods for decreasing the volume of C&D squander is to enlarge the act of deconstruction.

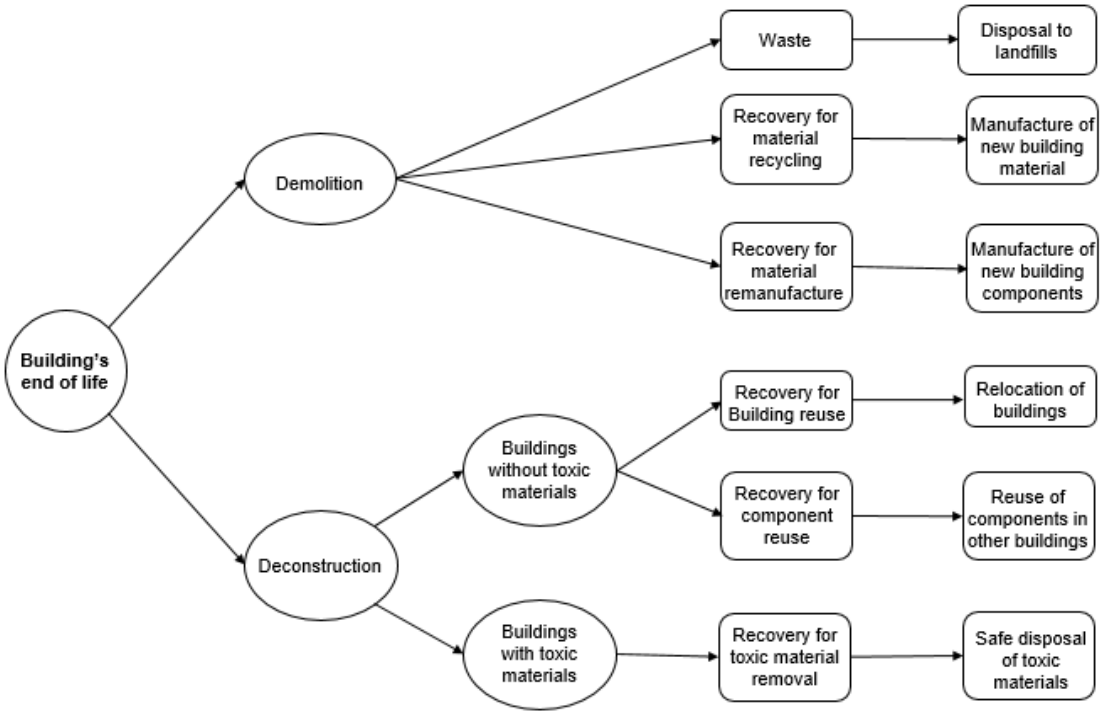
"Deconstruction is simply the construction process in reverse" (Greer, 2004). As contradicted to the conventional strategy for demolition in which all waste is trucked to landfills, deconstruction is a systematic procedure that plans to spare a bit of the waste materials for reuse on different ventures. This keeps away some construction and demolition squander from consistently entering the waste stream which results in lesser waste volume. As per Crowther (2005), deconstruction of structures without dangerous materials could be for four principle purposes, which incorporate (i) movement of structures, (ii) part reuse in different structures, (iii) material reprocessing and (iv) material reusing. This is inline with the perspective of Kibert (2003) who recommends that acknowledgment of successful outline for deconstruction for numerous reasons will essentially diminish CDEW and redirects squander from landfills. Proof demonstrates that up to half of CDEW could be redirected from landfill through an all around arranged deconstruction technique (Akinade et al. 2015).

Demolition is the way toward wrecking down or destroying or crumbling down of substantial structures after its service life period (Rathi & Khandve). Demolition is the ripping apart of buildings and other man-made structures down to ground. Destruction is inverse to deconstruction, which includes dismantling a building while precisely saving profitable components for reuse purposes. The procedure of decimation is completed with the assistance of some hardware or different strategies with legitimate strategy pursued by the assent of the nearby specialist (Rathi & Khandve). We know that each structure is intended for a particular life period for the most part 100 years (Yelamali et al. 2018).

A near inspection of the demolition versus deconstruction costs is performed utilizing the predominant wage rates, tipping charges, decimation expenses and its environmental impact on Dhaka city.

RESEARCH METHODOLOGY

Two exercises are conceivable toward the finish of life of structures, which incorporate demolition and deconstruction as appeared in [Fig. 1] (Akinade et al. 2015). Demolition as a building deletion methodology is essentially gone for transfer to landfill with little thought for material recuperation. Then again, deconstruction is done to recoup lethal materials from structures for safe transfer or to redirect squander from landfills through material recuperation. For instance, unsafe substances, for example, asbestos should be securely expelled through cautious deconstruction from old structures to stay away from word related occupational exposure.



CASE STUDY:

This case study includes deconstruction of seven residential building structures in Dhanmondi, Bonani, Uttara area of Dhaka city. According to the construction contractor of these area the number of building which have been broke down is 10nos, 30nos and 15nos in Dhanmondi, Gulshan and Banani area respectively in last one year. These building structure differed in size, area, age, and condition. These structures go from around 2000-5000 sft with a normal size of 3271.43 sft. Among these building some of the building were served as mixed i.e. both commercial and residential some were residential only. The information gathered in this study incorporates nearby work cost and other cost, for example, deconstruction cost, demolition cost, transfer cost, supervision cost, machine cost for utilized apparatus and tipping cost. The amount of waste and salvage materials were also recorded.

Fig. 2: Manual Deconstruction work in progress in Dhanmondi residential area, Dhaka

RESULT AND DISCUSSION

The net expense for demolition is evaluated as the whole of demolition work and hardware cost, transfer cost, and different expenses. The gross deconstruction cost is figured as the expense of deconstruction work in addition to transfer cost plus other expenses. The net deconstruction cost is the gross deconstruction cost less salvage. Salvage is the measure of cash picked up by offering the materials recouped from the building deconstruction. The salvage esteem used to ascertain the net deconstruction cost is thought to be at half of the evaluated retail estimation of the new material. Table 1 demonstrates the normal work necessity, transfer amount, evaluated decimation expenses, and deconstruction costs for the seven deconstructed structures.

Table 1: Average cost and salvage summary (according to collected data of seven building)

Typical demolition expenses	
Area (sft)	3271.43
Demolition worker/hardware (BDT./sft)	52.23
Demolition worker/hardware(% of project entire expenses)	36.7
Disposal (BDT./sft)	95.82
Disposal (lbs./sft)	353.33
Disposal (% of project entire expenses)	56.6
Other expenses (BDT./sft)	52.3
Demolition (BDT./sft)	200.35
Typical deconstruction expenses	
Area (sft)	3271.43
Deconstruction worker (BDT./sft)	188.93
Deconstruction worker (h/sft)	0.35
Deconstruction worker/hardware (% of project entire expenses)	65.2
Disposal (BDT./sft)	66.67
Disposal (lbs./sft)	166.67
Disposal (% of project entire expenses)	19.25
Other costs (BDT./sft)	68.2
Gross deconstruction (BDT./sft)	283.8
Salvage (BDT./sft)	177.36
Net deconstruction cost (BDT./sft)	106.44
Cost comparison	
Demolition minus(-) gross deconstruction (BDT./sft)	-83.45
Demolition minus(-) net deconstruction considering salvage(BDT./sft)	93.91

❖ **Some cost data:**

- Labor rate: According to the contractor the average labor rate for a common building in Dhaka city is BDT. 500/day with an eight hours of working day i.e. BDT. 62.5/h. Bangladesh Institute of Labor Studies (BILS March, 2015) records demonstrates that the average Construction worker's wage is BDT. 41.175/h. Here, we use the mean BDT. 62.5/h in our analysis cause it is most conventional in this field at present in Dhaka city.

- Disposal cost: The distance of disposal site varies in between 8-12km. Transportation cost of disposable materials is about BDT. 1000-1200 per truck. Average disposal cost BDT. 71.26 per sft.
- Salvage cost: Salvage cost is the assessed resale estimation of an asset toward the finish of its useful life. It is the evaluated esteem that a proprietor is paid when the thing is sold toward the finish of its valuable life. In Dhaka city the salvage value varies in between 40-60% of the evaluated retail estimation of the new material. It depends on the material condition. In our calculation we take the average incentive as half (50%) of the assessed retail estimation of the new material.

❖ **Data Analysis:**

The record data in Table-1 show that average gross deconstruction cost is higher than demolition cost. But considering salvage value, deconstruction could be more profitable than demolition. Besides it reduces the amount of generated waste remarkably. According to the expert, demolition of a typical house generates 40 metric tons of waste and by practicing deconstruction it can be reduced by 85%. One barrier is deconstruction is a labour intensive process and hence time consuming. Where 2 man can tear apart a house in two days, it takes 10 people and 2 weeks to perform deconstruction of the same house.

❖ **Environmental Impact:**

Demolition waste is a dominant part of industrial waste. About 45% to 55% (2200 ton per day) of the entire waste is unmanaged in Dhaka city and hence dumped in open spaces (Islam et al. 2015). With couple of special cases of little scale treating the soil plants, there is no network based support that has made a move for MSWM. DCC squander gathering vehicles daily gather roughly 1800 tons of MSW. (Yousuf and Rahman, 2007). About 47% of Non-MSW is C&D waste in Dhaka city (Concern, W. 2009).

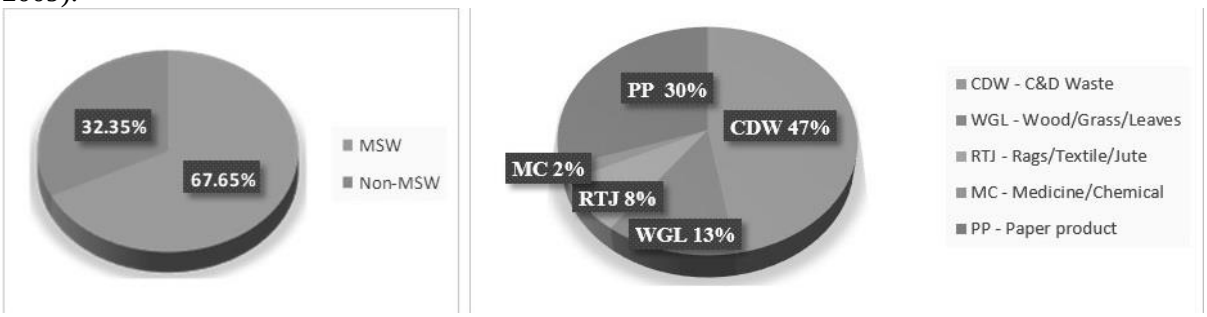


Figure 2: Average physical composition of (i) Non-MSW & MSW and (ii) Non-MSW in Dhaka (Concern, W. 2009).

Non-municipal solid waste is that isn't blended with waste produced by domestic activities. Non-municipal solid waste may incorporate glass, plastic, wood, roofing materials, sheetrock, and certain amounts of risky or pathogenic waste, construction demolition waste etc. In case of mechanical demolition it pollutes the surrounding air qualities by increasing the solid particles in air. Construction and demolition waste represents a substantial bit of garbage topping off landfills. There are numerous negatives related with increasing landfills, one of which is substantial amounts of methane gas are delivered by them. Growing landfills in local canals and lakes cause harm to the natural ecosystem and cause flooding in case of excessive rainfall.

CONCLUSIONS

For sustainable development, practice of deconstruction process has received great importance throughout the world. 2006– 07 statistics from the National Waste Report 2010 demonstrated that

22707000 tons or 52 percent of Australia's waste was reused. Of this, 42 percent was from the C&D squander stream. And this C&D waste recycling was done by practicing deconstruction. Though the contractor influence over choosing the methods of demolition. Project costs are essential to a contractor to choose a suitable demolition system. Also, risks for example, substantial forthright speculation and youthfulness in optional building material markets dissuade demolition contractor from performing deconstruction in building destruction project. Be that as it may, restriction exists while the investigation centres around just couple of residential building project. The government should introduce incentives and benefits by implementing an effective construction waste management plan giving importance to deconstruction and recycling of building materials for a sustainable development.

ACKNOWLEDGMENTS

1. Dr. M. Habibur Rahman, Professor, BUET email: habibr@ce.buet.ac.bd
2. Arnob Ghosh, B. Sc. in Civil Engineering, BUET email: arnobnghosh@gmail.com
3. Alamin Islam, Demolition Contractor.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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GHG MODELING USING WARM & MANAGEMENT OF MSW: A CASE STUDY IN SUNAMGANJ POURASHAVAS

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ABSTRACT
With radically increased population, rapid economic growth, expansion of urbanization and industrialization, Bangladesh faces the complexity of municipal solid waste (MSW) management. This paper presents an overview of current solid waste management (SWM) practices under Sunamganj Pourashavas. The four municipalities of Sunamganj district (Chhatak, Sunamganj Sador, Jagannathpur, & Derai) are the only responsible organizations for the collection and disposal of solid waste. In this study, Municipal solid waste generation rate and its composition were estimated and present condition of the four Pourashavas SWM system was assessed by collecting data through a semi-structured questionnaire and interviews encompassing 160 household units. The average waste generation rate of the four Pourashavas is 0.39 kg/capita/day at family level. But still now, majority of these wastes are uncollected due to lack of proper funding, manpower, and resources of the Pourashavas. Besides, some pourashavas do not have fixed landfill site. An energy-based GHG (Greenhouse Gas) model is prepared through WARM (Waste Reduction Model created by US EPA) in terms of MTCO_2E, MTCE & BTU that gives an overview of the emission of Greenhouse Gas. Furthermore, some crucial guidelines for the improvement of the collection and disposal system of these four Pourashavas are highlighted.

Keywords: Municipal solid waste; Solid waste management; Waste minimization techniques.

INTRODUCTION

As the world hurtles toward its urban future, the amount of municipal solid waste (MSW), one of the most important by-products of an urban lifestyle, is growing even faster than the rate of urbanization. Bangladesh, like most of the developing countries, is facing a serious environmental problem due to huge amount of GHG emission & increasing amount of MSW generation and its mismanagement. According to the last survey, waste generation in Bangladesh is around 16,015 tons per day or 150 kg/cap/year.There is an increasing rate of waste generation in Bangladesh and it is projected to reach 47, 064 tons per day by 2025 (Bahauddin and Uddin, 2012).

There are four municipalities which are known as “Pourashava” in Sunamganj district named Chhatak, Sunamganj Sador, Jagannathpur & Dirai and the areas occupied by them are 10.10, 22.17, 26.85, & 6.5 sq. km. respectively. The population under these four municipalities is 56425, 87570, 43064, 28157 respectively. According to available statistics, the generation of Residential wastes is far higher than the Sunamganj Pourashava’s collection. Waste collection in the four Pourashavas have been in a total mess as the Pourashava fathers are still not familiar with any modern waste management, appearing to have taken a “Devil-may-care” approach to tackling the problem. Since there was no detailed work performed in the four Sunamganj Pourashavas so a detailed study was vital to analyze the situation of the Pourashavas as they do not have any proper documentation. The objectives of the study are:

- Estimation of the WGR (Waste Generation Rate) and percent contribution of different wastes from Residential sources in Sunamganj Pourashavas.
- Assessment of present condition of the four Pourashavas SWM system.
- To prepare an GHG emission model through WARM (Waste Reduction Model).

METHODOLOGY

A simple method of sampling for the characterization of MSW is followed (USEPA, 1996). Two sampling points are generally being used, one is sampling directly from waste generation sources, which is known as primary data collection, and another is sampling from pourashavas, which is known as secondary data collection. Both of them are applied for this study. Preliminary survey, questionnaire survey, physical observation and survey for finding waste generation & GHG emission rates was conducted.

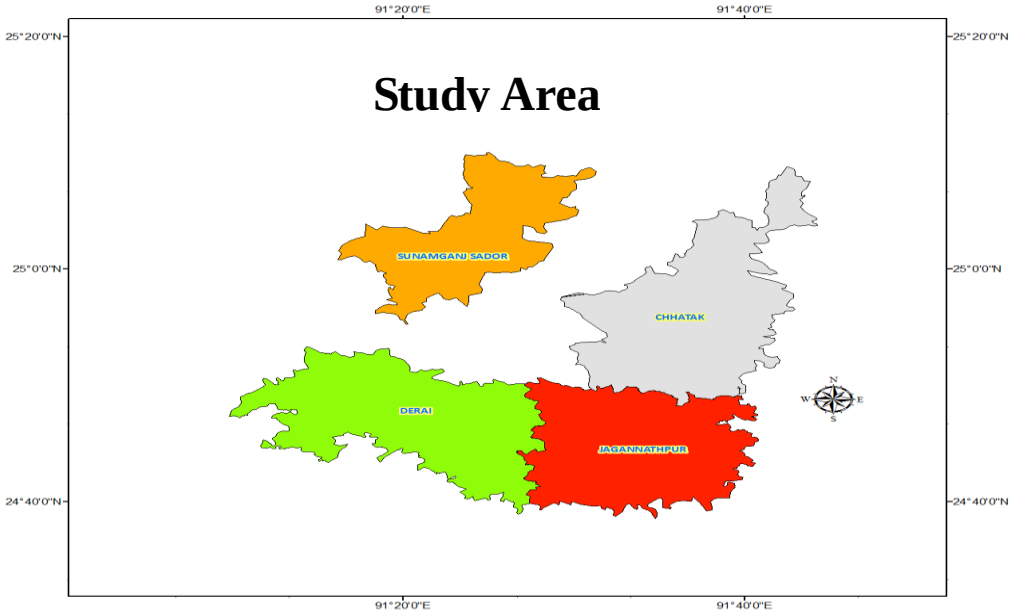

Fig 1: Sunamganj Pourashavas (Chhatak, Sunamganj Sador, Jagannathpur & Derai).

1. Primary Data Collection

Primary Data Sampling was designed to be 2-way stratified for this study because of geographical variation. It can have an impact on waste characteristics. The first level is the stratification by geographical regions i.e. by Old towns, new towns, villages e.t.c & the second is People's 4 different income level stratification because different classes of people generate different amount of wastes. A total of 40 households waste generation rates were considered in each pourashava. Sampling Data were collected from 20 October to 30 December, 2017. The daily average generation rate in each household with per capita generation was evaluated. Then the total amount of MSW generation from residential areas is evaluated by knowing total population in each pourashava.

Table-1: Municipal solid waste sampling sources of the four Pourashavas for primary data.

SL No.	Socioeconomic group	Monthly income level	Sampling sources
1	High socio-economic class	50,000+	40
2	Upper middle socio-economic class	30001-50000	40
3	Lower middle socio-economic class	10001-30000	40
4	Low socio-economic class	0-10000	40

2. Secondary Data Collection

Secondary data was collected from the four Pourashavas offices, and other different relevant government offices and NGOs, viz. Bangladesh Bureau of Statistics, & other sources. For waste minimization purpose, a small amount of data is collected from Vangari & Repair shop.

3. GHG emission modeling

WARM is a tool created by US EPA that calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, anaerobic digestion and landfilling. The model calculates emissions across a wide range of material types commonly found in municipal solid waste in the following:

- Metric tons of carbon dioxide equivalent (MTCO2E),
- Metric tons of carbon equivalent (MTCE), and
- Energy units (million British Thermal Unit - BTU).

Table-2: Waste composition category

Waste Category	Waste Components
Organic matter	Organic waste, or green waste from foodstuff such as fruit skin, food & vegetable refuse, stem of green, leaves, corncob, manure, & grass.
Paper	Newspaper, cardboard, book, magazines, tissue, office paper & mixed paper (all paper that does not fit into other category.
Plastic	Any product made of plastics.
Wood	Any product made from wood.
Tin	Any product made of tin material.
Glass	Any product made of glass.
E-waste	Any electronic product such as tv, refrigerator, computer, laptop, cell phone etc. that is permanently damaged.
Others	Any waste origin from yarn, rubber, batteries, medical waste & miscellaneous.

Fig 2: Overview of Methods.

RESULTS & DISCUSSIONS

Table 3: Contribution of sources in the total waste generation in Residential areas.

Pourashava	Chhatak	Sunamganj Sador	Jagannathpur	Derai	All stream
People	293	251	426	288	1258
Organic waste (Ton/year)	32.38	36.46	52.96	39.60	161.41
Paper (Ton/year)	0.49	0.79	0.85	0.69	2.82
Polythene & plastic soft (Ton/year)	0.54	0.90	0.84	0.70	2.98
Glass (Ton/year)	0.07	0.05	0.17	0.09	0.37
E-waste (Ton/year)	0.52	1.08	0.81	0.99	3.39
Total waste (Ton/year)	34.00	39.28	55.63	42.06	170.98

Waste Generation Rate (Kg/Capita/Day)	0.32	0.43	0.41	0.40	0.39
Standard Deviation	0.02	0.04	0.09	0.05	0.05

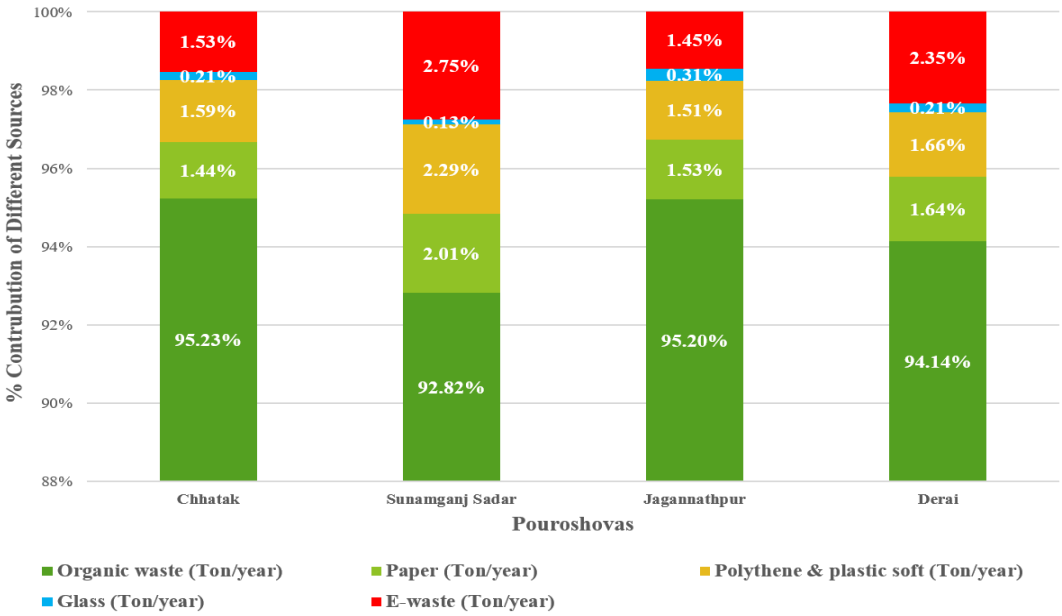

Fig 3: Contribution of different sources in Total Waste Generation.

Table 4: Pourashavas Solid Waste Collection Frequency & Disposal Locations.

Pourashavas Solid Waste Collection Frequency & Disposal Locations						
Pourashava	**Covered ward**	**Trip no.**	**Collection basis**	**Total waste collection (Ton/Day)**	**Dumping Type**	**Dumping Place**
Chhatak	6	2	Daily	4	Open Dumping	Near the entrance of a bridge
Sunamganj Sador	9	2	Daily	5	Open Dumping	In the land
Jagannathpur	9	1	Weekly	1.14	Open Dumping	In the river
Derai	4	1	Daily	0.45	Open Dumping	In the land

Source: Survey, December'2017, Study on MSWM, Sunamganj Pourashavas.

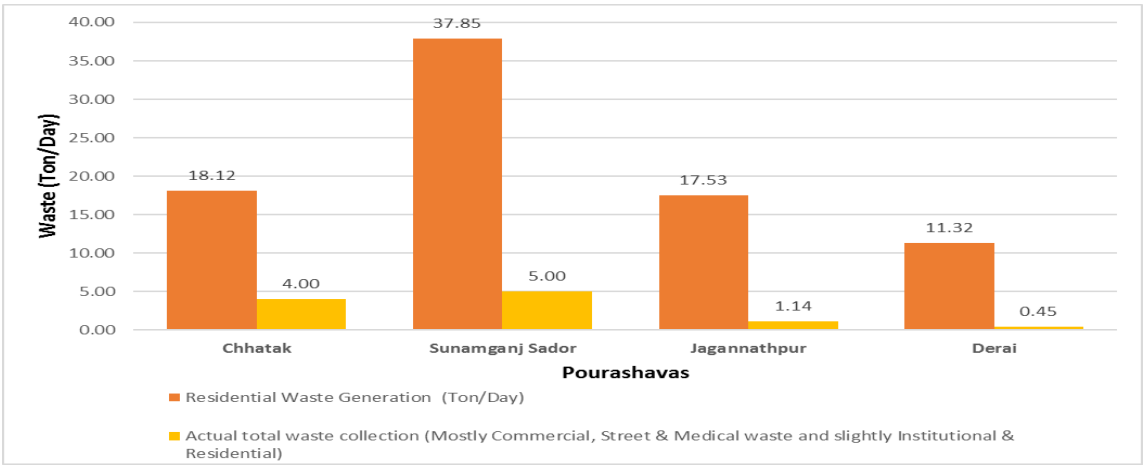

Fig 4: Residential waste generation vs Pourashavas collection.

Fig 5: Pourashavas MSW disposal locations.

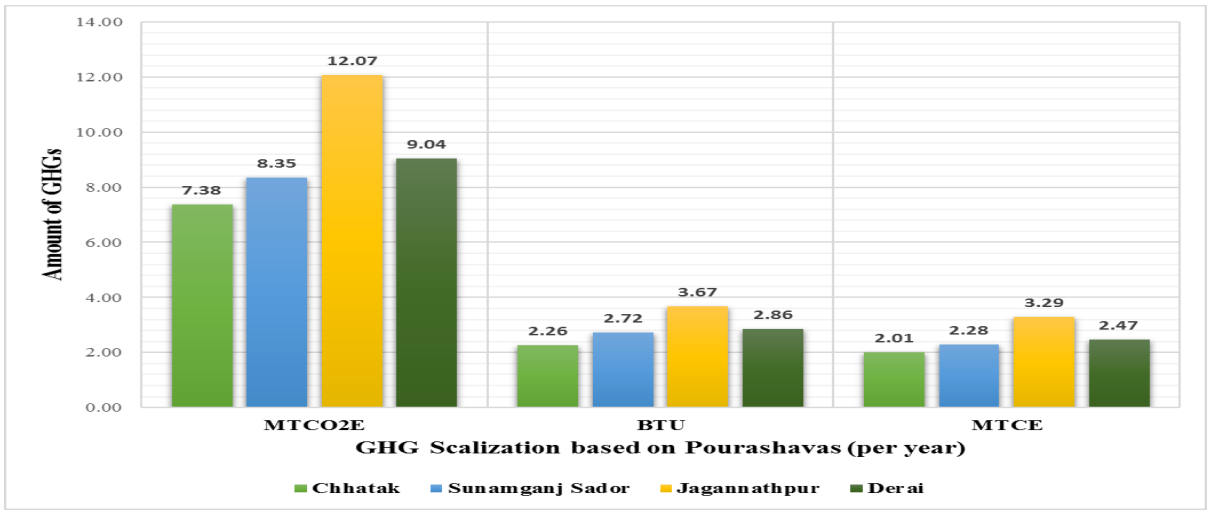

Fig 6: Estimated GHG Emission of the Baseline for the Residential wastes of the four Pourashavas.

Data interpretation

- It was mentioned that the assessment of our study is based on four socioeconomic level (HSG, UMSG, LMSG & LSG). The average RWGR (Residential Waste Generation Rate) of the four pourashavas is 0.39 Kg/capita/day where Sunamganj Sador pourashava generates maximum RWGR of 0.43 Kg/capita/day. Compostable or organic waste contributes above 90% in compared of the Total waste generation. Open dumping method is mostly followed by the families for the disposal of House Hold wastes.
- In the case of Pourashava waste management facilities, Sunamganj Sador alone provides door-to-door collection system. They also collect maximum amount of wastes in compared to the other three pourashavas. Jagannathpur Pourashava collect their waste on weekly basis.

- The four pourashavas collect a little amount of waste in compared of the total residential waste generation. They also do not have properly designed landfill sites & dump the collected wastes in open land or in the river which causes serious health hazard as well as serious environmental pollution.
- A large portion of GHG emissions is related to energy use in resource acquisition, manufacturing, transportation, and end-of-life life-cycle stages. The estimated GHGs per year found maximum in Jagannathpur Pourashava that are 12.07 in terms of metric tons of CO2 equivalent, 3.67 in terms of million BTU & 3.29 in terms of metric tons of carbon equivalent.

CONCLUSIONS

Municipal solid waste management is one of the key concerns of human health & also important for the better environment. The purpose of this study is to analyze the existing solid waste management system in the four Sunamganj Pourashavas. The main source of wastes in the Sunamganj Pourashavas are domestic waste (.39 kg/capita/day) & it's generation rate is increasing at an alarming rate. But the Pourashavas support are inadequate due to financial constraints and lack of recognition of the importance of this vital sector. From GHG emission figure, these poor management & open dumping practices are responsible for the emission of huge amount of GHG. To sink these GHG, proper recycling steps should be taken as soon as possible.

GUIDELINES FOR IMPROVEMENT OF SWM OF SUNAMGANJ POUROSHOVAS

- Different bin systems for different types of wastes should be placed in Residential areas. For this, proper steps should also be taken to aware the people about the necessity of different bins.
- Penal action for illegal disposal of waste on roads, drains & unauthorized places should be established.
- It is recommended that all bins should have covered lid & have a concrete bottom to prevent leachate & leakage. Another type of portable community bin or container, which can be lifted directly on the vehicle, could be used.
- For Waste Minimization, some approaches can be taken-
  - Plastic & Polythene waste should be minimized through R's.
  - Organic waste should be minimized through composting.
  - Public awareness on Recycling should be increased.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the help of the authority of the University for providing various facilities.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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PRESENT CONDITION OF BURIGONGA RIVER AND ITS CAUSES OF POLLUTION

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ABSTRACT
Water Pollution is a major problem in the Global Context. River pollution has turned up as one the greatest issues for urban Dhaka. This Article is based on the exploration of physicochemical parameters of water samples of Burigonga river of Bangladesh. Our main objective is to find the causes for river water pollution after the relocation of Hazaribagh tannery industries. In this aim, eleven samples were collected from different parts of Burigonga river, which were observed to determine different physicochemical parameters such as- pH, Turbidity, Alkalinity, Total Hardness, Dissolve Oxygen (DO), Biochemical oxygen demand (BOD) etc. All parameter values are compared with Bangladesh standard for waste water discharge to inland surface water as per ECR 1997. It was found that, there is a serious level of water pollution in Burigonga river resulting the water unsuitable for aquatic life and domestic purpose. Both land usage of the river and the dumping of Municipal waste water effluent have the potential to degrade water quality in the river. The major problem associated to this pollution depends on both natural & man-made causes. The major part of which is from man-made causes and these causes refer to physical, chemical, biological and socio economical causes.

Keywords: Physicochemical parameters; Relocation; Pollution

INTRODUCTION
Bangladesh has about 230 small and large rivers and Buriganga is the most popular of them. The length of Buriganga river is only 27 kilometer (Hasan et al., 2009). About 400 years ago, the Dhaka city was build up near Buriganga River because people use the river for easy way of communication and trade sources. One day Muslin and Jute was revealed by Buriganga River. That was the time when Buriganga River transmogrified the Dhaka city as Business Park in the south orient. This is the kinship of Buriganga River and Dhaka city. In present time the river is too much in use then the past. River plays a vital role in sustainability in a city but Buriganga is polluted by conquistadores and our in advertences. Ongoing polluting source is constituted by domestic and industrial wastewater (Singh et al., 2004). Gradually many industries were build up beside the Buriganga River such as tannery industries, dyeing industries, plastic industries, fertilizer industries etc. There were 343 tannery industries at Hazaribag beside the Buriganga River (Ahmed, 2005). Although all tanneries were removed at Savar but there is no large effective change that came into the quality of the water of Buriganga river because of rampant dumping of other industrial and human wastes. There are 627 dying industry at Jingira, Karaniganj near Buriganga river (Kamal et al., 1999). Those industries discharge daily about 5000 square meters effluents into the Buriganga River (Rahman et al., 2010). There are 104 fertilizer industries at Fatulla, Bosilla, Damra on the bank of the river which discharge daily 9000 square meters effluent (Rahman et al., 2010). And the plastic industries by the side of the river also discharge effluent. All the discharged

effluent are not treated and contain various types of materials and chemicals and all these effluents presence some toxic chemicals such as polyurethane, hydrochloric acid, alkalis, lime, caustic soda, aluminium, zinc chromate, zinc phosphate, asbestos etc.(Ahmed et al., 2016). So the water quality of Buriganga river is very harmful for human health and fishes. There is no treatment in industrial effluents as well as domestic sewage/wastes. On account of this, concentration of different kind of pollutants (including heavy metals) is not stopped (Gupat et al., 2009).

The aim of present study is determining physicochemical water quality parameters after relocating Hazaribagh tannery and compare the present results with the earlier taken samples and also with respect to Water Quality Parameters Bangladesh Standard, WHO guide line. From which we have a clear idea about the effective cause behind the pollution of the Buriganga river water and also shows whether it is useable or not.

METHODOLOGY

A water sample collection work was conducted for measuring the current quality conditions of the rivers. Water sample were collected by boat at 11 different point and Pyrex glass bottles were used for picking up sample water. Before collecting the sample all the bottles were washed with distilled water and dried using desiccator. At first the sample of the river water was taken from several points and the data was compiled accordingly. But when the relocation of Hazaribagh tanneries was finally put into act, we stopped for a time being. Later after one year, again the data was collected from the exact same points and a comparison was made.

Study Area:

The Buriganga River flows past the southwest outskirts of Dhaka city, the capital of Bangladesh. Its average depth is 7.6 meters (25ft) and its maximum depth is 18 meters (58ft). It is situated between Latitude: 23°37’59.99” N and Longitude**:** 90°25'59.99" E. Our study area was this river.

The locations from where the water samples were collected are as follows: Thus our sample stations are: Burigonga Shetu -3 (Boshila) is S-1, Hazaribag (Balur ghat) is S-2, Hazaribag (Jhao chor) is S-3, Islambag (Alir ghat) is S-4, Burigonga Shetu-2 (Mitford ghat) is S-5, Shoari ghat is S-6, Burigonga Shetu-2 (Badamtoli ghat) is S-7, Shodor Ghat (lonch ghat) is S-8, Tel Ghat (Sham bazar) is S-9. Table 1.2: Methods used for the analysis of different physicochemical water quality parameters of Buriganga River water.

Sample Collection: The collection of water sample was performed in the following steps:

Samples collected in glass bottles which were washed with 2% nitric acid after being kept in detergent solution in 24 hours and rinsed. Before sampling, 0.5gm of ascorbic acid was added to the bottle after cleaning. Sample was collected from 5ft below the surface of river water. The samples were kept in dark place with temperature kept at 4°C. It is to be noted that since we have compared with two data, we collected the samples twice; 1) before the relocation of Hazaribagh tanneries Industries at December 16, 2016 & 2) after one year of the relocation of Hazaribagh tanneries

Sample Compilation and Storage: Analysis was performed as soon as possible to prevent the effect of delayed residual effect of biochemical activities in sample water. Sample was maintained at 4°c and the sample bottle was not opened until the analysis was performed.

Table 1: Methods used for the analysis of different physicochemical water quality parameters of Buriganga River water.

SL NO	Parameter	Method
1	pH	pH meter
2	Turbidity	Nephelometer
3	Total Hardness (mg/L)	Titration Method
4	Total Alkalinity (mg/L	Titration method
5	Dissolved Oxygen (mg/L)	Titrimetric method
6	Biological Oxygen Demand (mg/L)	Titrimetric method

RESULTS AND DISCUSSIONS

pH:

Unlike lakes and ponds, rivers are open systems, where frequent water exchange occurs. Despite this fact, the organisms that depend on rivers require some equilibrium. pH is the figure expressing the acidity or alkalinity of a solution on a logarithmic scale.

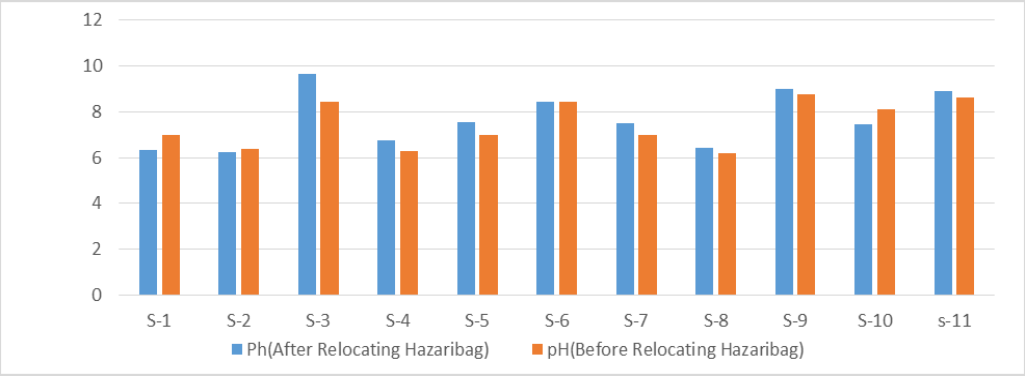

Figure 1: Comparison of pH level (mg/L) before and after the relocation of Hazaribagh tanneries.

We have indicated the pH of the Buriganga river water before and after the relocation of the Hazaribagh tanneries in a Graphical representation. It is clearly evident that the change of pH was not affected before and after the relocation of the Hazaribagh tanneries.

Turbidity: Turbidity is the water parameter which exhibited that, the suspended particle or dissolved in water which presents the passage of light through it. Turbidity makes water obscure. Turbid water particle can carry disease because of the toxic pollutants. According to the Bangladesh. Drinking Water Standards, the typical value of turbidity should be in between 5 NTU to 10 JTU. The Guideline of WHO (1993) suggests the typical value of turbidity is 5 JTU [8].

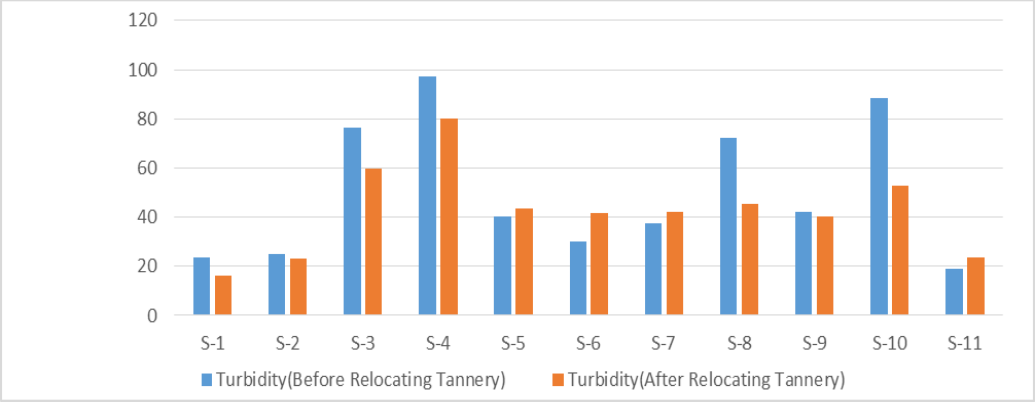

Figure 2: Comparison of Turbidity level (NTU) before and after the relocation of Hazaribagh tannaries.

We have indicated the Turbidity test of the Buriganga river water and after the relocation of the Hazaribagh tanneries in a Graphical representation. It is seen from the graph below that only at points S-8 and S-10, we have a considerable change in the turbidity level.

Total Hardness:

The sum of the concentration of calcium and magnesium ion is called total hardness. Hard water deposits a layer of calcium and magnesium on anything it comes in contact with. The water become harder because of high amount of dissolved minerals. The greater the hardness, the harder it is for toxic metals to be absorbed through the gills.

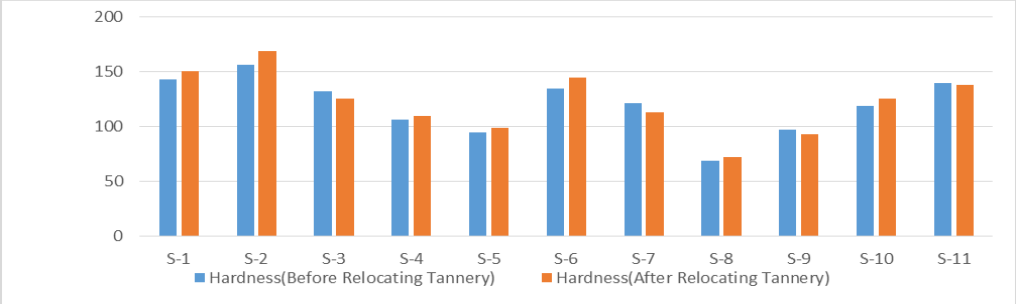

Figure 3: Comparison of Hardness level (mg/l) before and after the relocation of Hazaribagh tannaries.

It is also evident that there is no effective change at any location points based on the total hardness. It is found from the data that the total hardness has increased for most of the points excepting for the locations S-3, S-7, S-9 & S-11. It is because most of the wastes materials that were subjected to the Buriganga river were acidic in nature that explains the increase of the Total Hardnesss of the river water after the removal of the Hazaribagh tanneries.

Alkalinity:

Alkalinity is the measuring ability to neutralize acidic pollution from waste water. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater.

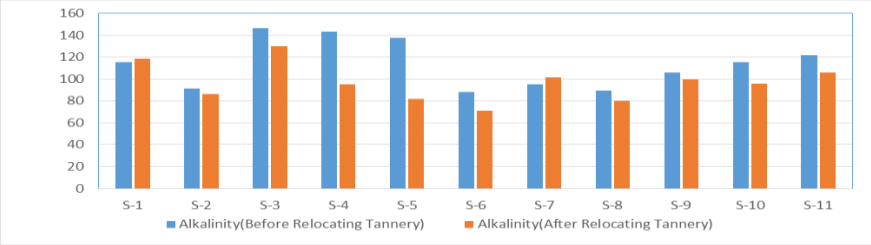

Figure 4: Comparison of Alkalinity level (mg/l)before and after the relocation of Hazaribagh tannaries.

Only for the location points S-1 and S-7, there is relatively a better change in the alkalinity of the Buriganga river water from the Graphical representation before and after the relocation of the Hazaribagh tannaries. For the points S-1 & S-7 the alkalinity has increased because of the upstream sedimentation and the thickening of the riverbed.

Dissolve Oxygen (DO):

Dissolve Oxygen analysis measure the amount of oxygen (O_2) dissolved in water. The amount of dissolve oxygen calculate by diffusion form the circumfluent air through rapidly flow of photosynthesis. Overall DO is amount of total biological activity of water masses. It is regarded by Standards from the Environment Conservation Rules 1997 is that the DO value must be 5 mg/L or above for purposes like irrigation, fisheries and recreational activities.[10]

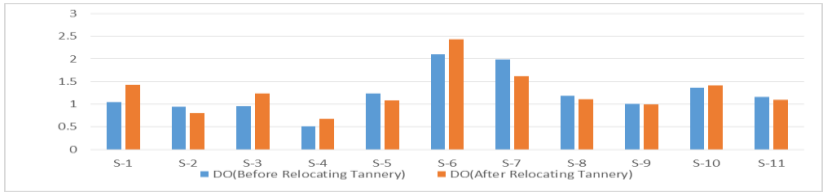

Figure 5: Comparison of the DO level (mg/l) before and after the relocation of Hazaribagh tannaries.

Like the other physicochemical parameters, it is observed from the graphical comparison that the Dissolved oxygen before and after the relocation of the Hazaribagh tanneries had no considerable effect.

Biochemical oxygen demand (BOD):

Biochemical oxygen demand is the quantity of oxygen required by bacteria and other micro-organisms in the oxidation of organic matter. According to the Bangladesh Drinking Water Standards, the permissible limit for BOD for drinking water is 0.2 mg/L and for the other purposes it will be 5 mg/L or less. The river water is used for irrigation and other purposes along with maintaining the natural habitat. The contribution of the nitrites and phosphate salts along with the organic waste is disposed in the water, which is then decomposed by bacteria. This results in a high BOD level.

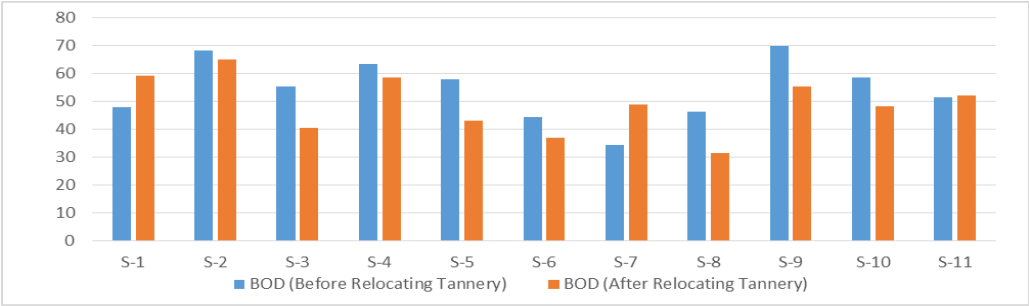

Figure 6: Comparison of the BOD level (mg/l) before and after the relocation of Hazaribagh tannaries.

The BOD before and after the relocation of the Hazaribagh tanneries was more or less same. The relocation had a very little effect on the BOD of the Buriganga river water. At location S-1, S-7 & S-11 we can see that the BOD has rather increased. This can be explained by the upstream sedimentation and the rising of the riverbed in those points.

It is seen that the dumping of the solid wastes in this river by the industries are been mixing in this river soil which makes it more vulnerable now because despite of removing the Hazaribagh tanneries the pollution level have not decreased. It is due to different clinical wastes and human wastes are directly exposed in the river which has the direct impact in polluting the river water. Moreover the upstream sedimentation, land grabbing and the increases of the users of this Buriganga river is also responsible behind the present pollution of the river water.

CONCLUSIONS

So, after analyzing the data before and after the relocation of Hazaribagh tanneries it is clear that the relocation was not that much effective and moreover it actually had barely any effect on the river water. This puts us to the conclusion that the chemicals that had been dumping for years actually been oozed in riverbed. For this reason the relocation did not bring any considerable change in river water. So we have to first remove the solid wastes that have been oozed in this riverbed and also have to dredge the river in over to lower the upstream sedimentation.

ACKNOWLEDGMENTS

This research is inspired and conducted under the supervision of Dr. Engr. Md. Rashidul Hasan, Associate Professor and Head of Civil engineering Department, BAUET. Also authors would like to thanks Dr. Md. Saiful Islam, Assistant Professor and Head of Chemistry Department, BAUET & Md. Moynul Islam, Lecturer, Chemistry Department Bauet. All the researches were conducted at House And Building Research Institution (HBRI), Dhaka.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
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CUET, Chittagong, Bangladesh
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STUDY ON RAINWATER HARVESTING IN DACOPE UPAZILA, KHULNA, BANGLADESH

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ABSTRACT
The coastal belt of Bangladesh suffers from high salinity in surface and groundwater, arsenic contamination of the shallow aquifer, lack of aquifer and difficulties in extracting saline free water are some of the causes. It is so pathetic that a lot of water is available in the coastal area but not drinkable. It is high time to be concerned about the drinking water problem of the coastal area like Dacope. Rainwater Harvesting System (RWHS), the technology for collecting and storing rainwater for human use from a rooftop or any other means, may be an alternative solution to solve the present scarcity of water. This study is conducted to evaluate the existing drinking water sources and the opportunity of rainwater harvesting at Dacope Upazila of Khulna district. In this project existing water supply sources were investigated by field visit and questionary survey. The water quality parameter of the existing reservoirs was examined. They were found to be acceptable for drinking and cooking purposes but need some treatment.

Keywords: Rainwater harvesting; Annual rainfall; Quality parameters.

INTRODUCTION

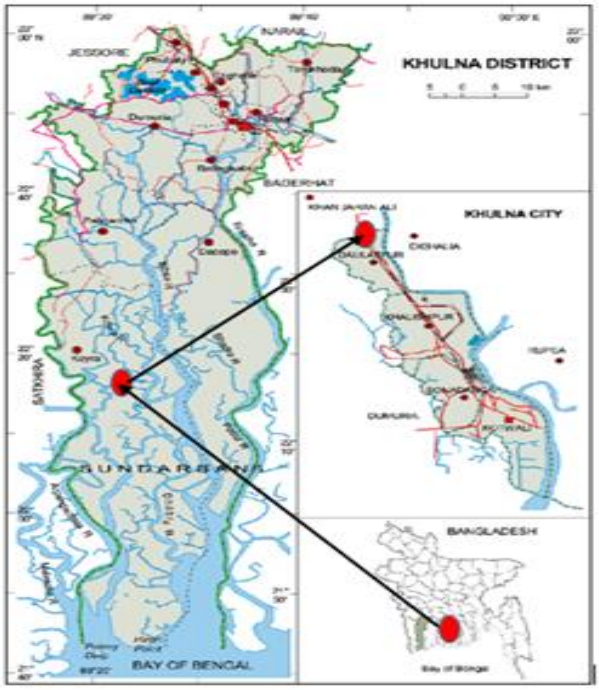
Safe drinking water is a pre-requisite for the development of any society. The majority of the populations in developing countries still lack safe drinking water and more than 50 % of the populations have no access to potable water (UNDP 1992, WHO 2004) reported that in south-west Bangladesh (Khulna, Satkhira and Bagerhat district) the ground water is unsuitable for human consumption due to high salinity rather than due to arsenic contamination. As a result of rapid population growth, combined with industrialisation, urbanisation, agricultural intensification and water-intensive lifestyles is resulting in a global water crisis. In the face of increasing scarcity of water resources, there is a need for every user to think about the possible solution to cope with the crisis. Like many other developing countries, public water supply in Bangladesh evidently provides a shortfall in demand.

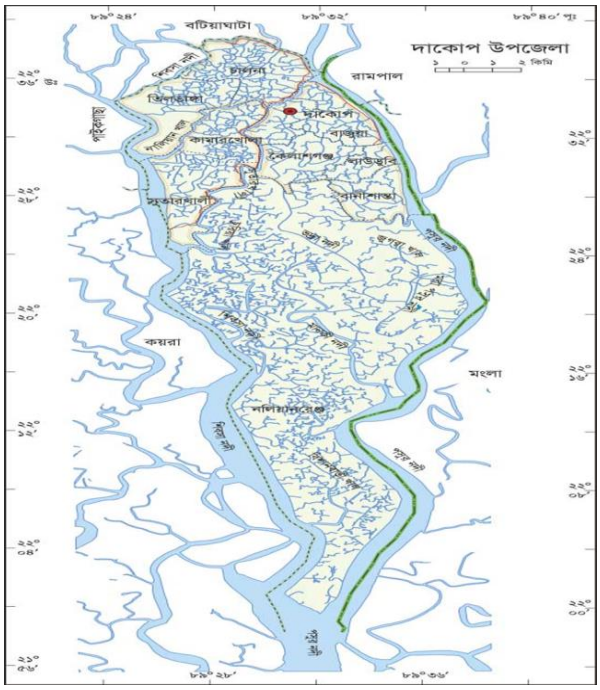
To cope with this disastrous situation, different water treatment options and alternative strategies like Rainwater Harvesting System (RWHS, newly introduced sustainable water supplier) is tried to adopt in government and non-government sectors. The Southwest coastal region of Bangladesh has been severely facing pure drinking water crisis due to saline water intrusion on one hand and arsenic content of groundwater on the other where RWHS have been installed as an alternative water supply system.

Hence, this paper first investigates the present water demand (cooking and drinking) and supply scenario in the study area and socio-economic aspects of rain water harvesting. In addition, it evaluates the performance of RWHS in supplying safe drinking water through water quality analysis.

Description of study area

Khulna is the third-largest city in Bangladesh and the administrative seat of Khulna district and Khulna division. Dacope Upazila (Khulna District) area 991.57 square kilometres, located in between 22°24' and 22°40' north latitudes and in between 89°24' and 89°35' east longitudes. Dacope Upazila in Southwest coastal region of Bangladesh has been selected as study area. Many RWHS have already been established. RWHS and pond water are the major water supplier to the study area which is





ation Map of Dacope Upazila, Khulna.

supplying about 90 % of the total drinking water. About 8.7% people using water from river, dug well and tap. The use of tube well water is decreasing rapidly as it contains arsenic, salt and sand in most cases. Total number of households of Dacope Upazila is 36,597, total area 991.58 square kilometre, Population Total 157489; male 83193, female 74296; Muslim 65756, Hindu 88842, Buddhist 2760 and others 131, population density 154 per square kilometre, literacy rate 56 percentage respectively according to Bangladesh Bureau of Statistics (BBS 2011).

METHODOLOGY

To complete the thesis, a strategy including literature review, different methodology and analysis were taken. The flow diagram of the strategy is given below:

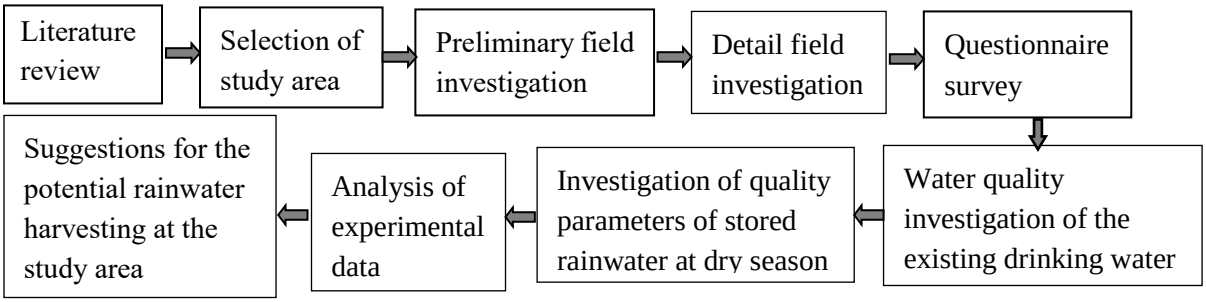


Fig. 2 Outline of the experimental strategy.

Site selection for rainwater harvesting system

To determine the location and size of the system, a questionnaire survey was conducted in that locality. The following were the key findings from the survey that was conducted among the beneficiaries of the project regarding the design and maintenance of the systems.

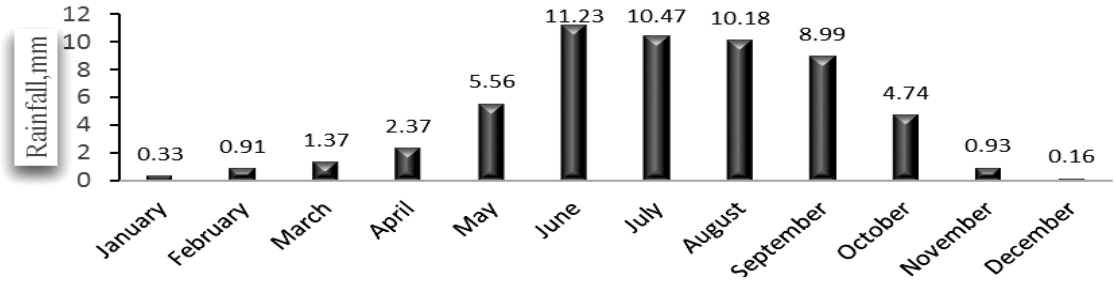
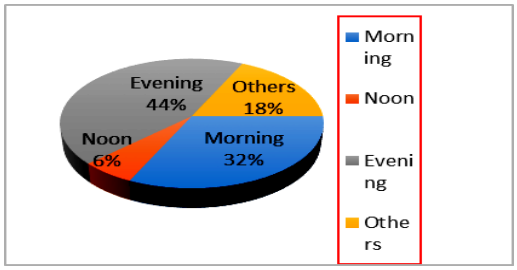
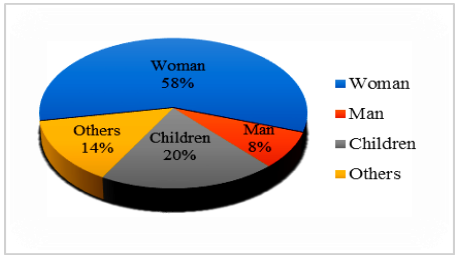


Fig. 3 Average monthly distribution of rainfall in Khulna from 1960 t0 2015.

The total amount of water required for drinking and cooking purposes is 13.8 litres per person per day. From the analysis of rainfall data from the year of 1960 to 2016, the average annual rainfall is 1.748 m/day. If the catchment area (Roof area) is considered as 8 m length and 4 m width, then the catchment area will be (4 x 8) =32 m^2. Amount of water stored by this catchment area in a year = (1.748 m x 32 m^2) =55.936 m^3 = 55,936 litre per year. If 50% water is collected then the total collected water =50% x 55,936 litre = 27,968 litre. Theoretically which will fulfil the daily drinking and cooking water demand.



Water collection time and collector



collection.

Fig. 5 Type of water collector.

RESULTS AND DISCUSSIONS

Samples from selected drinking water sources were collected and brought to the laboratory to determine water quality parameters. The test results of different sources were tabulated separately. From the test result, the variation of different parameters was presented by the figure. All the test were performed in accordance with the standard method.

Table 1 Water quality parameter results of existing water sources

Sample	TC	FC	pH	Color	Turbidity	Conductivity	Acidity	Alkalinity	Iron	TDS
Units	N/100 ml	N/100 ml		Pt.co	NTU	µs/cm	mg/L	mg/L	mg/L	mg/L
WHO	0	0	-	15	5	<250	-	-	0.3	1000

STD.

Bang. STD	0	0	6.5-8.5	15	10	<250	-	130	0.3-1.0	1000
A-CB-1	26	5	8.3	13	1.11	46.9	12.5	10	0.11	0.004
A-GT-1	13	3	8.82	0	0.8	108.4	0	13.75	0	0.009
A-GT-2	11	4	8.65	2	0.95	79.7	6.25	12.5	0	0.007
A-M-1	18	4	8.44	0	0.65	67.5	7.3	5.12	0.01	0.003
D-TW-1	20	6	7.98	24	2.38	2.92	27	32	0.34	0.017
D-M-1	11	0	6.98	8	1.45	17.53	15	15	0.18	0.009
D-GT-1	5	2	6.9	0	1.19	18.22	10	10	0.06	0.011
D-CB-1	17	0	6.98	29	2.73	20.8	7.5	10	0.18	0.006
D-P-1	0	0	6.98	1	1.85	125.6	2.5	35	0.05	0.014
D-GT-2	27	5	6.96	0	1.22	6.78	5	15	0	0.006
J-GT-1	5	1	6.75	0	1.74	43.33	7.5	6.25	0.07	0.004
J-CB-1	9	3	6.68	4	1.29	7.21	2.2	12.75	0.03	0.009
J-GT-2	4	0	6.73	14	1.45	21.53	5.2	30	0	0.003
J-CB-2	11	2	6.66	4	1.29	13.37	27.3	10	0.13	0.004
J-M-1	5	1	6.7	2	2.23	88.36	15.2	12.5	0.03	0.006

(TC-Total Coliform, FC-Faecal Coliform, TDS- Total Dissolved Solids, A-CB-1= August-Concrete Box-Sample-1, A-GT-1= August-Gazi Tank-1, A-M-1= August-Mat-1, D-TW-1= December-Tube well Water-1, J-GT-1= January-Gazi Tank-Sample-2)

Birds always sit on the roof and these faeces may get mixed with water and this is the reason for presence of TC and FC. Here J-GT-2, D-CB-1 and D-M-1 are free from FC as that collection systems were neat and clear. Due to aeration the value of pH was slightly increased in A-GT-1 and A-GT-2. In D-TW-1 and D-CB-1 contained a large amount of Algae so the colour of these containers exceeded the standard value. The Turbidity, Conductivity, Acidity, Alkalinity and Iron are within the allowable limit.

Variation of water quality parameters of stored rainwater

The quality parameter of stored rainwater was investigated from December to June month to verify the quality of stored water in the rainwater tank after 6-7 month of the stored of water, during the dry season. The test result was attached with the report through appendix**.**

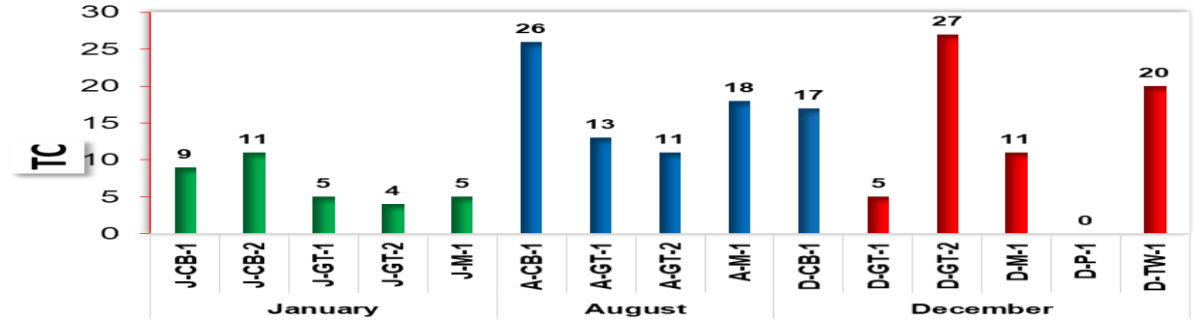


Figure 6, 7, 8, 9, 10, 11, 12 show the variation of Faecal Coliform (FC), Total Coliform (TC), pH, Turbidity, Total Dissolve Solid (TDS), Alkalinity and Acidity of stored rainwater respectively.

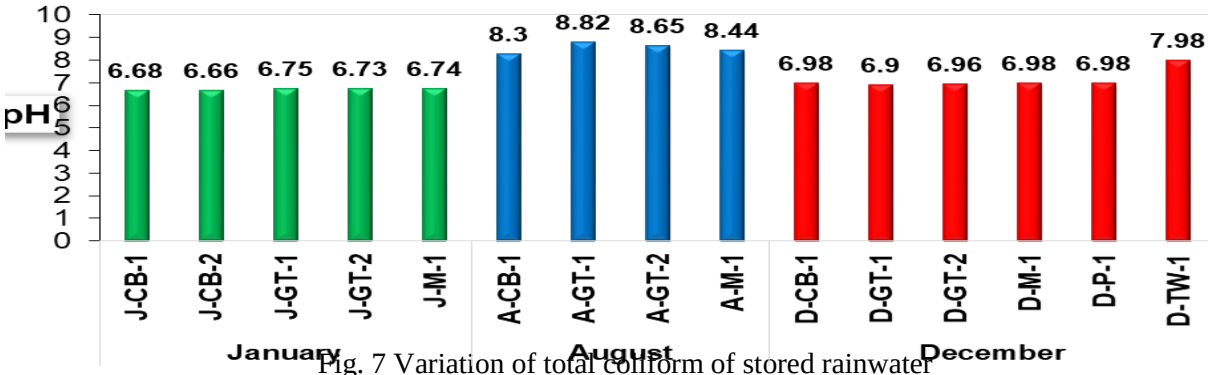
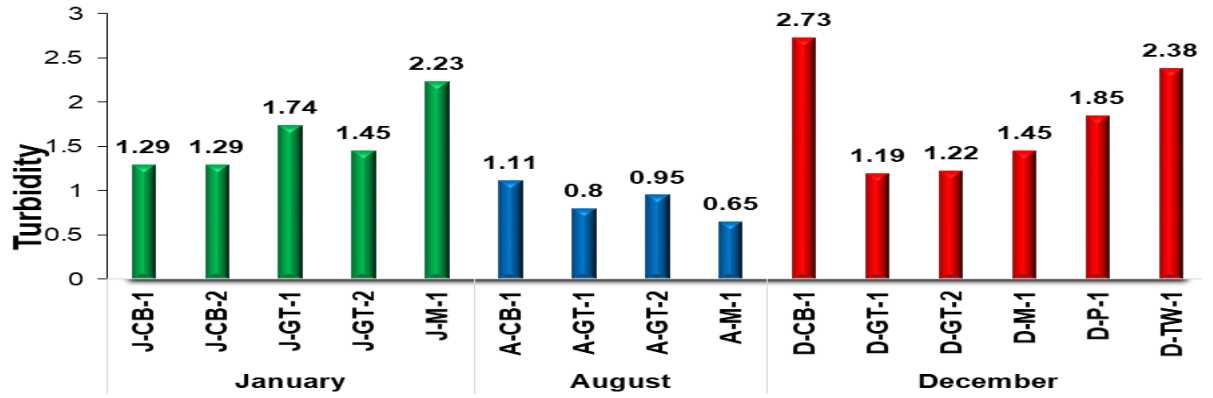


Fig. 7 Variation of total coliform of stored rainwater

Fig. 6 Variation of faecal coliform of stored rainwater



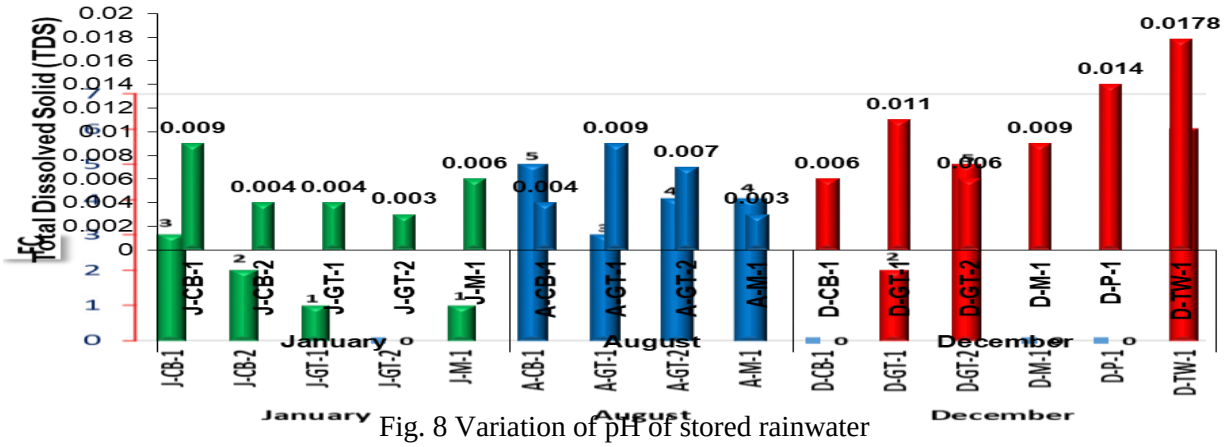


Fig. 8 Variation of pH of stored rainwater

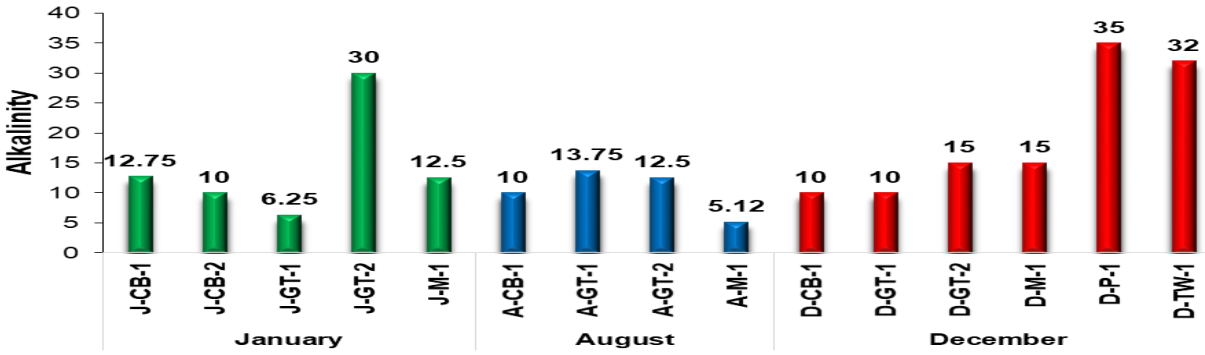


Fig. 11 Variation of alkalinity of stored rainwater

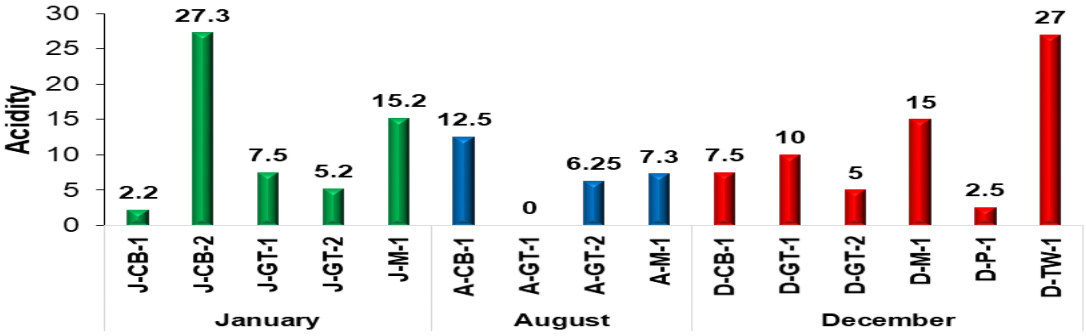


Fig. 12 Variation of acidity of stored rainwater

CONCLUSIONS

Suitable technology for safe drinking water supply which will be feasible to the local community, both in terms of available resources and adaptive capability in different geographic parts of the world is still an important issue. Apart from the limited supply of safe drinking water, quality of available water is of great concern also. To ensure an adequate supply of safe water and thereby, protect public health, particular attention should be directed to the implementation of comprehensive water safety plans and techniques. Rainwater harvesting is a good option in areas where good quality fresh surface water or ground water is lacking. It can also be thought as an alternative in areas where centralized water supply system capacity is not able to deal with the whole demand. Therefore, the application of rainwater harvesting technology could be considered as an alternative to the current paradigm of water supply sector In Bangladesh, acute scarcity of fresh water in rural areas is forcing people to look for other alternatives among which rainwater harvesting is a very familiar one. But the lack of maintenance practice and knowledge often turn this water into contaminated water and cause health concerns. Therefore, microbial contamination is often found in stored rainwater and the quality deteriorates with time due to lack of maintenance. So proper maintenance practice is the first priority to maintain the quality of stored water to be used for long period.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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A CASE STUDY ON ENVIRONMENTAL AND HEALTH EFFECT OF BRICK FIELD AT SAVAR UPAZILA IN BANGLADESH

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ABSTRACT
Brick manufacturing is the fastest-growing industrial sector in Bangladesh. In Savar Upazila among the other environment pollution, air pollution is one of them. Brick kilns are the major source of air pollution along with other sources. This research is based on both primary and secondary data sources to know about brick kilns pollution impacts on human health and environment around brick kilns zones, and to find out for minimize the air pollution do brick kilns adopt new technologies. For this research, primary data were collected from Savar Upazila because many brick kilns were situated there and secondary data sources were provided the information about brick kilns production of different toxic pollutant components for air pollution and human hazards. Respondents of this research have shared that they are suffering with diseases like skin disease, eye irritation, respiratory problems, which accelerated many accidents on that particular area due to brick kilns. Crop loss, decreased soil fertility and subsequent reductions in crop production were reported. Trees around brickfields were dusted badly and water quality of nearby water bodies deteriorated because of emerged dust and ash from brick fields. Noticeable negative impacts on aquaculture were found. Except few, majority of the respondents were suffering from various diseases like eye irritation, skin diseases and respiratory problems. Despite creating work opportunities for local people, brick fields of the study area adversely affected environment and social economy.

Keywords: Brick kiln emission; Environmental effects; Health effects; Socio-economic impacts.

INTRODUCTION

It has been said that the study of brick making is the study of civilization because brick, made of mud and straw, has been used for thousands of years Brick production was started in Bangladesh from the very beginning and this is a part of art and architecture. In conjunction with the urbanization, brick industries are rapidly increasing and migrations of people into the city areas pressurize to produce more brick. As a result, more and more brick kilns are being built. At present, over 400,000 people are engaged in work in the brick industry in Bangladesh. Brick industries contribute as the second chief source of air pollution next to vehicle emission and road settlements. Brick burning contributes to environmental pollution, ecosystem damage and also to absorption of greenhouse gases in the atmosphere in higher quantities (IUSS, 2002). Besides, brickfield workers are forced to accept a subhuman life because of polluted air and poor water quality. Exposure to such high levels of pollutants

can jeopardize immunity of human body, contributing to respiratory disorders like lung cancer, asthma, chronic bronchitis, and emphysema (Joshi and Dudani, 2008). The most severe health impacts of outdoor air pollution are associated with particulate matter (size >10 microns) (Raut, 2003), which is commonly found in brick kilns. Exposure to higher temperatures, higher dust density and particulate matter over a long time result in occupational health problems, including serious disease (e.g. lung cancer) (Begum *et al.*, 2010). Brick kilns have long term and short-term impacts on the environment. Hampering normal vegetation process, reducing crop production, deforestation etc. are short term effects while long-term impacts include ozone layer depletion, global warming, production of photochemical smog, reduction in land fertility, etc. (Pokhrel, 2011). Once top soil is removed for making bricks, it takes 25 to 30 years for those lands to regain fertility. On average, each kiln burns 350 tons of woods per year, so more active kilns cause rapid deforestation. Black smoke from brick kilns moves away the species which are involved in pollination process, in turn declines agricultural production (Islam and Rahman, 2011). In Bangladesh about 8000 brick fields are set up without clear environmental guidelines (The Financial Express, 2013). Traditionally, brick manufacturing is a small-scale and unorganized industry which is mainly concentrated in the rural and peri-urban areas of developing countries. About 25 to 26 percent of country's wood is used for burning bricks every year, causing deforestation. Usually brickfields in Bangladesh are located near towns or major construction sites (Banglapedia, 2009). But according to the Brick Kiln Control (amended) Act-2001, "there must be no establishment of brick kilns within a three-kilometer radius of human inhabitation or reserved forest" (The Daily Star, 2014).

While the sector is important for Bangladesh's economy, the brick industry is resource intensive and polluting, having significant social and environmental consequences. The industry is characterized by the use of outdated technologies, high emissions and the dominance of a single raw material (clay) and product (solid clay brick). Bangladesh currently produces around 17 billion bricks per year, consuming around 45 million tons of fertile soil – equivalent to around 2,600 hectares of agricultural land. At this rate, the country is quickly moving towards severe food shortages in the foreseeable future. Apart from using soil, brick kilns burn nearly 3.5 million tons of coal and 1.9 million tons of wood annually in kilns with outmoded designs, causing severe air pollution. According to a study by the Bangladesh University of Engineering and Technology, almost 38 percent of particulate matter pollution around Dhaka is attributable to brick kilns.

The study aimed to reveal changes in socio-economic, environmental aspects and health effects what the respondents observed before and after establishment of brickfields around them. Resulting information was expected to indicate positive or negative impacts of the brickfields on agriculture, aquaculture and socio-economic condition of the study area.

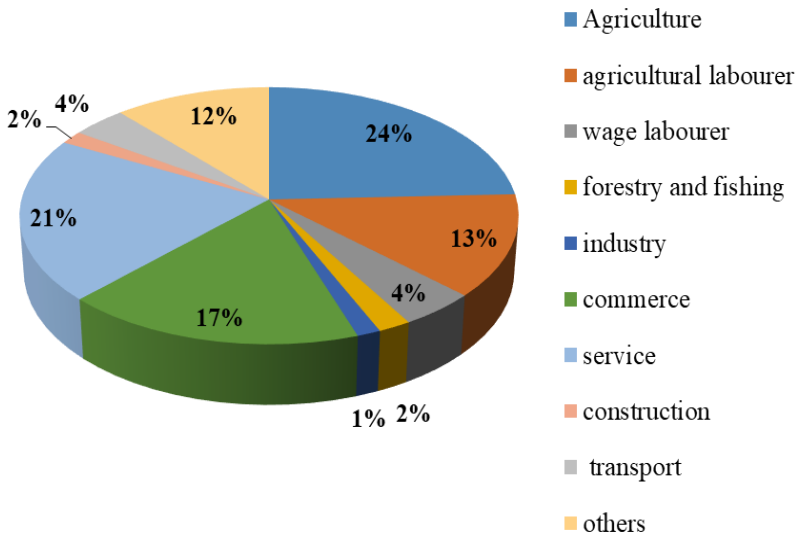
Present scenario of study area

Savar is located at 23.8583°N 90.2667°E. It has 66,956 units of household and a total area of 280.13 square kilometres (108.16 sq mi). It is bounded by Kaliakair and Gazipur Sadar upazilas on the north, Keraniganj upazila on the south, Mirpur, Mohammadpur, Pallabi and Uttara thanas of Dhaka City on the east, and Dhamrai and Singair upazilas on the west. The southern part of the upazila is composed of the alluvium soil of the Bangshi and Dhalashwari rivers. Main rivers are Bangshi, Turag, Buriganga and Karnatali. The total cultivable land measures 16,745.71 hectares, in addition to fallow land of 10,551.18 hectares. As of the 2011 Bangladesh

Fig. 1.1 Location of the study area (Savar Upazila)

census, Savar Upazila had a population of 1,387,426. Males constituted 54.20% of the population, and females 45.80%.

Over 200 brick kilns have been set up in Savar including 30 to 35 in Amin Bazar and 10 to 15 in Genda area, locals sources said. The



socio-economic impacts of brickfield on a participant were assessed in terms of his/her occupation, income, health and housing conditions.

Fig. 2 Socio-economic status of Savar upazila.

METHODOLOGY

The review attempts to summarize and interpret the available recent evidences of the extent of exposure to risk factors and health problems of brick field workers. Review of existing research work (e.g., published research articles, unpublished research works, organizational and corporate reports and theses) was carried out taking into consideration the types of environment and occupational pollutants and their effect on human health.

Data collection

A field investigation and questionnaire survey on environmental and health effect of brick field Savar Upazila, Dhaka was done to justify the evidences and to get actual data. The questionnaire survey was done among 140 people who are directly or indirectly associated with the brick fields. All respondents were later divided in two group workers and the people who are living surrounding the brick fields.

There were 40 workers in category-1 and 100 peoples are in category-2. The people in both categories were in the disastrous effect of brick fields.

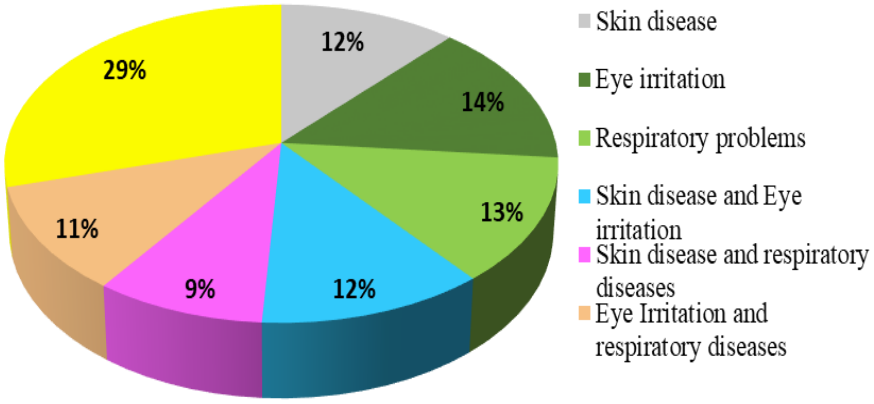
RESULTS AND DISCUSSIONS

Income level of respondents

All respondents who worked in brickfields were found to be economically benefited. Most of them were of medium income range 8000-12000 BDT (46%), although this amount of wage is not fairly adequate for standard living. They considered this as a chance to have better life because brickfields created permanent job opportunities locally which were not available previously. 36% of the respondents were engaged with other works and were of lower income range (5000-8000) BDT.

Effect on agricultural production

A few respondents 26% opined that, there were no effects of brickfields on agricultural production. Majority of the respondents 74% alleged emission of black smoke for reduction in agricultural production. After brick kiln was set up near the crop field; production of crops had been declined. During survey, we could observe directly that many of the agricultural lands had become unsuitable for producing any crops due to over exploitation of its top soil, drying water sources, low water holding capacity on soils, poor crop stability and reduced crop productivity. Emissions from brickfields puts harmful effect on Coconut trees, mango trees and mustard seeds.



Air pollution of brick fields

The smoke generated from the brick field reduces the amount of oxygen by increasing the amount of Carbon-di-oxide in the air mixed with air. Air pollution was visible in the study area due to emissions and dusts form brick fields. Many people in those areas suffered from various respiratory diseases due to acute air pollution. According to International Ambient Air Quality Standards (IAAQS). The average concentrations of SOx for the non-operational phase was about 6 to 9 times less than the operational phase of brick kilns. Similarly, NOx values were found to be 4 to 6 times less than the non-operational phase.

Health effect of brick field

Due to black smoke in the brick kiln, people are suffering from various diseases Health examination of people located next to brick kilns showed the worse hygiene condition in case of direct exposed group of people as compared with non-exposed group of people. Because of unusual chemical composition and optical behavior, it affects visibility and climate differently than other particulate species and all these are responsible for the emission of toxic gases.

Fig. 3 Various types of diseases due to brick field

Effect on aquaculture

More than half (58%) of the respondents said that, "brickfield has major effect on fish production and aquatic plant production" and rest of the respondents reported minor effects on aquaculture. The respondents who owned pond near the brick fields reported that fish production declined after setting up brickfields in that area. Brick fields are directly or indirectly responsible for water logging, water pollutions which is responsible for various types of diseases to the aquatic life.

Effect on vegetation

Majority of the respondents (85%) told that agricultural productions were decreasing with time and brick field had major effect (lower production, poor development, different diseases etc.) on vegetation [fruits and vegetables] and 9% of the respondents commented that brickfield had minor effects on vegetation and 6% respondents were not aware of any adverse effects on vegetation.

Effects on soil fertility

Majority of the respondents (83%) opined that brick field had major effect on soil fertility as well as agricultural production. The respondents who owned agricultural lands near brick fields were negatively affected by black smoke and ash that spread over the crop. On the other hand, 16% of the respondents complained about minor effect and 10% of respondents felt no impact on soil fertility. The Upazila Agricultural Office also reported that crop production has reduced adjacent to the brickfield area in recent years. Burning of soil decreases soil pH, increase sand and decrease clay content It has serious impacts on physical, biological, and chemical properties of soil resulting sharp declination in soil fertility and productivity.

CONCLUSIONS

From the study it was found that most of the brickfields of the study area were located near agricultural lands and residential areas those were responsible for loss of agricultural production, fish cultivation and local community's health problems in great extent. Besides, brick fields were considered as the principle reason of top soil degradation and environmental pollution of the study area. Besides, community's health problems in great extent. Skin disease, Eye irritation, Respiratory problems, gastrointestinal, injuries, reproductive and mental health are such kinds of problem. Gastrointestinal health problem is one of the major concerns for the brick kiln workers because there is no sufficient and clean water supply including use. Mental health is a great concern for brick kiln workers because it is very low paid job and has to work under pressure in an excessively polluted worksite.

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4thInternationalConference on Advances in Civil Engineering 2018 (ICACE 2018)
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CUET, Chittagong, Bangladesh
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PERFORMANCE EVALUATION OF THIN CEMENT-SAND MORTAR SHEET AS PROTON EXCHANGE MEMBRANE IN BIO-ELECTROCHEMICAL SYSTEM

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ABSTRACT
Microbial Fuel Cell (MFC), a device to generate electricity with the use of organic waste, is considered to be a better option now-a-days for waste management as well as power generation. This could be a sustainable power source (SPC) for the future world where the power demand is expected to increase by a large amount. The performance of the MFC is mostly depended on the materials used for its electrodes. However, its constituent materials are too expensive to make it a viable product for power generation. Replacing its membrane with thin cement-sand mortar (CSM) sheet could be an option to reduce its cost. This study assessed the performance of a MFC where CSM sheets of different thickness (4mm, 7mm, 9mm, 10mm) were used as proton-exchange membrane, and variable water, cement and sand ratio was also used to prepare CSM sheets as well. Sediments from a local Lotus Pond were taken as substrate to run the MFC. Verification of a thin cement-sand mortar sheet as a replacement for traditional membrane materials of MFC to produce electricity was performed and it was found that the prepared sheet for this study has the capacity to generate power. The performance evaluation of the sheet showed that production of electricity was increased with the decrease of the thickness of proton exchange membrane (PEM) of CSM sheet and the optimum production was observed at 4 mm thickness of the sheet. However, further evaluation of the study is recommended to get optimum production from the CSM.

Keywords: Microbial Fuel Cell (MFC), Electricity, Proton exchange membrane (PEM), Cement Sand Mortar (CSM) sheet etc.

1INTRODUCTION

A microbial fuel cell (MFC) can be defined as bio-electrochemical system which can produce electricity from organic compound producing electro-active bacteria (Ebrahimi, Najafpour, & Yousefi Kebria, 2018). Electricity production by a microbial fuet cell (MFC) has drawn much attention as it can be a future renewable power source (Park, Kim, Kim, Kim, Kim, & Kim, 2001). In recent years, some significant progresses have been remarked in MFC. But the requirements of cheaper and efficient materials have made it difficult to implement in large scale (Jonathan Winfield, 2016). MFCs show the attractive power generation tendency though it's required only low power, but where replacing batteries may be impractical, such as wireless sensor networks (Mukhopadhyay & Jiang, 2013) (Wang, et al., 2014). Any kind of substrates containing organic compound that uses in the bio-electrochemical system can produce power electricity with the use of membrane or mediator as proton exchange membrane. Proton exchange membrane(PEM) used in between cathode and anode chamber plays a vital role in the performance of a microbial fuel cell (Z. Du, 2007). Although some recent progresses have been remarked in development of proton exchnage membrane (PEM) some limitations are still left such as

proton transfer incapability and oxygen leakge which increase internal resistance and decrease the performance of microbial fuel (MFC) (W.W. Li, 2011). These factors limit the large scale implementation of MFC. In recent years, many materials have been used as proton excahnge membrane such as cation exchange membrane, anion exchange membrane, ultrafiltration membrane (J.R. Kim, 2007), bipolar membrane (A. Terheijne, 2006), microfiltration membrane (J. Sun, 2009), j-cloth (Y. Fan, 2007) and salt bridge (B. Min, 2005). Potential mediators include natural red, methylene blue, thionine and resorufin (Bennetto, Stirling, Tanaka, & Vega, 1983). But these above materials are expensive. To make the microbial fuel cell (MFC) more feasible, obviously these costly materials are required to be replaced by cheap materials. As we know, efflorescence caused on building foundations and masonry walls or chimneys where all outer part is plastered by the cement-sand mortar. So thin cement-sand mortar sheet may transfer ions through it. Electron transfer capability of thin cement-sand mortar sheet is mostly dependent on porosity which is a function of water: cement: sand ratio. In this research, potentiality of thin cement-sand mortar sheet has been investigated with different water: cement: sand ratio.

2METHODOLOGY

To check the potentiality of thin cement-sand mortar sheet as a proton exchange membrane, all the experiments are directed by using Microbial Fuel Cell. For this purpose four analogous MFC are made with the same fabrication method. MFC preparing procedures are explained below and discussion on experimental results and analysis is done in the following section.

2.1 ANODE AND CATHODE CHAMBER AND PEM PREPARATION

For the preparation of four MFCs, 8 cubic shaped plastic bowls [Fig.1(a)] were collected having size of 4”x4”x3”.[Fig.1(b)] One of the faces of each bowl was cut down to make an opening of 28mm X 28mm.

For the Proton Exchange Membrane (PEM), there also needed a matrix where PEM would be placed. Matrix was built up with plastic wood thickness of 2mm with 28mm x 28mm cross section area. [Fig.1(d)]. Preparation of the thin cement-sand mortar sheet there used a standard ratio of water: cement: sand = 1:1.5:3. This was so sensitive work that if there used the ratio of 1:2:3 because it showed less voltage than 1:1.5:3 as experienced. And for this purpose 1:1:3 ratio was also picked up, but it was too vulnerable to maintain. On the other hand it should be kept in mind that the membrane needed to be permeable. Considering all these phenomena the standard ratio had been chosen. [Fig.1(c)] shows the PEMs.

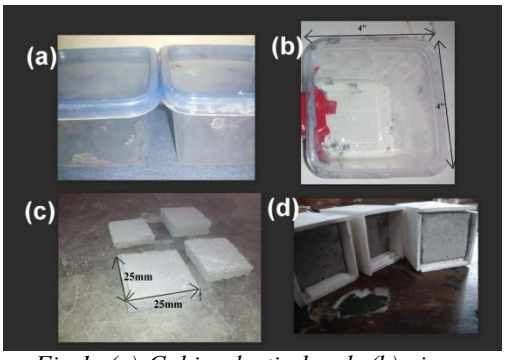

Fig.1. (a) Cubic plastic bowl, (b) size of the bowl (4”x4”x3”), (c) PEM preparation, (d) placing of PEM in the matrix or chamber.

2.2 CONNECTOR PLACEMENT

At the time of placing of a connector in the MFC it should not be overlooked that there leaving any leakage between the bowl and the connector. Cause, if there remains any leakage the Anode chamber would not fulfil the anaerobic condition when MFC runs which is the major condition during running the MFC.

2.3 ELECTRODE PREPARATION

Electrodes are most important things in the MFC. As an electrode, graphite rods are used because it is cheap and much available. In this case there six electrodes are brought with size of 300mm length and reshaped with 80 mm length and 5mm dia. But because of unavailability of these electrodes in nearby shops it's borrowed from the laboratory that used before. And the placement of those electrodes is shown in [Fig.2]. And the feedback from these electrodes was unknown before running the MFC. Electrodes were fitted together with copper wire and for removing the holes used some adhesive when placing in the cover of the chamber. Holes of air pipe and copper wire had also provided in the cover plate of the bowl.

Fig. 2. Electrode Fabrication

2.4 SUBSTRATE PLACEMENT

At first there used cow dung as substrate in the Anode chamber. But with this substrate the expected result wasn't found. After failing this experiment there collected sediments from the beneath part of the CUET Lotus Pond. Because dead green plant and fisheries are deposited too much under the beneath of the pond which takes small amount of time to generate voltage. 0.7kg substrate used for the experiment and placed in the Anode chamber. Figure [Fig.3] shows the placing of substrate in the Anode chamber. The efficiency of the MFCs can be shown with the various thickness of membrane as experimented.


Fig. 3. Substrate placement in the anode chamber with electrodes

2.5 FULL SET-UP OF MFC

Anode and Cathode chambers are prepared. These two chambers were connected with the connector that was prepared before and the PEM was placed in the connectors. Various types of thickness used in different cells to determine the optimum thickness of the membrane at which maximum efficiency would be found. Thicknesses are 4mm, 7mm, 9mm and 10mm were used in four different cells. The air pipe also placed in 5mm dia hole. Electrodes were inserted through the copper wire holes. Air pipe placed in the cathode chamber to keep aerobic condition in the chamber. With full of substrates in the Anode chamber electrodes were provided and sealed well so that there remained anaerobic condition. After all set-up temperature was measured as 31°C. And distilled water also provided in the cathode chamber as bearer of proton. The crucial part of the set-up was to watch carefully that with the transport of cell there created any leakages or not. If there any leakages found putty used as adhesive and tape to seal the chamber. Because, if there remained any leakage in the cell the expected result never be found. [Fig. 4] shows the MFC when it already ran.


Fig. 4. Full set-up of MFC

2.6 DATA COLLECTION

After finishing the full set-up of MFC it was kept for 5 days. Then with the help of multi-meter the reading of voltages that created in the cell was taken. It's naturally showed a reading at the very beginning. With the increase of time the value literally risen up. But after 1 day it's remain constant. And one more thing is that after removing to supply air to the cathode the value differs a little bit. It remained almost 3-4 days as constant. Then it's started to decreasing. Now, performance of microbial fuel cell would be evaluated. Power density as well as current density also calculated later in the results and discussions.

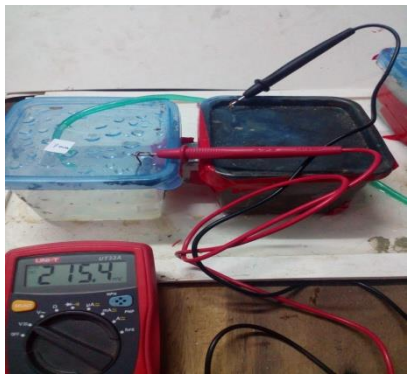

Fig. 5. Data collection with multi-meter.

3 RESULTS AND DISCUSSIONS

MFCs were kept for five days after assembling without taking reading and then the reading of voltages from multi-meter were taken at an interval of one hour. It was explained before that several thicknesses of the membrane were used for the different cells. At first it was taken 10mm thick membrane, and the performance of this sheet was verified at different water-cement-sand ratio. Table1 shows voltage production for three identical cells of 10mm thickness but with different water: cement: sand ratio of PEM. It was found that the ratio 1:1.5:3 having maximum potentiality to produce voltage. Therefore the other PEMs of y 9mm, 7mm and 4mm thicknesses were made with the same water, cement and ratio and subsequently their performances were evaluated.

Table 1: Multi-meter reading for different water: cement: sand ratio

Sample No	Water: Cement: Sand	Voltage(mV)
01	1:2:3	134
02	1:1.5:3	162
03	1:1:3	-

The current and voltage found from the multi-meter are represented in the Table 2. It was observed that there is an increase of current and voltage generation with time after 5days but the optimum performance was between 9-12th hour.

Table 2: Multimeter reading for current and voltages from 4mm thick PEM in MFC

Time after 5days (hr)	Current (μA)	Voltages (mV)	Time after 5days (hr)	Current (μA)	Voltages (mV)
1st	0.6	134	8th	7.2	238
2nd	1.1	167	9th	7.3	242
3rd	1.8	175	10th	7.3	245
4th	2.6	189	11th	7.2	249
5th	3.4	197	12th	7.3	253
6th	4.9	208	13th	7.2	251
7th	6.7	221	14th	7.2	253

Table 3 shows the current and voltage production from PEMs of different thickness. The resistances, current and power densities are also showed in Table 3. The current and power densities were calculated from produced current and voltage by the following equations.

Current density = $\frac{\boldsymbol{Values\ of\ current}}{\boldsymbol{surface\ area\ of\ the\ electrodes}}$ Eq.1

Power density= $\frac{Power}{surface\ area\ of\ the\ electrodes}$ Eq.2

Where surface area of electrode= 2πrl*2.

Table 3: Average electricity production with varying thickness of PEMs

Thickness of Membrane (mm)	Mass of Substrate (kg)	Voltage (mV)	Current (μA)	Resistance (MΩ)	Current Density (mA/m^2)	Power Density (W/m^2)
10	0.7	162	1.3	5.6	2.57	0.000042
9	0.7	185	2.2	4.3	4.37	0.000081
7	0.7	232	4.2	3.2	8.35	0.000193
4	0.7	253	7.3	2.7	14.51	0.000367

4 PERFORMANCE EVALUATIONS

The relation between current and voltage production with time is shown in Fig. 6 where it is evident that both the current and voltage production initially increased with time but it became reasonable steady after 8 hours. It was also observed that the current and voltage production was decreased after 6-7 days of MFC set up. The performances of PEMs of different thickness were also observed (Fig 7 and 8). It was observed that with the decrease of thickness both the power and current density increased (Fig.7) while both current and voltage increased with the decrease of thickness shown in Fig. 8.

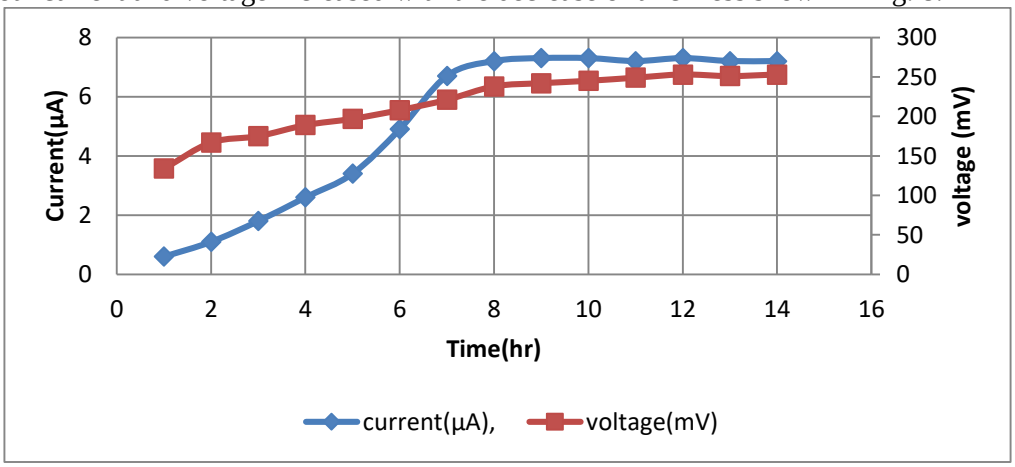

Fig.6 Variation of Current and Voltage with Time (4mm thick)

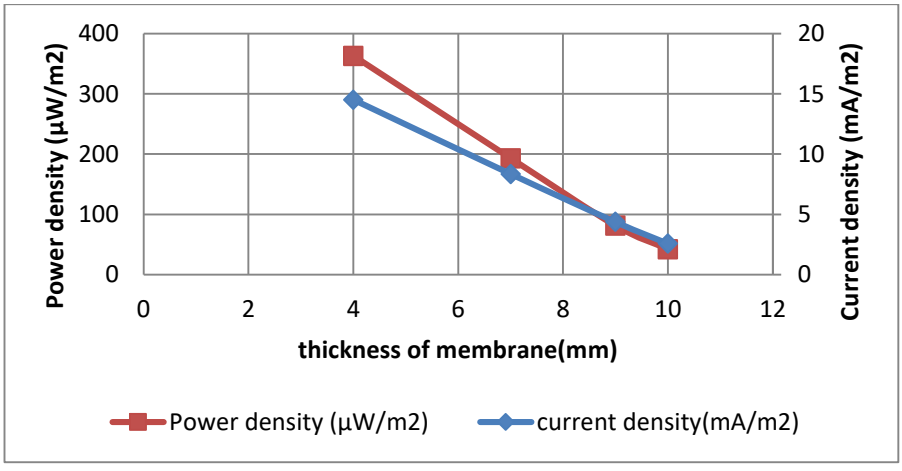

Fig.7. Variation of Power Density and Current Density with varying thickness

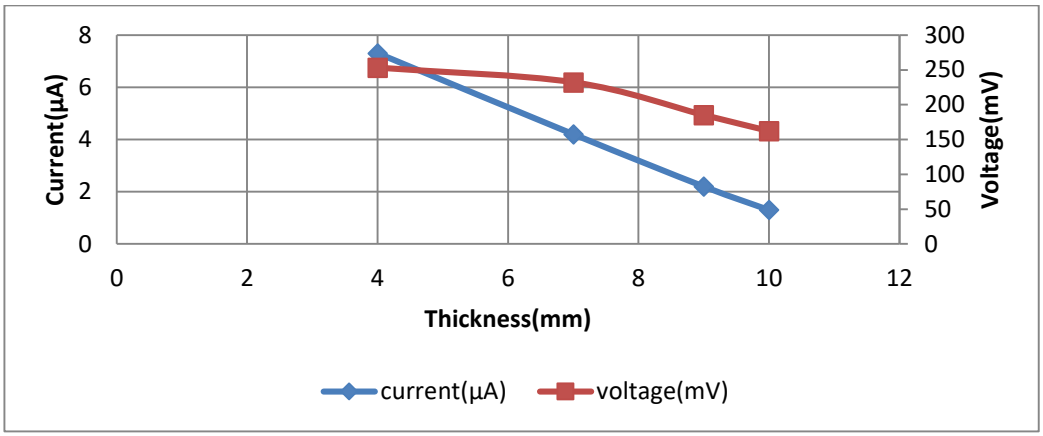

Fig.8. Variation of Current and Voltage with varying thickness.

From the above performance assessment it is obvious that the optimum performance was obtained with 4 mm thick PEM. It is noteworthy to mention that the installation or preparation of the sheet made with the thickness below 4 mm was not possible due to its stability concern.

5 CONCLUSIONS

The main objective of this study was to verify the proton transfer capability of thin cement-sand mortar sheet and it was found that the prepared sheet for this study has the capacity to pass proton from anode to cathode. Moreover the results show that decreased resistances but increased productivity of power electricity with the decreases in membrane thickness. The optimum performance was observed with 4mm thick membrane sheet the detailed analysis should be needed further though.

However type of substrates to be used for power generation of MFC is also an important factor as the other substrates might have the higher potential rather than the substrate used in the study. Gradation and porosity of the raw materials used in preparing the cement-sand sheet might be of important concern, and hence further evaluation must be needed taking these engineering properties into account and with other indigenous materials as well. Another important thing is that the set-up of the MFC is not costly as there were used indigenous materials and low cost electrodes. And the wastes that collected from the beneath part of the pond consists of huge organic compounds. When it digests, it produces huge amount of electro-active bacteria which plays a vital role in running the MFC. Just need to keep the anode chamber in anaerobic condition otherwise it fails to generate power. Finally, it can be assured that this power generation system is very handy.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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FIELD STUDY ON PRESENT SITUATION OF THE BURIGANGA RIVER FOR THE HARMFUL EFFECTS OF PLASTIC SOLID WASTES

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ABSTRACT
The Plastics are one of the common versatile materials in this modern era. In general sense, plastic contains chemicals, additives like pigments, concentrates, anti-blockers, light transformers, UV-stabilizers etc. Though it is providing a leading question about the bio-ecology all over the world, sufficient studies or researches are not being conducted yet in Bangladesh. As a consequence, for the last two or three decades, the quantity of plastic solid wastes in the Buriganga river is increasing tremendously as well as converting it to a dead river. In this paper, the authors have tried to collect primary information from field study and different journal papers about the current situation of plastic solid wastes in Buriganga which have been compared to each other and that have been presented. This study has also demonstrated that a large unseen volume of submerged plastic is flowing into this river and many of the problems associated with plastic wastes attract considerable public attention. The authors have concluded the paper by recommending that, more studies are needed relating to the dangers of dumping plastics on the river that pose an immediate and long-term threat to the state of the Buriganga river and improved technologies should be applied**.**

Keywords: Buriganga river; Harmful-effects; Plastic solid wastes; Pollution; Technology.

INTRODUCTION
For the last 60 years, the plastic production is increasing tremendously and now it has reached 288 million tons from 1.7 million (Plastics Europe, 2013). From 1960, several official and unofficial studies have been conducted and they have claimed and proved that plastic liter is responsible for marine environment pollution and subsequent harmful effects; these publications have disclosed that the major contributors of these pollutants are river and land-based sources (Andrady, 2011; Barnes et al., 2009; Carpenter et al., 1972; Coleet al., 2011; Derraik, 2002; Rech et al., 2014; UNEP, 2009). There can be found a huge amount of plastic wastes with other debris like glass floats, bottles and light tubes, metal cans and derelict traps, and nets and line in the marine environment but (60–80) % is predicted as petroleum-based plastic (Derraik, 2002; Thompson et al., 2004; Browne et al., 2010,2011). In the Buriganga river, the amount of plastic wastes is increasing tremendously. A lot of marine life including marine mammals, birds, and reptiles in this river are affected by plastic pollution through liberation and ingestion as well as through the persistent organic pollutants that sorbs onto the plastic. Marine environment can receive plastic pollutants from several sources like drainage systems or sewage treatment especially at the time of huge rainfall (EPA, 2007) or developed structures, like ferries and wharves. Another two dangerous elements which are responsible for marine pollution are Polyethylene and polypropylene; mostly used in facial cleaners (Gregory, 1996; Fendall and Sewell, 2009). Textile industries are also important sources of micro plastic fibers (Browne et al., 2011), and since the early

1990s, micro plastic particles from sandblasting industries have been suspected to contribute in polluting the marine environment (Zitko and Hanlon, 1991). The Buriganga river basin is heavily exposed through the impacts of human activity. This paper has been designed to evaluate the quantity and quality of plastic solid wastes blowing down the River Buriganga within the Dhaka city.

METHODOLOGY

The research work was conducted in the following way:

(1) Site Exploration: Before collecting sample pictures, the site of the bank of the Buriganga was visited several times for the purpose of site selection and photograph collection.

(2) Photograph Collection: Some photographs were collected from the bank of the river and the upper surface of the river, photographs were collected by the authors. Fig. 1 shows the plastic wastes at river bank.

(3) Data Collection from journal papers and books: After observing the locations, different journal papers, books were used for collecting data.

Table 1: Geological positions of the selected sites.

Site name	Longitude	Latitude
Babu Bazar Ghat	E 90° 24' 9.78"	N 23° 42' 33.57"
Badamtoli Ghat	E 90° 24' 13.47"	N 23° 42' 31.8"
Sadarghat	E 90° 24' 31.6"	N 23° 42' 24.5"

(a)

(b)

(c)

Fig. 1: Photographs showing: (a) Plastic wastes at Babu Bazar Ghat; (b) Plastic wastes at Badamtoli Ghat; (c) Plastic wastes at Sadarghat.

RESULTS AND DISCUSSIONS

Present situation

To describe the current situation of the Buriganga River, it is essential to understand the volume, variety, and types of dumping are being received by the river. The average depth of the river is 7.6m with a maximum depth of 18m (Khan, 2005). More than 249 tanneries are situated on the Buriganga River's bank and most of these industries do not have any effluent treatment plants (Sarker, 2005). As a consequence, every day the river receives approximately 22,000m³ of liquid waste containing different elements. Besides that, there are many other sources such as industries like dyeing industry, fertilizer industry, workshops for aluminium, steel and iron, car repairing, production of battery, different pharmaceutical materials, hardware and cold storage units-which are responsible for adding 3,500m³ liquid wastes to the Buriganga's water per day (Gain et al., 1998; Khan, 2005; Hossain, 2007). According to Daily Star Magazine, Buriganga river receives around 9,000m³ of untreated effluents in total from domestic and industrial sources per day. The bank in between the second Buriganga Bridge and Kamrangir Char is one of the most wasted places where a huge amount of wastes is deposited directly into the river water daily.

This paper has identified the environmental health risks facing or will be faced for Buriganga's water pollution, following the approach presented in the methodology. The data represented here has taken along with secondary literature and information. The explicit analysis is presented here.

Sources of plastic wastes:

Domestic wastes:

From the very beginning, Dhaka residents are throwing different kinds of domestic and solid wastes into the Buriganga river. Every day Buriganga-Turag system receives about 900 cubic meters of untreated human and domestic wastes. The plant located at Pagla is the one and only one sewage treatment of Dhaka WASA and its everyday capacity is only 0.12 million cubic meters that cover one-tenth of the total sewage disposal. The worst situation is, because of negligence, the plant can use only one-third of its rated capacity at most.

Sewage and industrial waste

Most of the industrial units around the Buriganga River do not have their own sewerage treatment plants. This river receives about 60,000m³ toxic wastes containing washing, textile dyeing, printing and pharmaceutical wastes daily.

Local vessels

Local vessel operators indiscriminately dump plastic wastes into the Buriganga, completely disregarding the DCC laws. BIWTA sources ensure that at the time of river dredging, they get an enormous amount of polythene dumped beneath the water. When the building located at the river bank is broken for new construction, then it adds a huge amount of dangerous elements into the river water. Numerous mechanized trawlers and vessels play in the rivers that make the situation worse. Unawareness of the harmful effects of materials coming from the vessels and burnt oil and the lack of stringent laws of BIWTA are also responsible for this huge pollution.

Sedimentation

In the dry season, due to the sedimentation upstream, Buriganga-Turag system's flow gets cut off. Bangladesh Water Development Board's (BWDB) hydrologists and engineers have informed that the flow of water at that time is next to zero. At this time, the system mainly carries sewage and industrial wastes. Therefore, sedimentation is also indirectly contributing to river water pollution. Sedimentation could be resulted by means of both natural and man-made. Sedimentation can be occurred by

man-made non-biodegradable materials like polythene. A recent study expresses that about 10 feet polythene stratum has been embedded under a certain stretch of the Buriganga. Giving shallowness of the river, polythene makes the terribly polluted river's situation worse.

Harmful effects of plastic wastes:

- One of the most recent and important effects of plastic pollution is bio-accumulation of plastic inside animals. Harmful chemicals are released by these accumulated plastic wastes and also break down into small pieces with cause adverse effect on the animals. Even after their death, those plastic wastes remain present in the marine environment.
- Another important source is wind which carries and deposits plastic from one place to another. Sometimes these plastic waste gets stuck on fences, trees, buildings, developing structures etc, when an animal that comes in its close area that might even get involved in it and strangle to death.
- The atmosphere becomes polluted when plastic materials are burned because of releasing of poisonous chemicals, contributing to air pollution. Even if the labors work for recycling of plastic materials, have the risk of developing skin and respiratory problems by inhalation of toxic chemicals.
- Extravagant dumping of plastic wastes has created countless negative impacts on the ecosystem of the Buriganga River. Previously, many native fish species such as Rui (Labeo rohita), Katla (Catla catla), Mrigal (Cirrhinus cirrhosus), Kajuli (Ailia coila), Mola (Amblypharyngodon microlepis), Raj Puti (Barbonymus gonionotus), Tangra (Batasio tengana), Koi (Anabas testudineus), Gojar (Channa marulius), Taki (Channa punctata), Shol (Channa striata), Grass cup (Ctenopharyngodon idella), Chabli (Devario aequipinnatus), Chapila (Gonialosa manmina), Bata (Labeo bata), Khoil (Colisa fasciata), Batashi (Neotropius atherinoides), Pabda (Ompok pabo), Pangas (Pangasius pangasius), Rita (Rita rita), Potka (Tetraodon fluviatilis), Boal (Wallago attu), and Kakila (Xenentodon cancila) were available at a large amount in the Buriganga River. At this present time, dumping of plastic waste is increasing, many of those fish species are about to extinct. The pollution level in the Buriganga River is higher than any other rivers in Bangladesh (Rahman, 2011).

Table 2: Simple tests to identify recyclable plastics

Test	**PE**	**PP**	**PVC**
In water	floats	floats	Sinks
When burning with yellow tip	Blue flame with blue base	Yellow flame	Yellow sooty flames
Smell	Like candle wax	Like candle was but not as strong as PE	Hydrochloric acid
Scratch with fingernail	Yes	No	No

Source: Appropriate Technology. Vol 23, No.3. p35. December 1996.

Table 3: Percentage distribution of total solid wastes of Dhaka city

SOURCE OF SOLID WASTES	**PERCENTAGE**
Residential	75.86
Commercial	22.07
Institutional	1.17
Municipal services	0.53
Others	0.37
Total	100

Source: Bangladesh Compendium of Environmental Statistics, 2009 (BBS, 2010, p 323).

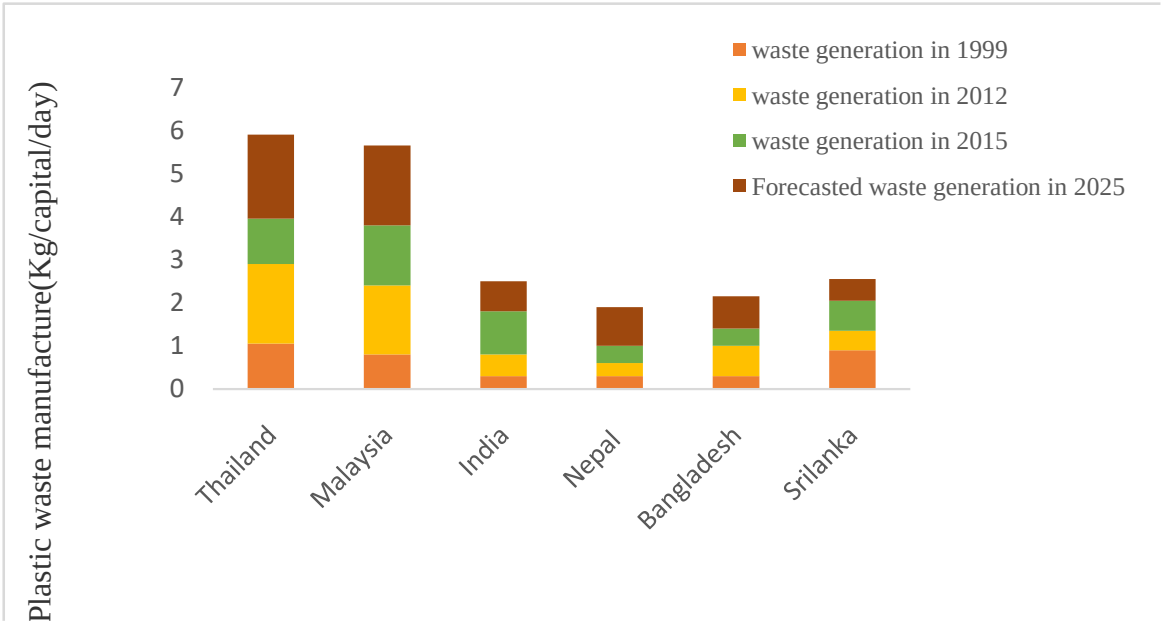

Fig 2: Plastic waste manufacture in different countries. (kg/capital/day)

CONCLUSIONS

By studying plastic wastes at a considerable scale and using many networks, the authors have presented reliable information about the quality and quantity of plastic waste conveyed by the Buriganga river of Bangladesh. A huge volume of plastic product is being produced all over the country; as a result, plastic wastes are increasing highly. Proper waste management is necessary to save the environment from harmful effects. However, want of facilities, structure development, human unawareness, and inadequate budget thwart plastic waste management in Bangladesh.

Furthermore, conventional approaches are ineffective and not enough. Effective application of the plastic waste management methods would lessen the plastic waste pollution-related problems and be the hopeful source of renewable energy.

ACKNOWLEDGMENTS

The Authors would also like to gratefully thank the teachers of Department of Soil and Environmental Sciences, Barisal University for their kind support and suggestions.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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ROADSIDE URINATION PROBLEM IN DHAKA NORTH CITY, BANGLADESH

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ABSTRACT
Roadside urination is one of the current burning issues of Dhaka North City. Mass migration, booming populations, unplanned urbanization and lack of public toilet facilities boosts this impermissible practice of roadside urination. This work focused on identifying spots, to find out the reasons behind it and to evaluate the existing public toilets facilities. This study was carried out by manual field survey throughout the different spots of Dhaka North City Corporation (DNCC). Total three different questionnaire forms were prepared for three different groups of people like i) roadside urinator, ii) affected people and iii) public toilet users. All the questionnaires were focused on the acceptance of this bad practice, frequency of the incidents etc. After analyzing collected survey data, the results indicated that among all the urinators, 29% urinators was rickshaw puller and 45% urinators choose that spots because the spots was already used by others, 50% spot users said they faced problems while using public or mobile toilets. 90% spots did not contain any urination prohibition sign. 70% affected people said City Corporation did not take any effective actions against this bad practice. Deficiency of law enforcement was also accountable for remaining this problem.

Keywords: DNCC; roadside urination; public toilet; survey; questionnaire.

INTRODUCTION
Dhaka is the capital of Bangladesh and one of the megacities of the world. Dhaka city is divided into two govt. administrative agencies. These two govt. administrative agencies are -Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC). Nearly half a million migrants flow into Dhaka each year to try to make a living in the city due to various push and pull factors. If this trend continues, predictions show that by 2025, Dhaka will be home to more than 20 million people larger than Mexico City, Beijing or Shanghai (Salam et al., 2011).

Roadside urination is one of the current burning issues of Dhaka North City. Mass migration, booming populations, unplanned and over urbanization, lack of public toilet and urinal facilities boosts this impermissible practice of roadside urination but unfortunately this matter remain under-focused to the city policy makers. As an inevitable consequence, urinating and open defecation becomes a usual practice among the citizens.

Urination is the release of urine from the urinary bladder through the urethra to the outside of the body. It is also known medically micturition, voiding, uresis, emiction (Urination, n.d.). Roadside urination is a

type of open urination in which people (especially men) pee beside the road. Generally people choose less crowded streets, beside the electric pole, tree to urinate.
Roadside urnation is never a pleasant sight and is not acceptable in any society. It causes health issue and environmental pollution. Urinators are one of the main polluter of city environment who are contributing to odor problem. By urinating at the wall, urinators obliterate the aesthetics of the surrounding area. Released Urine on adjacent footpaths makes footpath more slippery which is hazardous to person. It makes obstacle on movement for the pedestrian (Kazi et al., 2016). Moreover some of the urinators may affected by Urinary Tract Infection (UTI). Urinary tract infections (UTIs) are some of the most common bacterial infections and caused by a range of pathogens (Flores-Mireles et al., 2015).

This work is focused on identifying roadside urination spots, to find out the reasons behind roadside urination and to evaluate the existing public toilets facilities.

METHODOLOGY

This study was carried out by manual field survey throughout the difference spots of Dhaka North City Corporation (DNCC).Questionnaire was the main data collection tool of this survey. To fulfil the aim of the study, a well designed questionnaire was formed to collect data from the respondents. Total three types of questionnaire forms were prepared for the respondents.

Questionnaire for Urinator

This questionnaire is formed for the urinator. It focuses on to know their profession, reason of deciding the spot, frequency of use, paying penalty, problems faced by urinator in using public toilet.

Questionnaire for public toilet users

This questionnaire is designed to gather information from the users of mobile or public toilets. It mainly focuses to gather information of their satisfactory level about the hygienic condition, availability of toilet accessories and present privacy condition of public toilets.

Questionnaire for affected people

This questionnaire is formed to gather information of the people of surrounding spot who are affected by the road side urination. Questions regarding in this form mainly focuses on the level of acceptance of this activity among general people, types of problems they are facing due to this bad habit. It also helps us to know the satisfactory level of the affected people about the steps taken by the city corporation and other law enforcement authority.

Conduction of Survey

A survey was conducted in the selected area of Dhaka North City Corporation (DNCC).Before the survey a pilot survey was conduct to identify the spots of the selected area. Later on the selected spots were visited to collect data from the respondents by taking face to face interview of urinator and affected people of surrounding area. Mobile and public toilets were also visited to collect data from the public toilet users.

RESULTS AND DISCUSSIONS

Urinator

Total 100 numbers of people were covered as urinator in around 50 different spots through 10 different areas. Survey shows that among all the urinators, 29% urinators are rickshaw puller (Fig. 1) and around 95% spots (Fig. 2) do not have any urination prohibition sign. Because of no alternative way, 50% of the urinators (Fig. 3) still urinate while prohibition sign is available. Among the 100 urinators 45% of them (Fig. 4) showing reason that it is already used by others as urinating spot which sounds like an excuse. Around 63% urinators (Fig. 5) are frequent urinators, 90% peoples (Fig. 6) are not interested to pay any penalty and 50% spot users (Fig. 7) faces problems while using public or mobile toilets. Around 60% of

the urinators (Fig. 8) are interested to use sufficiently provided mobile/public toilet facilities with a condition. They will use those only if there is no fee regarding the facilities.

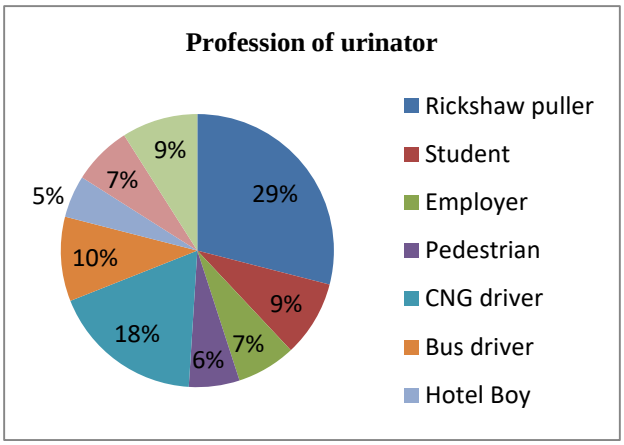

Fig.1: Urinator profession

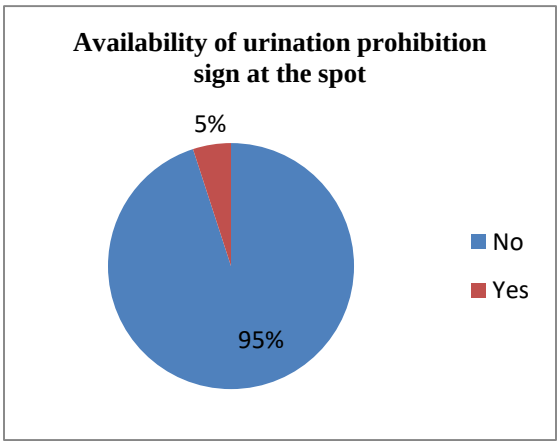

Fig.2: Availability of urination prohibition sign.

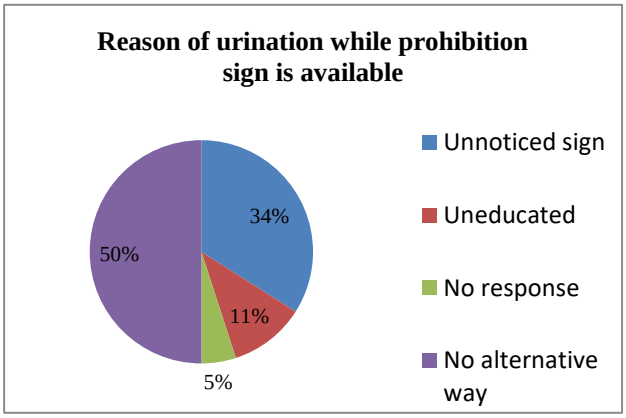

Fig.3: Reason of urination while prohibition sign is available.

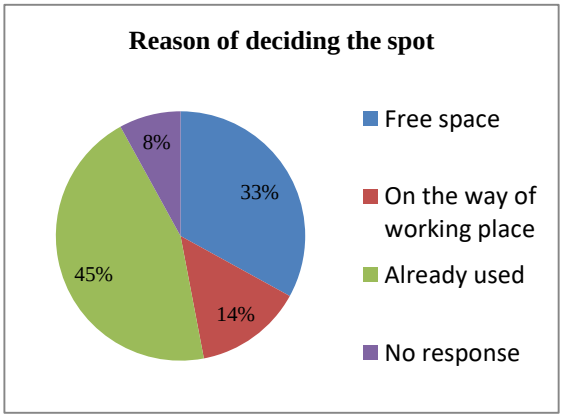

Fig.4: Reason of deciding the spot

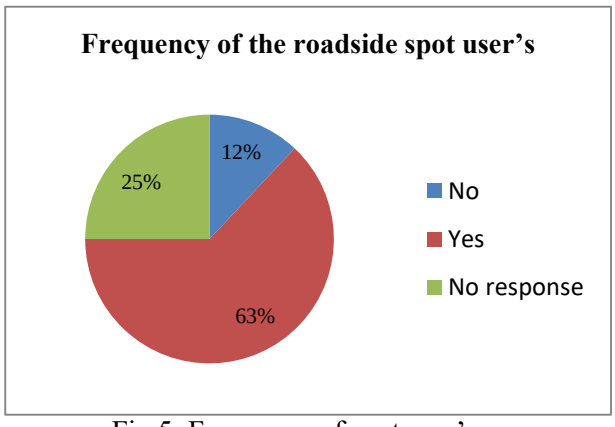

Fig.5: Frequency of spot user's.

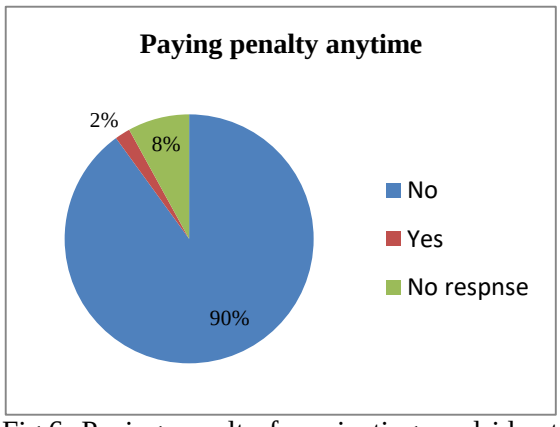

Fig.6: Paying penalty for urinating roadside at anytime.

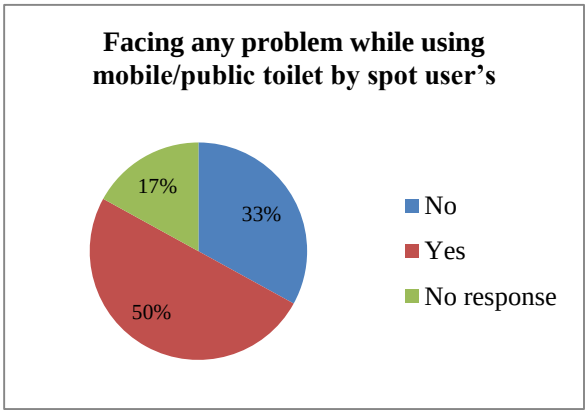

Fig.7: Facing any problem while using public toilet by spot users.

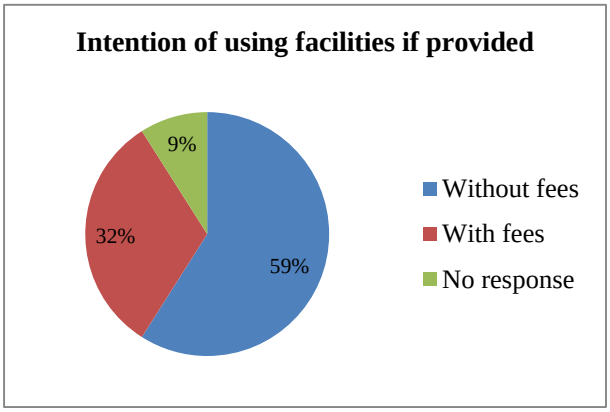

Fig.8: Intention of using facilities if provided.

Public toilet users

Data shows that, large number of users (45% users classified the situation as bad and 12% as very bad) are not able to satisfied with the present hygienic condition (Fig.9). 46% public toilet users say, all the toilet accessories are available. On the other hand 35% (Fig.10) users say not enough toilet accessories are available. Result shows that 41% public toilet users are not satisfied by the present public toilet privacy conditions but 53% users (Fig.11) say they have enough privacy while using public toilet. 69% public toilet users (Fig.12) think that, they are paying excess fees for using public toilet.

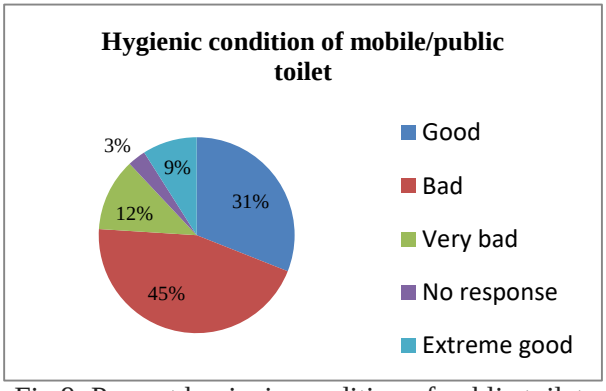

Fig.9: Present hygienic condition of public toilet

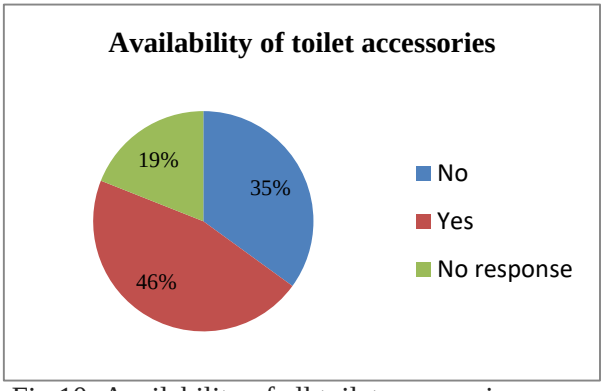

Fig.10: Availability of all toilet accessories

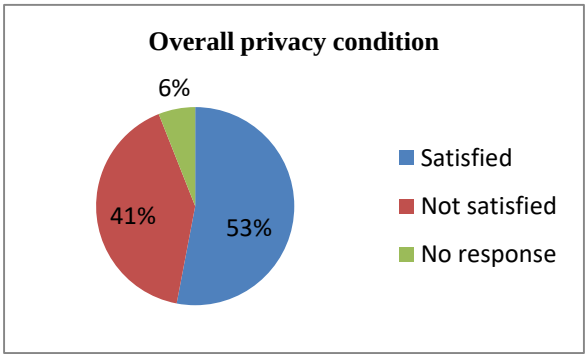

Fig.11: Overall privacy condition of public toilet

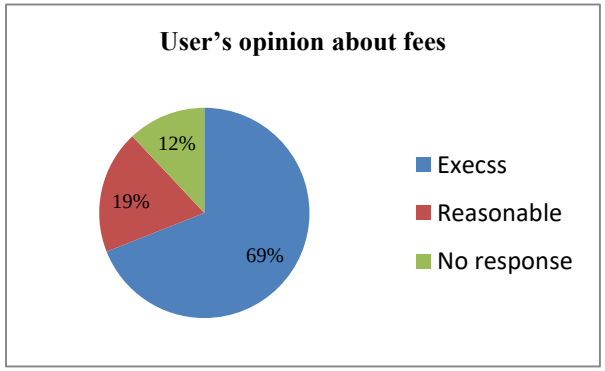

Fig.12: Users opinion about fees

Affected people

Total 100 numbers of people were covered during the survey as affected people. Among them 85% are not accepted this bad practice while 6% accept (Fig.13) it as there were no alternative and suitable options. Most of the affected people (around 61% in Fig.14) are complaining regarding difficulty in movement and some of them (20% in Fig. 15) change the direction but majority percentage (58%) never use the alternative way due to avoid traffic congestion and time constraint. 70% of affected people thinks city corporation did not take enough steps to stop this bad habits (Fig.16).

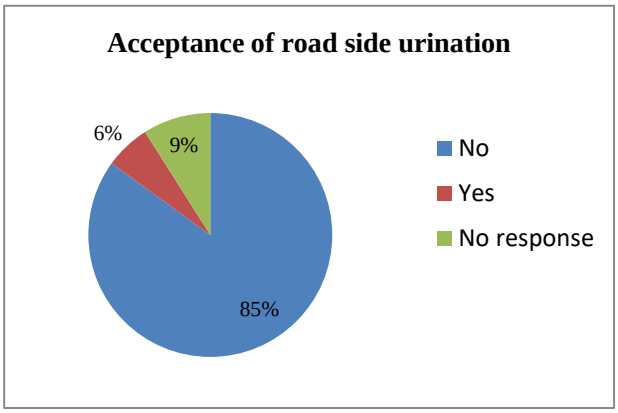

Fig.13: Acceptance of roadside urination by people

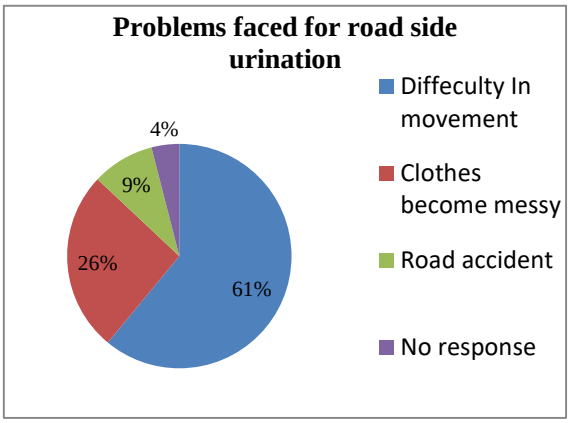

Fig.14: Problems faced for roadside urination by people

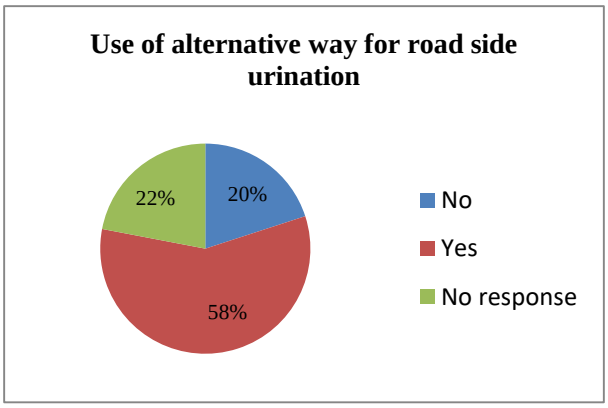

Fig.15: Use of alternative way by the affected people for roadside urination

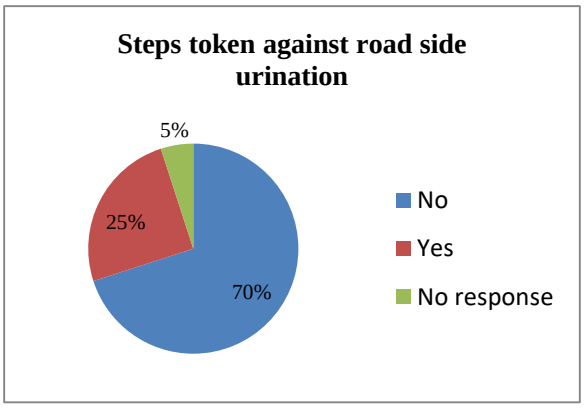

Fig.16: Steps taken against roadside urination by city corporation

CONCLUSIONS

The main findings of this study are as follows-

1. Among all the urinator, most of the urinator was Rickshaw puller (around 30%).
2. About 45% urinator used the spot because the spot was already used by others.
3. More than half of the urinators were frequent spot users.
4. Half of the spot users were faced problems while using public toilets.
5. More than half of the users were not satisfied about the hygienic condition of the public toilets and nearly half of the users said, all the toilet accessories were available.
6. Law enforcement was totally absent to stop this bad habit.
7. Most of the existing sign boards of public toilets were found less workable.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

EFFECTIVENESS OF SODIS (SOLAR DISINFECTION SYSTEM) IN BANGLADESH

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ABSTRACT
In SODIS (Solar Disinfection System), solar energy is used in the form of ultra-violate radiation and infrared heat to disinfect pathogenic microorganisms in water. Because of low-cost and technological easiness, SODIS has greater potential to be effective in reducing the level of water contamination in Bangladesh particularly in rural areas. At present More than 5 million people worldwide clean their drinking water with this SODIS method (Meierhofer et al., 2002) and SODIS projects have been conducted in 15 countries of Africa, Asia and Latin America. In order to identify the effects of solar radiation and heating on the inactivation of Total Coliform (TC), Fecal Coliform (FC), Escherichia Coli (E.Coli), and Heterotrophic Plate Count (HPC) several experiments were conducted. The effectiveness was compared by undertaking the SODIS experiment in different backing surface (Black surface, Aluminum surface etc.) and different material (PET bottle, Glass bottle etc.). Significant pathogen removal efficiency using this SODIS method has been found from the laboratory experiments specially using foil backing surface. But experimental results also posed certain anomaly, such as, increase of number of bacteria at the initial time period, which may seriously question the reliability of this technology to treat water for drinking purpose.

Keywords: Solar Disinfection System, solar radiation, low-cost, technological ease, bacteria reduction, Foil Backing Surface

INTRODUCTION

Bangladesh is mostly attributed to health problems like high infant and child mortality and fecal-orally transmitted diseases. The majority of these cases occur in rural areas where the water supply is polluted with a variety of microorganisms, including viruses, fecal coliforms, and protozoa, on the account of inadequate sanitation system. The need for a low-cost, low-maintenance, and effective disinfection system for the improvement of water quality is high. (Caslake et al., 2004). The available methods of house hold disinfection of water in Bangladesh include filtration, boiling or heating of water. For a developing country like Bangladesh, SODIS method can be both economic and effective for treatment of potable water. It is a simple but effective method to improve the quality of water by using sunlight to inactivate pathogens, where, the pathogens are destroyed by direct exposure to sun (Conroy et al., 1996). As early as the 1984s, Lebanese scientist Aftim Acra, Professor at the American University of Beirut discovered that exposing water to the sunlight decreased the number of microorganisms. This became the starting point for the development of solar water disinfection. (UV-A) light has been found

to be the most significant component of sunlight that is responsible for the inactivation of microorganisms, (Wegelin et al., 1994).

METHODOLOGY

Sampling:

Samples were collected from different water sources. Mainly, pond water and rain water were taken in plastic bottles. While taking sample, the bottle was ringed with source water. After taking sample, the bottle was kept air tight (figure 1(a)) in order to avoid any kind of contamination. During each sampling period, time, sun intensity, weather conditions, water temperatures, air temperature, and sample volume collected were recorded.

Fig. 1 (a) Different Sample Bottles

Fig. 1 (b) Exposed sample in the sun

Data Collection Process

Each sample was kept under the sun (figure 1(b)) for exposing in the intense sunlight and for further laboratory test. Then sample was collected from the bottles hourly for further laboratory test. The total exposure time of experiments varied from 6 to 8 hours depending on weather condition. In our country, sunlight is typically strongest from 10 am to 2 pm so initial experiments were conducted to capitalize this time backed by up to 1.5 hours before and up to 3 hours after (from 8:30 am to 4:30 pm).

Laboratory Test

For laboratory experiment streak plate method was used. For the preparation of media several agars and broth were used. Such as: MFC agar, mEndo broth, Nutrient agar etc. MFC media was used for Total Coliform (TC) and Fecal Coliform (FC), mEndo broth was used for Escherichia Coli (E.Coli), Nutrient Agar was used for Heterotrophic Plate Count (HPC).

After preparing the media, 100 micro liter of each raw sample was used to place over the media by micro pipette (figure 2(a)). Each drop of water was posited individually. In some case raw water was diluted depending on the quality of the water before placing on the media.

After placing the sample on media, they were kept in the incubator in different temperature for different media for 24 hours. HPC, mEndo and TC were kept at 35°C-37°C and FC was kept at 44°C. After keeping the media for 24 hours in the incubator the petri dishes were observed and counted. E.coli showed Golden metallic shin, FC and TC showed bluish black spot, Heterotrophic plate counts showed white colored spots.

Fig 2 (a) Placing of Water in Media

Fig 2 (b) Petri Dish after 24 hours of Incubation

All processes were carried out using aseptic technique, including the use of 70% ethanol to sterilize workspaces and hands. All glassware, test solutions, and media were sterilized by autoclaving at 121°C for an amount of time recommended by the autoclave manufacturer (Sterilmatic Sterilizer, Market Forge Industries Inc., Everett, MA), according to the volumes being autoclaved. Pre-sterilized pipette tips and petri dishes were used.

RESULTS AND DISCUSSIONS

To measure the effects of solar radiation and heating on the inactivation of Total Coliform (TC), Fecal Coliform (FC), Escherichia Coli (E.Coli), Heterotrophic Plate Count (HPC), several experiments were conducted. Different bottle types like pet bottles, glass bottles, bottles with foil backing were used. Some of the experiments were done with bacteria cultured sample and some experiments were done using raw water from pond. Graphical analysis of different parameters with variations of quantity of bacteria with respect to time is illustrated below:

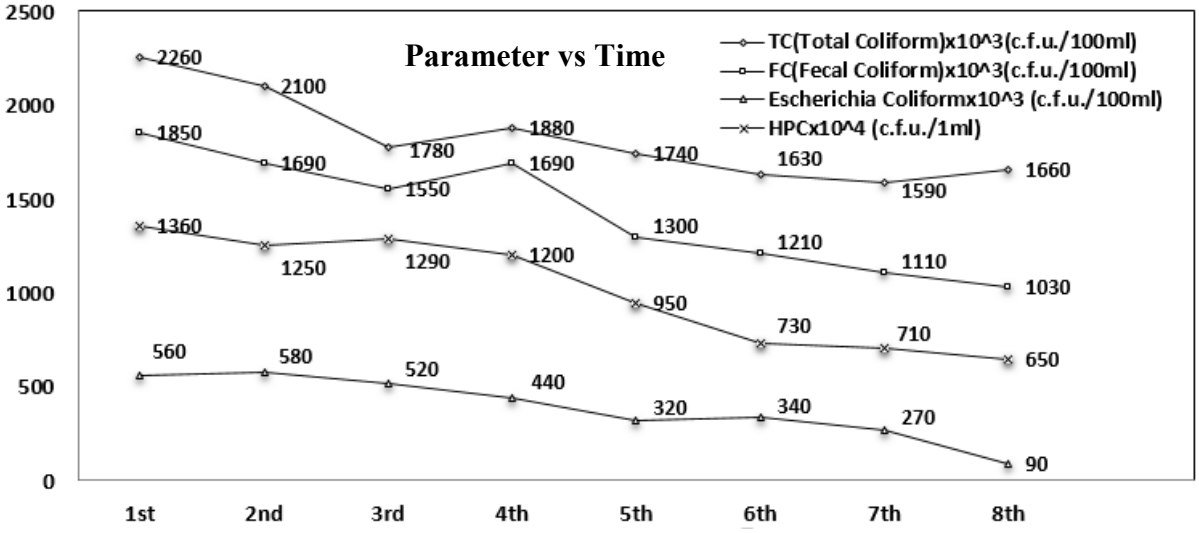

Fig 3: This experiment was done using water sample with cultured bacteria in pet bottle container

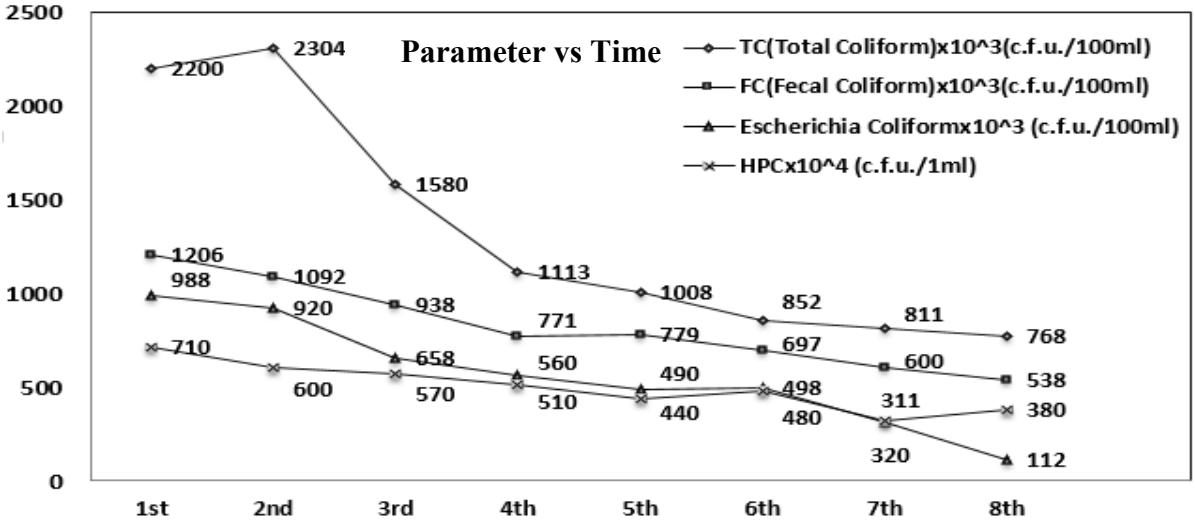

Fig 4: This experiment was done using water sample with cultured bacteria in pet bottle container

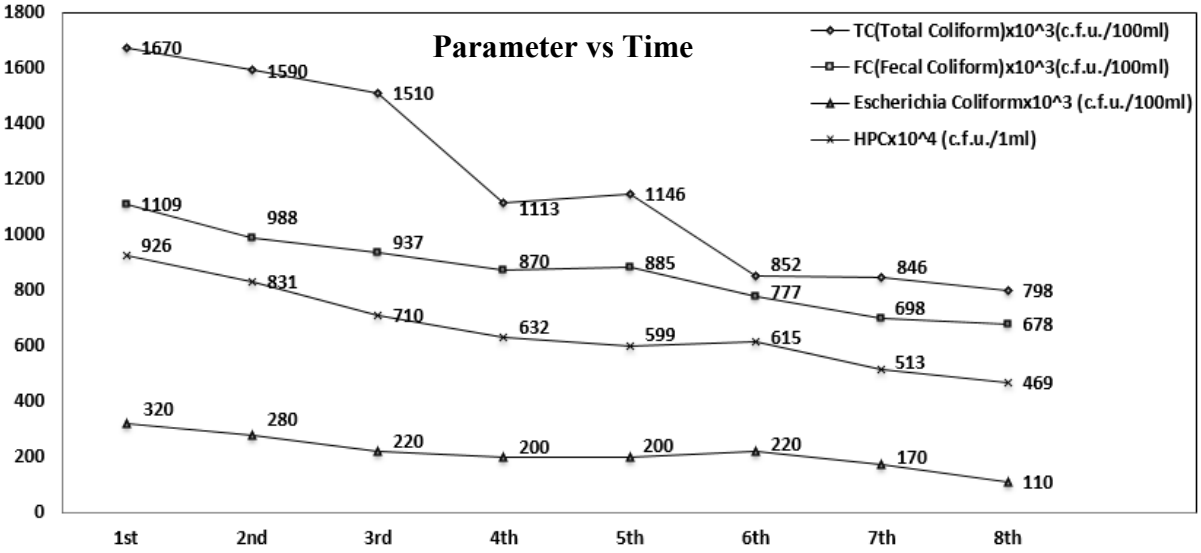

Fig 5: This experiment was done using water sample with cultured bacteria in pet bottle container

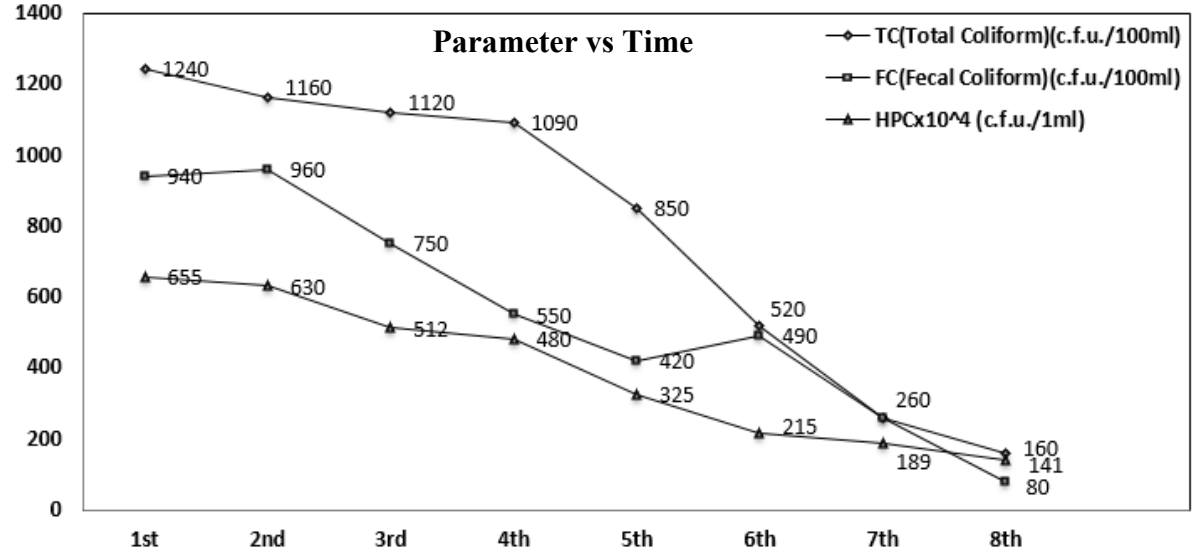

Fig 6: This experiment was done using water sample from natural pond in foil backing container

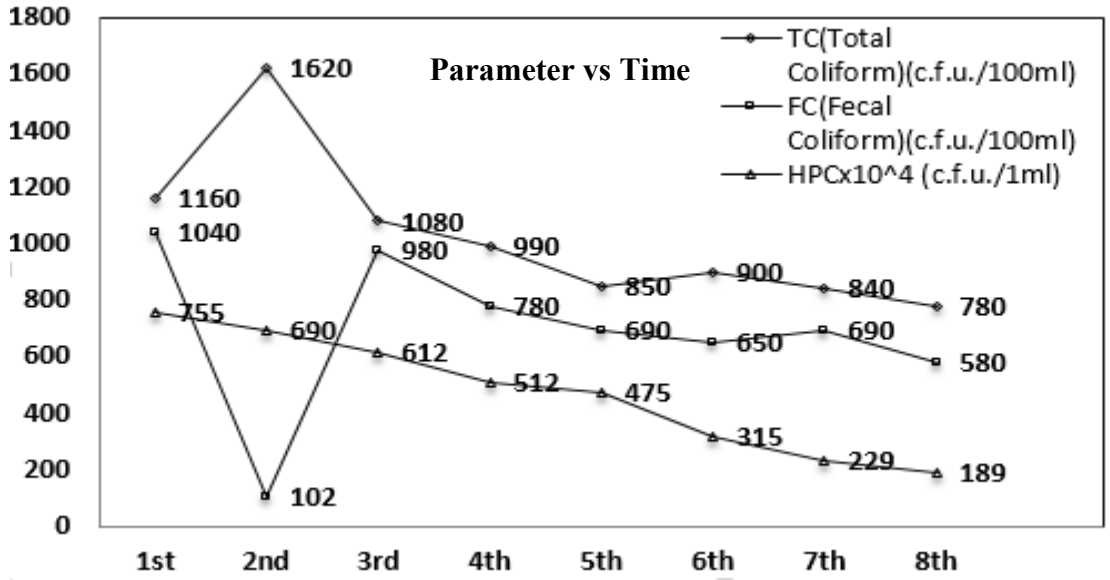

Fig 7: This experiment was done using water sample from natural pond in glass bottle container

CONCLUSIONS

The study focused on the effectiveness of SODIS method in inactivation of pathogens. By analyzing the results from the experiments, the following conclusions were drawn:

1. Significant reduction of bacteria has been observed by keeping water sample in sunlight exposure for 8 hours. At least 6 hours of exposure in sunny day may reduce significant number of the bacteria. However, the study has not detected a relation between temperature and intensity of light, which would have been a useful tool to understand the bacterial removal efficiency of this method.

2. PET bottle with Foil Backing surface was found to be the best choice among different material variations. As such, reduction of Bacteria in foil backing surface and PET bottle is around 87.10% and 67.86% respectively, whereas, reduction in glass bottle is only 32.76%.

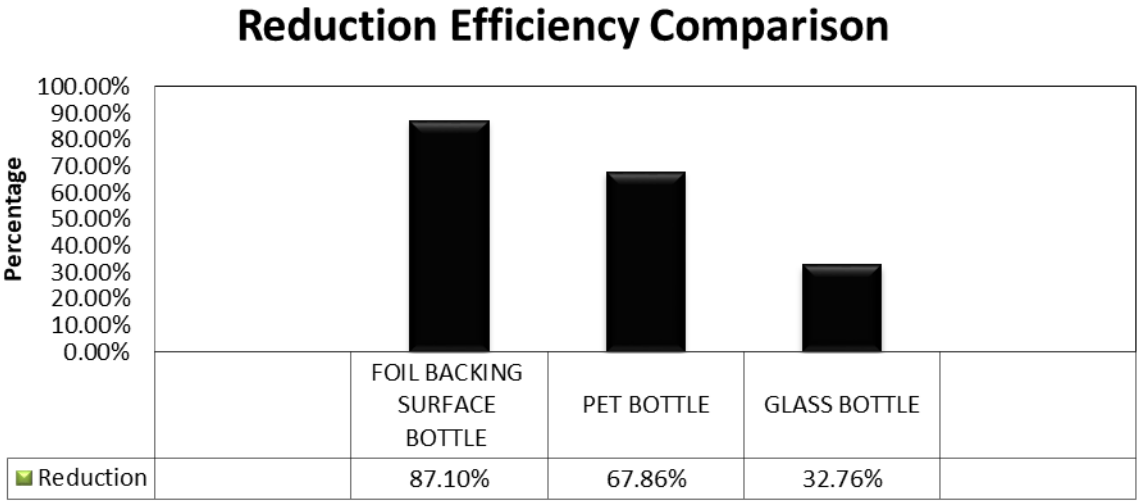

Fig 8: Comparative Efficiency Analysis of Different Bottles

3. During analysis of data, the number of bacteria was observed to be increased at some points instead of decreasing.

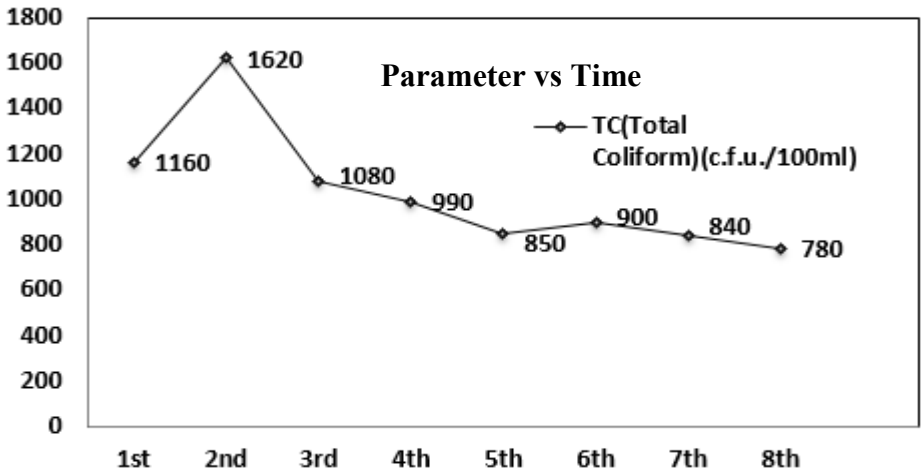

Fig 9: Sudden growth of bacteria in the 2nd hour

This apparent re-growth in water samples could indicate an incomplete inactivation and sub-sequent repair of cells or could relate to the analytical procedures overestimating the inactivation effect (Reed 2004). This may seriously compromise the viability and potential health impact of the SODIS method.

ACKNOWLEDGMENTS

First, we would like to thank The Almighty Allah without Whose grace we could not have successfully completed this. Next we would like to pay our heartfelt thanks to Prof. Dr. Md. Rezaul Karim, for his guidance and appreciation. Special thanks to the researchers from icddr,b for their endless help.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
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ASSESSMENT OF GROUND WATER QUALITY OF CHITTAGONG WATER SUPPLY AND SEWERAGE AUTHORITY

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ABSTRACT

Chittagong is the second largest city in Bangladesh and it is a premier sea port and industrialized city but the kind of population and urban growth in Chittagong, is going through present tremendous challenges to impart the utility services. Chittagong water Supply and sewerage authority (CWASA) is the responsible authority for supplying water to the city dwellers, which is being use for drinking purpose also CWASA supplies two types of water to the city dwellers. That is surface water collected from Halda River and is being treated by MWTP and ground water that is being treated by KIRP. But the problem of water shortage, to fulfill the tremendous demand of water as emergency basis, near about 36.12% ground water of total ground water supplied to the city dwellers without treatment. The aim of the study is to reveal the present untreated ground water quality supplied by CWASA to measure drinking water quality parameters of CWASA deep tube well water and to find the reason of water quality deterioration. Sample of water collected from the CWASA pump house under MOD 2, DTW location at various point of Chittagong cities. The study revealed that most of the important water qualities except iron, pH, DO, turbidity, color were in the permissible limit. In every location dissolved oxygen found less than the permeable limit at 6 mg/l. Most of the location concentration of iron in water found more than permissible value (0.3-1.0 mg/l). Presence of color found in almost every location of CWASA DTW water. Concentration of iron is the main reason for presence of color in this ground water also turbidity value was higher than the permissible limit. In order to avoid water contamination problem CWASA should supply treated ground water, should reduce dependency on ground water source and should rely on surface water source, awareness rising and regular monitoring of water distribution have been suggested in this study.

Keywords: Ground water; Treatment; Quality; Contamination; Concentration

INTRODUCTION

Water is absolutely essential for human, animal and plants. Without water life on earth would not exist. The quality of drinking water is one of the important factors for human health. The water quality depends on various physical and chemical characteristics (Kumar and James, 2013). Underground water is much clean and free from pollution than surface water. But prolonged discharge of industrial effluents, domestic sewage, nuclear explosion waste and solid waste dumping causes the groundwater to become polluted and created health problems (Craun *et al*. 1999). When waterborne bacteria and virus enter the potable water various types of dangerous diseases such as diarrhoea, cholera, polio, typhoid, hepatitis etc. are appeared in our body (Sharma et al. 2014 and Achakzai et al. 2014).

Estimated 80% of all diseases (Shivasharanappa et al. 2012) and over one third of deaths in developing countries are caused by the consumption of contaminated water and on the average as much as one tenth of each person's productive time is sacrificed to water-related diseases (Ahmed et al. 2011).
Ground water is the main source of water supply in Chittagong city & also in Bangladesh. The high concentrations of arsenic, iron & hardness are main quality constraints for development of a ground water based water supply system. There are 89 deep tube well presents in the entire Chittagong Water Supply and Sewerage Authority (CWASA) jurisdiction (CWASA office document April 2012). There are only 40 (Forty) deep tube well water is treated in the Kalurghat Iron Removal Pant (KIRP) and then the treated water is supplied to the distribution network of CWASA without any treatment. The treated ground Deep tube well water is supplying to the consumer. CWASA is supplying untreated water to fulfill the tremendous demand of water of the city dwellers. Deteriorating water treatment facilities and distribution can pose a significant public health threat, as illustrated by a study in Uzbekistan (Semenza et.al, 1999).
Due to increasing population and industrial growth the demand of drinking water is rising rapidly. The service area of Chittagong Water Supply and Sewerage Authority (CWASA) has been divided into two zones. These are MOD-1 and MOD-2 zone. Under MOD-1 zone 41 nos. DTW operated whereas untreated DTW water supplied to WASA distribution line from 39 DTW. On the other hand 59 nos. DTW operated by MOD-2 zone where as untreated DTW water supplied to WASA distribution line from 20 DTW (CWASA office document April 2017).The study area is located in the various places of Chittagong city area where CWASA is supplying ground water to the city dwellers. The aim of the study is to reveal the present untreated ground water quality supplied by CWASA to measure drinking water quality parameters of CWASA deep tube well water and to find the reason of water quality deterioration.

METHODOLOGY

The area of CWASA has been divided into two zones. These are Maintenance Operation and Distribution-1 (MOD-1) and Maintenance Operation and Distribution-2 (MOD-2) zone. Under MOD-1 zone 41 nos. DTW operated whereas untreated DTW water supplied to WASA distribution line from 39 DTW. On the other hand 59 nos. DTW operated by MOD-2 zone where as untreated DTW water supplied to CWASA distribution line from 20 DTW (CWASA office document April 2017) which shows in [Fig. 1].

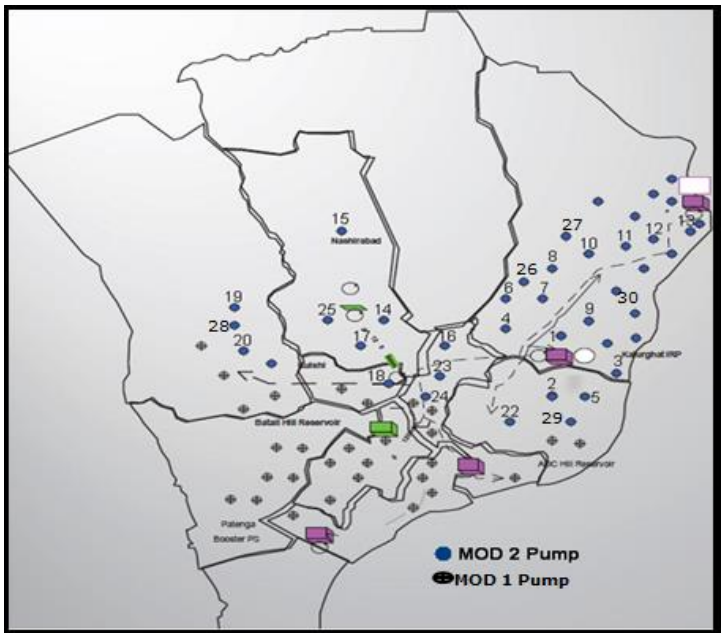

Figure 1: Maintenance Operation and Distribution of CWASA

MOD-2 is selected for present study area. It has been divided into 5 individual areas and 30 samples have been collected. Here is the proposed methodology shows in [Fig.2].

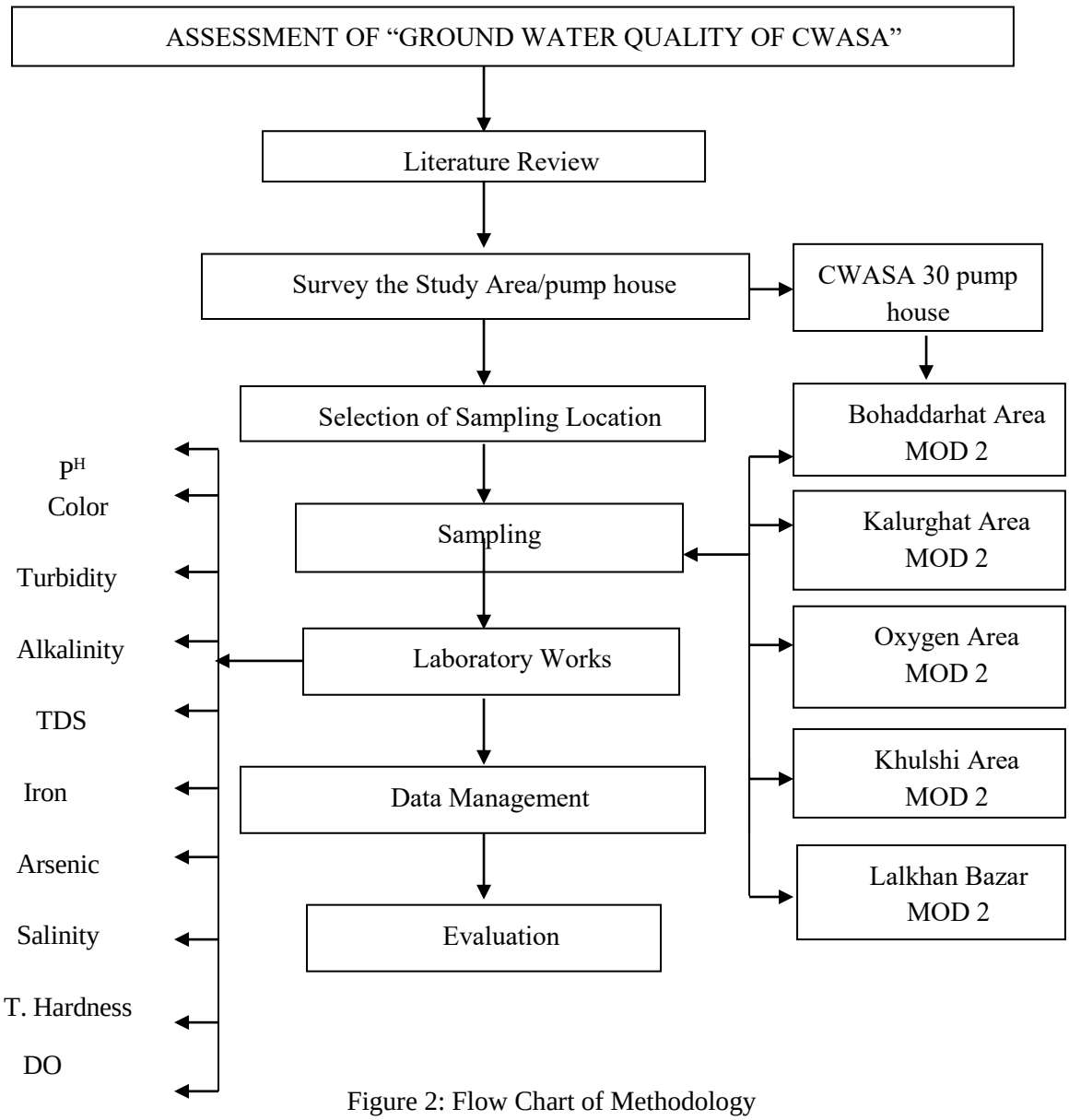

Figure 2: Flow Chart of Methodology

RESULTS AND DISCUSSIONS

The measured value of ground water quality parameter of the collected water samples from different pump house along MOD 2 are summarized in [Fig- 5.1-5.10]. Findings of the study have been assessed for suitability of drinking water with WHO drinking water quality guidelines and Bangladesh standards.

P^H: P^H is a measure of whether a liquid is acid or alkaline. Lower P^H water is likely to be corrosive. P^H values of the water samples were determined directly by a digital P^H meter. Among 30 pumps house of mod 2 the maximum P^H value 8.6 was found in a water sample collected from a pump house at Holy Crescent, near Khulshi area & the minimum was 6.5 in a water sample collected from Mominbag pump house which shown in [Fig.3].

Dissolved Oxygen: DO is denoted dissolved oxygen & measured by DO meter at the sampling site. The highest DO value 4.6 ppm found at Hajirpul Pump & lowest value 1.2 ppm at Chandgaon Thana pump. The test value of DO investigated in every pump house did not exceed the permissible range of WHO & BDS according to ECR-1997 which shown in [Fig.4].

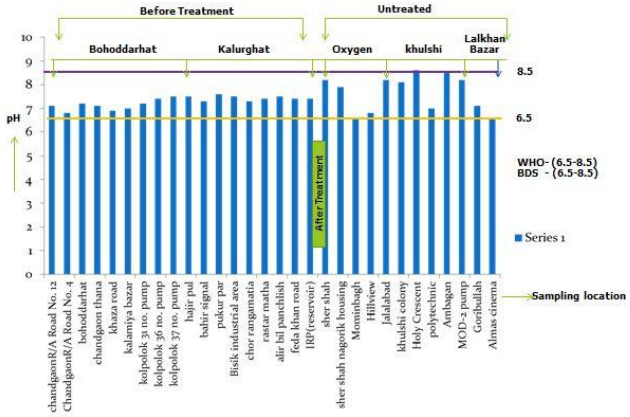

Figure 3: Variation of P^{H} values in CWASA Pump house in various locations

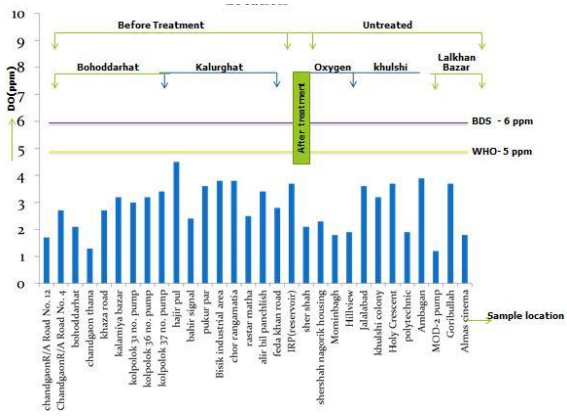

Figure 4: Variation of DO values in CWASA Pump house in various locations

Total Dissolved Solids (TDS): Total dissolved solids were measured within 5-10 minutes after collection of sample at the sampling site by TDS meter/combo meter. The maximum concentration of TDS was 500 ppm at Kolpolok 36 no. pump near Bohaddarhat area, whereas the minimum 46 ppm found at Hill view near Oxygen area, as seen in [Fig.5] .TDS level did not exceed the limited value of 1000ppm according to BDS & WHO.

Iron: Iron may also be present in drinking-water as a result of the use of iron coagulants or the corrosion of steel and cast iron pipes often used for distribution. The maximum concentration of iron was found 3ppm at Feda khan road pump house near Kalurghat. All values of Iron which found in different locations shown in [Fig.6].

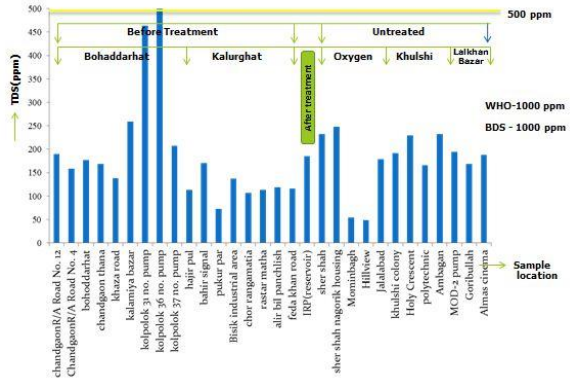

Figure 5: Variation of TDS values in CWASA Pump house in various locations

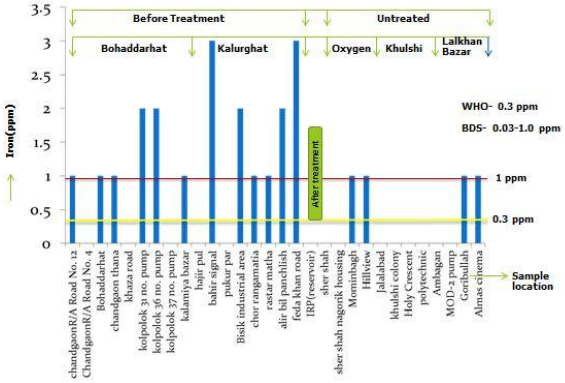

Figure 6: Variation of Iron values in CWASA Pump house in various locations

Total Hardness: Total hardness in water samples was determined by titration method. Depending on P^{H} and alkalinity, hardness above about 200 mg/litre can result in scale deposition, particularly on heating. The maximum hardness 149 ppm found at water sample collecting from kolpolok No. 36 Pump & minimum 19 ppm at Hajirpul shown in [Fig.7].

Alkalinity: Alkalinity values of different location shown in [Fig.8]. The maximum Alkalinity found 217.8 at Khulshi colony pump and the minimum value was 36.4 at Hill view Pump which is under the limit 600ppm of CPCB. There is no Standards for alkalinity in WHO guidelines and BDS.

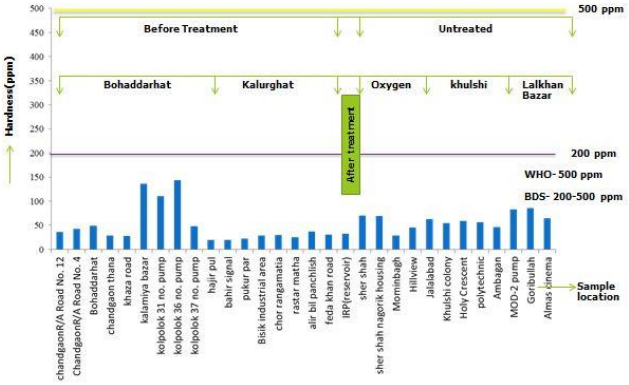

Figure 7: Variation of Hardness values in CWASA Pump house in various locations

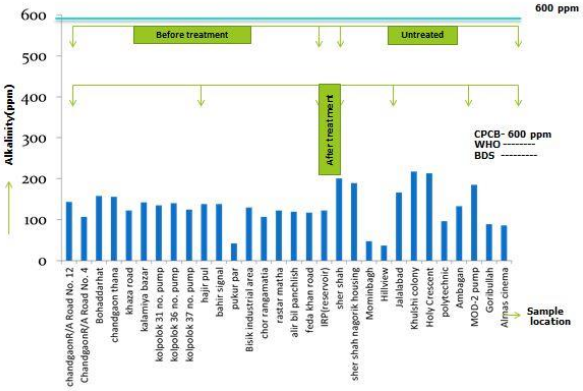

Figure 8: Variation of Alkalinity values in CWASA Pump house in various locations

Arsenic: Fortunately for us there was no arsenic found in 30 samples that has been tested under MOD-2 as seen in [Fig.9]. Long-term exposure to arsenic in drinking water can cause cancer in the skin, lungs, bladder and kidney.

Salinity: Salinity is the relative concentration of salts in water & in general term for water that contains a significant concentration of dissolved salts (NaCl). Salinity of water determined by TDS meter and test conducted after four hours of collecting sample. Salinity was not found in any sample from the 30 samples that has been assessed from MOD- 2 [Fig.10].

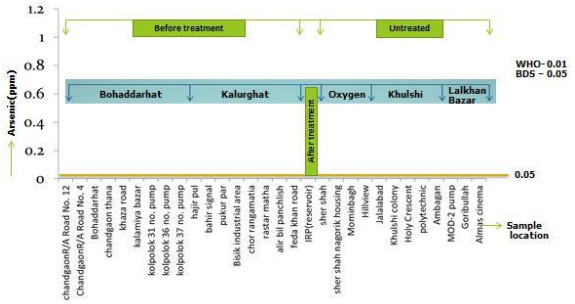

Figure 9: Variation of Arsenic values in CWASA Pump house in various locations

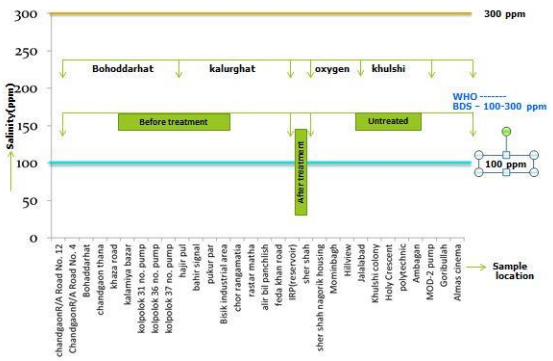

Figure 10: Variation of Salinity values in CWASA Pump house in various locations

Turbidity: Turbidity, or cloudiness in water, is due to very small solid particles which tend to float because of their low weight. The maximum turbidity was found in a water sample collected from Chandgaon R/A 12No. The minimum value was 3.33 NTU found in a water sample collected from KIRP as seen in [Fig.11].

Color: Color test of collected water samples were measured with the help of BCSIR. The maximum value 25 TCU was found in Chandgaon R/A 12No. Road Pump house & minimum value 10 TCU found in KIRP which shown in [Fig.12].

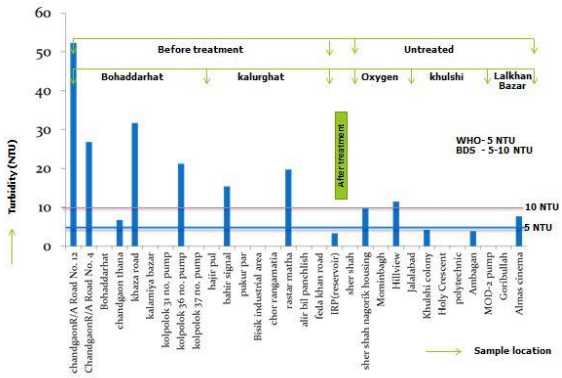

Figure 11: Variation of Turbidity values in CWASA Pump house in various locations

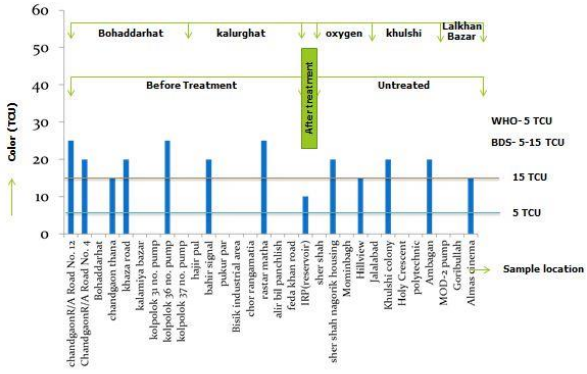

Figure 12: Variation of Color values in CWASA Pump house in various locations

CONCLUSIONS

From the analysis of collected samples from 30 pump houses under MOD-2 of "CWASA" supply revealed that quality of ground water abstracting/withdraw by the assessed pump not in satisfactory condition. Though the laboratory analysis indicate most of the measured parameter i.e. TDS, Salinity, Total Hardness, Alkalinity, arsenic & salinity in the acceptable range as per BECR, 1997 & WHO, 2006 standard. The overall results of analysis are given below in short.

i. TDS, Arsenic, Hardness, Alkalinity, and Salinity of all sample satisfied by both WHO and BD standard.
ii. Around 96% sample satisfied both WHO and BD standard for P^H.
iii. Around 94% sample did not satisfy WHO standard for Color.
iv. Around 80% sample did not satisfy WHO standard for turbidity.
v. Iron is found in too many samples.
vi. DO in all the samples found to be less than the standard value.

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USE OF AN AIR ENTRAPPED COVERING TO CONTROL ROOM HEATING

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ABSTRACT
As Bangladesh is lying on the tropic of cancer; sun is directly overhead for a longer day time during summer season making the average country temperature between 30 ^{O}C to 40^{O}C. Structures in urban areas in Bangladesh are mostly constructed with masonry and/or reinforced concrete (RCC). These structures are ended up with RCC slabs as a roof surface. The heat energy received from sun flows through the walls and roof slab making the inner space hotter. The objective of the presented work is to find a solution for the existing building to convert them an energy saving structure. Thus an investigation was carried out for the technique of laying an air entrapped layer on the traditionally build roof surface to act as a heat flow barrier. Hence, two model rooms were constructed to investigate the performance of an air entrapped layer as a heat flow barrier. Field data were collected for different case scenario on the basis of sun exposure on different surfaces of model rooms; and the analysis of data shows that conventional RCC slab with air entrapped barrier helps to improve thermal condition and reduces the inner room temperature.

Keywords: Concrete Slab, Air entrapped layer, Heat flow, Green building, Thermal barrier, Cool roof

INTRODUCTION

Bangladesh is a tropical country. During summer season, the weather becomes hot raising the temperature up to 40^{O}C which feels even more. Sometimes it exceeds the tolerable limits for the inhabitant of living under roof surface. This is because of the sunlight directly merged on the surfaces of the house [1]. The heat that radiated from sun is absorbed by the external surfaces of room which are then gets heated [2, 3]. The heat energy flows through the materials of the room surfaces by conduction, and transfer it to cooler internal surface from where it goes to air of the room by convection [5, 6]. Thus, the temperature of room is rises as long as it comes to balance with external environment [7]. Heat can come through the building openings like windows but keeping them close cannot stop rooms receiving heat through these walls and roof.

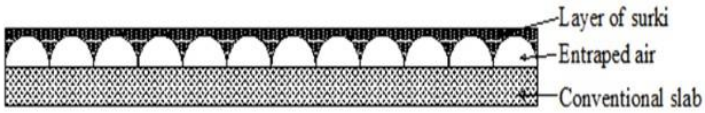
In our country most of the buildings in urban areas were constructed using masonry and/or RCC with a flat concrete roof. Roofs receiving heat contributed a lot to make structure very hot. Cool roofs are energy efficient and save lot of money by reducing energy bills [4]. There are many options available in the market to create an existing roof surface or new building roof cooler. These techniques and methods are available for example chemical painting, coating, solar reflectors etc. But most of them are expensive and some are not available in our country. So a low cost technique with locally available materials would be a search option.

VOIDED COVERING

BubbleDeck system (figure 1) is currently used many countries around the world for making the floor slab lighter. Use of such type voided slab currently attracted engineers and practitioners for its various advantages. It can help making space cooler. This concept can be used for controlling excess heat from sun in top floors of an existing structure.

Fig.1: Bubble deck system (*source: Canadian consulting engineer*)

Mud or card pots (figure 2) can be use to create voids which are locally available in Bangladesh and economical compared with other insulators.Voided covering can be produce by putting these pots upside down with a layer of shurki on top. In such a condition, the sunlight cannot heat roof surface directly due to the presence of voided top overlay. Airs which get trapped in the created voids will breakdown the conduction paths of heat flow. Thus it can be an effective way in controlling the temperature of top floors.



a) Section of voided slab covering

b) Mud pot on top roof slab

b) Mortar topping on and around mud pot

Fig.2: Voids created with mud pots on a conventional slab

METHODOLOGY

Two masonry model rooms with RCC slabs were built. The size of the model rooms were 1.2m x 1m x 1m with the slab of 100mm thick, 125mm thick brick walls were made (figure 3) and 10mm diameter single layer reinforcements were used in the slab with a spacing 100mm both ways; and a 19mm clear cover was used. The mix ratio of the concrete was 1:2:4. Curing was applied for 14 days for mortar and 28days for roof slab. One of these rooms was used as a reference room i.e. without any covering and other one as a test room which have an extra voided covering.

The slab of the test room was enclosed with an additional layer of mud pot to make air voids (figure 2 a); and over that a 50mm thick shurki layer was poured to make a usable flat roof top surface (figure 2 b). These air voids has a profundity of 75mm and separating of 100mm focus to focus as shown in figure 2.

a) Digital meter

b) Thermocouple in slab

Fig.3: Temperature data collection system

Thermal sensors were placed at different location of these rooms to collect temperature data. The data were collected in the days having clear sunny weather.

DATA COLLECTION AND ANALYSIS

Field data were collected for two forms of test case as explained below-

Case 1: When all walls are exposed- In this case data were collected when all sides of walls were uncovered. In this case heat passes all walls slab inside the rooms (figure 4).

Case 2: When all walls are covered- In this case all the brick walls were covered by crock sheet to allow the heat to transfer to the room by roof slabs only (figure 5).

Heat sensors (k-type thermocouple) were put at both outside and within roof top surfaces of the two rooms and temperature information were gathered from them by utilizing computerized meter. In the meantime, surrounding temperature and room temperatures were also recorded. The gathered information was then analyzed to find the effectiveness of the adopted procedure to control room warming.

Fig.4: Side walls exposed

Fig.5**:** Side walls covered

RESULTS AND DISCUSION

Field data was gathered for a specific timeframe. The days having clear cloud free sky was focused for correlation. There was other impact now and again which was tendency of sun.

Case 1: When all Walls were exposed

On day 1 (figure 6), it was a very sunny warm day. At 11 am the room temperature of entrapped air slab is lower than the inner room temperature of bare slab by 2^0C. This condition existed until 3pm. Afterwards the temperature difference in them starts to get reduced and within next four hours, at 7:00 pm in the evening it came down to zero.

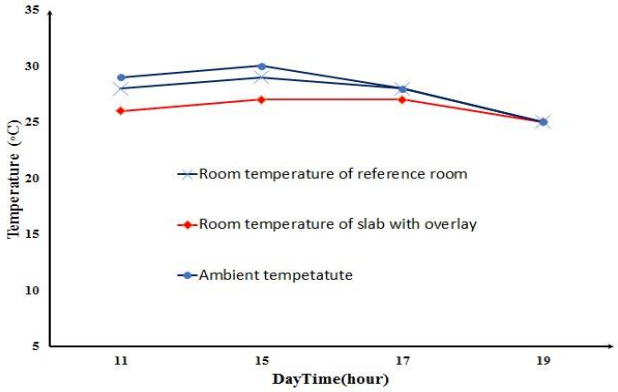


Figure 6: Day time vs. Temperature graph

Similar result was found on day 2 (figure 7). The room temperature difference between reference room and test was maximum of 2^0C until late afternoon. Afterwards this difference was decreased slowly and room temperature was same in the evening at 7:00pm like the day1. From these results it can be assume that even if all the side walls are left open to receive heat, this form of voided overlay can help to have a comparatively cooler space.

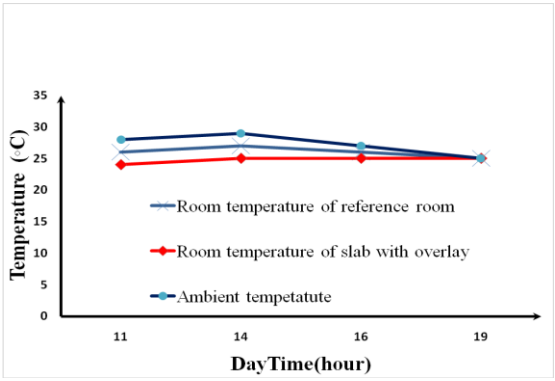


Figure 7: Day time vs. Temperature graph

Case 2: When all walls are covered

The side walls were insulated externally on day 3. It was a bit warm day with maximum ambient temperature of 27^0C (figure 8). While inside temperature of reference and test room were 26^0C and 24^0C respectively. It was observed that as the day time passes, the temperature inside reference room matches the ambient temperature pattern with a constant 1^0C difference until 6:00 pm in the evening, afterwards it matches with ambient. On the other hand, temperature in test room was significantly lower than the ambient temperature which was at maximum of 4^0C in the noon at 2:00 pm. But it maintained this temperature throughout the day and it was found that room is a bit warmer in the evening than reference room.

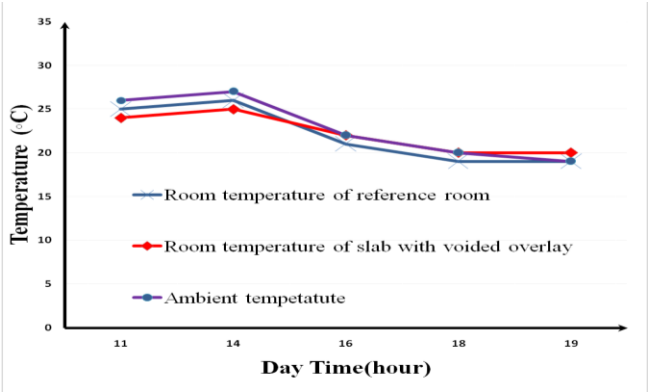


Figure 8: Day time vs. Temperature graph

On day 4, similar pattern as day 3 was observed. Temperature difference was not much in between reference and test room (figure 9). However, in the evening the room temperature of slab with overlay was raised a little bit.

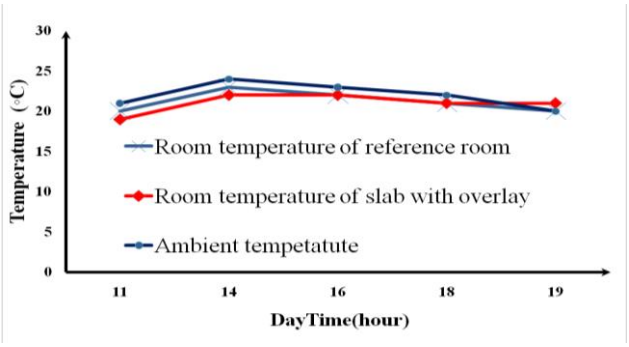


Figure 9: Day time vs. Temperature graph

CONCLUSIONS

An energy efficient structure consumes lesser energy and requires relatively lesser heating and cooling cost. From experimental study it was found that a voided overlay on the traditionally built RCC roof slab can be use to make a structure more energy efficient. As it was observed, in both cases the test room was cooler than the reference room in middle of the day. Thus it requires lesser cooling energy for a top floor room. However, in case two when all sides were covered, the test room holds the same temperature even in the evening, and was a bit warmer than reference room. This is due to the slab concrete mass, which was stored lot of heat energy and was then released inside the room in the evening. The contribution of side walls in heating of the room needs to be checked to come to a better conclusion. Hence further study is needed to find the amount of energy received by individual surfaces of a structure which actually are exposed to sunshine during day hours.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
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CUET, Chittagong, Bangladesh
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USE OF NON-AIR ENTRAPPED COVERING TO CONTROL ROOM TEMPERATURE

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ABSTRACT
In Bangladesh most of the construction ended up with a flat concrete roof slab which usually are exposed to sunlight thereby absorbing heat from sun. Eventually such a condition creates discomfort for the inhabitant on the top floor. This research was carried out to investigate the suitability of using locally available material to overlay on top of existing slab, which can be use as a barrier to slow down the heat receiving process for top floor. This paper deals with a concept of laying an extra layer which has an air space between the slab and the overlay on top of a traditionally build RCC roof surface. Two laboratory model rooms were built and were kept exposed to sun for day long period to collect the temperature data at the different locations of these model rooms. The results show that the proposed concept is useful to reduce the temperature to some extent in the middle of the day.

Keywords: Heat transfer, Concrete, Thermal Control, Thermal Barrier, Green building, Cool roof

INTRODUCTION

Bangladesh is located in the southern part of the Asia, and the continental latitudinal position is located on the North axis. The latitude is located 20°-34' to 26°-38' North axis and the longitude is located between 88°-01' to 92°-41' East longitude, and the tropic of cancer passes through the middle of the country. The monsoon of Indian Ocean region has passed through the South-Western zone of Bay of Bengal. For this reason, the climatic condition of Bangladesh is tropical monsoon. There are three distinct seasons in Bangladesh. These can be characterized as i) a hot, humid summer from February to June; ii) a comparatively cooler, rainy monsoon season from June to October; and iii) a cool, dry winter from October to February. In general, April is the warmest month and maximum summer temperature ranges between 30°C and 40°C [2]. January is the coldest month when the average temperature is about 10°C throughout the country. The effect of such a climatic condition comes to the daily life of the people of Bangladesh, as they require more energy to make their spaces cooler especially people who live under the roof.

Most of the constructions in the urban areas of are made of bricks and reinforced concrete. This type of structure usually absorbs a huge amount of heat during summer and this is why the temperature inside the structure raises higher causing discomfort for its inhabitant (figure 1). Again, the use of house insulators is very rare because of its availability and cost.

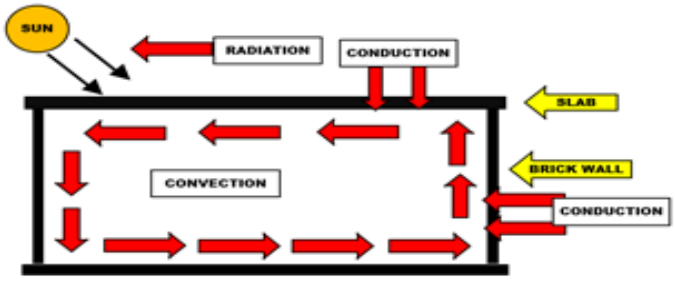
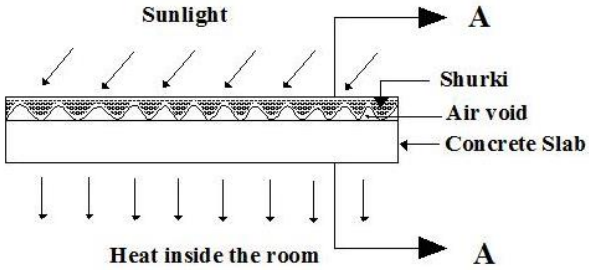


Fig.1: Heat transfer mechanism inside the room

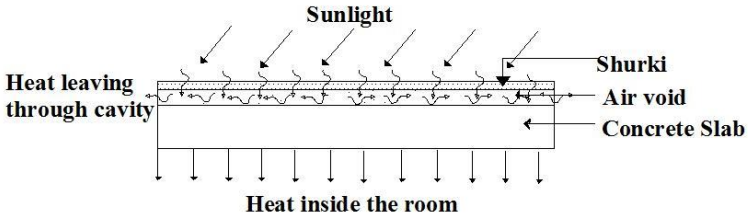
CONCEPT OF THE STUDY

A structure when exposed to sun received heat from all the surfaces of the structure which are exposed to sun. Therefore the inside temperature of structures get increased causing an extra demand in setting up air conditioning system meaning extra costing for the user [1, 6]. The presented work was to look for a solution so that energy consumption can be reduced or control in such a case thereby making buildings greener. An experimental study was designed based on the assumption that laying an extra layer of voided topping on roof can effectively work to breakdown the heat flow path. Moreover, if these paths are exposed to atmosphere directly may even delay the heating of top floor due to direct exposure to sun.

The solid concrete slab materials works as a medium for heat transfer. After receiving heat from sun it literally starts absorbing heat energy afterwards starts transferring this energy to the cooler space i.e. inside the room [4, 5]. But, presence of voided space with a mortar layer can delay the reception of heat by concrete thereby can work as a heat barrier or heat transfer process breaker in such a system. Again, keeping the ends of the created air void exposed to atmosphere can further may slow down this heat transfer phenomenon resulting in a cooler space inside the structure as explained in figure 2.



a) Heat Transfer process through the overlay



b) Heat leaving passage in overlay (section A-A)

Fig.2: Assumed of heat transfer mechanism through slab with asbestos sheet

METHODOLOGY

Two masonry model rooms of 1.2m×1m×1m size with slab thickness of 100mm and proportionate doors and window opening were constructed. Brick walls with 125mm thick were coated with mortar with a ratio of 1:3. Reinforced slabs 10 mm diameter at a spacing 100mm both ways and 19mm clear cover was used. The mix ratio of the concrete was 1:2:4. Curing was applied for 14 days for mortar and 28days for roof slab.

One of these rooms having only RCC roof slab was used as reference room. The slab of the second room was covered with an extra layer of asbestos sheet to create a series of air voids; and on top of that a 50mm thick shurki layer to make a usable flat roof surface. These horizontal air voids has a depth of 25mm and spacing of 75mm centre to centre which are exposed to atmosphere at both ends. Thus there exists a non air entrapped path for the excess heat to transfer in the surrounding air through this cavity which is explained in figure 2. After construction of these rooms, filed data was collected and analyzed to find out the effectiveness of using the presented technique.

DATA COLLECTION AND ANALYSIS

Field data was collected for two cases of sunlight exposure of model room surfaces. In case 1 (figure 3), all the side walls of models rooms were covered with cork sheet, so that heat transfer through walls can be avoided and temperature inside the room can be increases due to the heat coming through roof slab only. Thus the contribution of slab heating in increase of room temperature can be determined. On the other hand, case 2 (figure 4) was use to monitor heat reception by an uncovered room. That means allowing heat to come through all the side walls and roof.

Fig.3: case 1

Fig.4: case 2

Thermal sensors were placed at both outside and inside of roof surfaces of both rooms and temperature data were collected from them by using digital meter. At the same time, ambient temperature and room temperatures were also recorded. The collected data was then analyzed to find out the effectiveness of the proposed method to control room heating.

Figure 5: Creation of non air entrapped covering

Figure 6: Thermocouple Setup on Slab

RESULTS AND DISCUSSION

Data was collected for a certain period of time. The days having clear cloud free sky was targeted for comparison. There was other influence from time to time which was inclination of sun. As the presented data are of close intervals in time so it can be assumed that sun inclination effect can be neglected. For each case two different day's data are presented.

Case 1: When all walls are exposed

On day 1 (figure7), the maximum ambient temperature was to 29^0C in the morning at 11:00 am while inside temperature of both room were below 25^0C at that time. It was found that after 11 am the temperature inside the room with non-air entrapped slab was 1^0C lesser than another room till 6 pm and after 6 pm it remains same for both rooms.

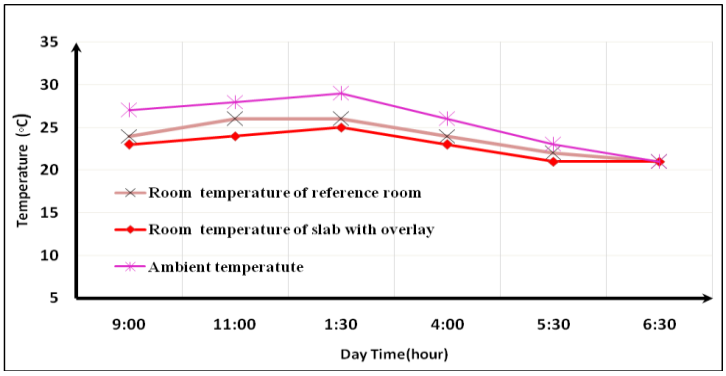


Figure 7: Day time vs. Temperature graph (on Day 1)

On day 2 (figure 8), it was cooler than the previous one, and in the morning temperature inside the room with overlay was 3^0C lesser than another room and at noon this differences dropped 2^0C down and then it remains equal for both rooms.

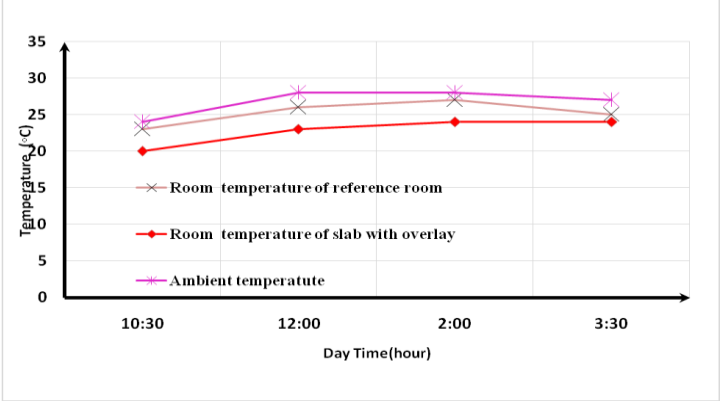


Figure 8: Day time vs. Temperature graph (on Day 2)

Case 2: When all Walls are covered

On day 3 (figure 9), the maximum day temperature was 24^{0}C, and in the morning the room with overlay was warmer than reference room. At noon the temperatures were remains same for both rooms, meaning the reference slab was heating quicker than the test room. Afterwards, within a few hours the reference room gets 2^{0}C warmer. This phenomenon gets reverse afterwards and test room temperature rises in the evening.

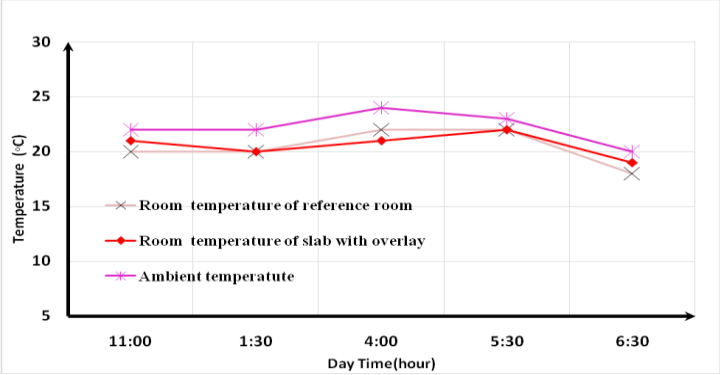


Figure 9: Day time vs. Temperature graph (on Day 3)

On day 4 (figure 10), almost similar phenomenon was observed as in day 3. The ambient temperature and inner room temperatures for both rooms were around 23^{0}C which is comfortable. Afterwards ambient temperature was increased with 26^{0}C while the inner room temperatures for reference room and room with overlay were 25^{0}C and 24^{0}C respectively, meaning a bit cooler space due to overlay. At night the inner room temperature for non-air entrapped slab was higher than reference room. The similar thing was happened in day 3 as well.

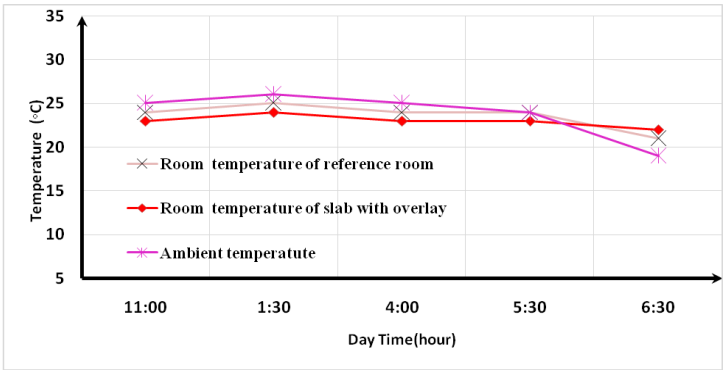


Figure 10: Day time vs. Temperature graph (on Day 4)

6. CONCLUSIONS

A concept of laying an extra layer of shurki usually increases the mass of the structure thus can store more heat from sun. But the presence of an air space between the slab and the overlay on top of a traditionally build RCC roof surface working as a barrier to heat transfer. As these air spaces are connected to the atmosphere it should be more effective. But there are other factors like side walls which also receiving heat and transferring it inside the room. As in case 1; it was really difficult to

identify the effect of overlays as both of these rooms were receiving heat from sidewalls. But in case 2 when the entire side walls were insulated then the effect came to visible. It can be explained that due to the presence of a non air entrapped layer on roof top, rooms on roof top will get less heated, especially in the noon time when the external temperature goes up. In contrast, this slab storing a lot of heat energy which starts get released in the evening as in the case 2. Further study can be carried out to quantify the amount of heat actually it absorbs and releases to increase inner room temperature, and its cost effectiveness.

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CHARACTERIZATION OF WATER DRAINED OUT FROM AIR CONDITIONER

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ABSTRACT
Earth's atmosphere contains billion cubic meters of fresh water, which is considered as a reliable water resource, especially in sultry areas. Gradual increase of use of air conditioner in such type of areas opens an opportunity to collect this atmospheric water. Humid air condensate in contact with condenser of air conditioner and comes out as water through drain out pipe. This condensate water might be free from impurities due to the production from moisture present in air. The present study was carried out to evaluate the suitability of this water produced from air conditioning system. The water samples were collected from drain out pipe of ten different split type air conditioners for three days in each month during the period of April to June of 2016. The collected water samples were analyzed for determination of Total Solid (TS), Turbidity, pH, Acidity, Alkalinity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), total hardness, Chloride, Iron, and Corrosivity for characterization. The experimental results show that all the tested parameters are within acceptable range which is suitable for municipal and industrial water applications. However, water is slightly corrosive in nature which leads to continue the extensive research in future.

Keywords: Air conditioner, condensation, drain out, water quality, application

INTRODUCTION
Water is an essential requirement of life for drinking, domestic, industrial and agricultural uses. Its quality and quantity which vary over space and time are important components in the integral development of any area. Any change in the natural quality of water may disturb the equilibrium system and it would become unfit for designated uses (Ato and Ayua, 2013). Of all the water available on Earth, 97.6% is concentrated in the oceans. Fresh water corresponds to the remaining 2.4%. Of these 2.4%, only 0.31% is not concentrated on the Poles in the form of ice. Of all the water on Earth's surface, less than 0.02% is available in rivers and lakes as fresh water ready for consumption (Roaf, et al., 2009).

A growing number of countries are now experiencing increasing water stresses because of a higher demand for usable water. As populations climb, per-capita use increases, and current water supplies grow shorter, water resources are becoming more critical globally. Most urban areas face difficult choices and expensive solutions to meet existing and future demand. The topic water reuse boosted several studies and research. In most cases, water reclamation takes place in industries and agriculture (Hespanhol, et al., 2003). Water scarcity has knock on effects not just for drinking water supplies. Food production can be affected, while landscapes can be altered and degrade without sufficient water. Extracting too much water from underground reserves can also be damaging. Reusing of wastewater with treatment for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a ground water basin (referred to as ground water recharge) makes it as an expensive source of water. Therefore, looking for a new alternative source of water is essential for saving the water cost.

Now-a-days air conditioning is familiar all over the world. Every developed and developing country use air conditioning in their office, classroom, house to create comfortable environment by maintaining

humidity, efficiently cooling room air during certain seasons, heating or helping heat the rooms in winter. Most common air conditioning devices generate water by condensation of atmospheric water. Every hour a 2 ton air conditioner discards 3.5 to 4.5 liters water (Bastos and Calmon, 2013). Split type air conditioner produced more water than window air conditioners. Each air conditioner produced 36 liter per day averagely (Mahvi, et al., 2013). This water could be favorable for any municipal and industrial purpose, irrigation, washing cloth, fish culture in aquarium, drinking with conventional treatment followed by disinfection, for cooling the parts of a machine (Mahvi, et al., 2013). The average factory water consumption in Bangladesh is estimated to be around 250 to 300 liters per kilogram of fabric produced. It is equivalent to the daily water use for two people in Dhaka. A 2 ton air conditioner unit can provide 1.4% of water per kilogram of fabric produced per hour. However, quality of water must be acceptable for these purposes of use. Therefore, the aim of this study is to examine the suitability of water produced through air conditioning system for different purposes of use.

METHODOLOGY

Collection of Samples

Samples of water produced from air conditioners were collected for three different days from ten different air conditioning units used at different buildings in Rajshahi University of Engineering & Technology (RUET) campus. A clean PET bottle of 1 liter capacity was fixed with the water outlet of air conditioner. Prior to sample collection, all bottles were washed with diluted acid followed by distilled water. Before taking final water samples, the bottles were rinsed with the water to be collected. The sample bottles were labeled with date, time, and temperature and sampling source.

Water Quality Analysis

Water must be tested with different physic-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we are going to use that water and what extent we need its quality and purity. The physical quality parameters such as total solids (TS), turbidity, BOD, COD, p^H, Corrosivity and chemical parameters such as hardness, chloride, acidity, alkalinity, iron were experimentally determined.

RESULT AND DISCUSSION

The quality of water produced from air conditioning system was determined for the evaluation of suitability to use in different purposes. The physical and chemical characteristics of this water sample were examined in triplicate for each day samples. The results are prepared as mean with standard deviation. The obtained results are discussed in following sections.

Total solid (TS)

The term "total solids" refers to matter suspended or dissolved in water and is related to both specific conductance and turbidity. Total Solids includes total suspended solids and total dissolved solids. The result of TS for draining out air conditioner water is shown in Figure 1.

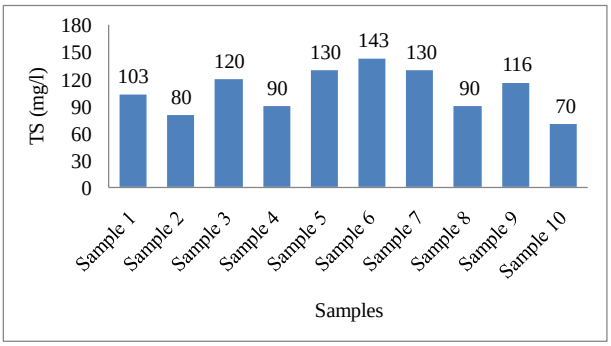

Figure 1: Total solid of draining out air conditioner water

The result ranges from 70 to 143 mg/l and average concentration of TS is 107.2 ± 24.2 mg/l. Total solids also affect water clarity. Higher solids decrease the passage of light through water, thereby slowing more rapidly and hold more heat; this, in turn, might adversely affect photosynthesis by aquatic plants.

Turbidity

Turbidity is the technical term referring to the cloudiness of a solution and it is a qualitative characteristic which is imparted by solid particles obstructing the transmittance of light through a water sample. When the turbid water in a small, transparent container is held up to the light, an aesthetically displeasing opaqueness or milky coloration is apparent. The result is shown in Figure 2.

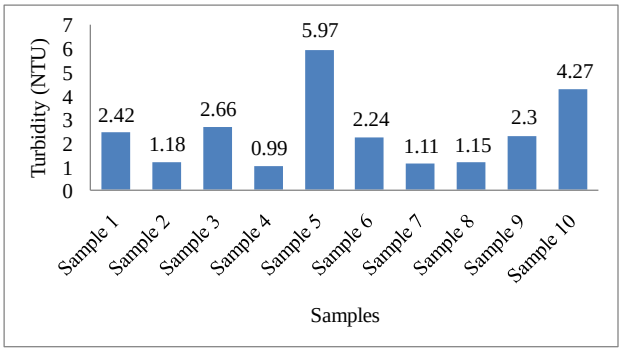

Figure 2: Turbidity test result of drained out air conditioner water

The result ranges from 0.99 to 5.97 NTU with the average value of 2.43 ± 1.6 NTU while the standard value is 10 NTU. The water having turbidity of 3 to 50 NTU can be used for industrial activities and turbidity should be less than 100 NTU for irrigation.

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

BOD is the test to give an idea of the biodegradability of any sample and strength of the waste. The BOD concentration from 3-5 mg/l indicates water is moderately clean and from 6-9 mg/l is considerd poor while BOD concentration of 100 mg/l or grester indicates very poor quality.

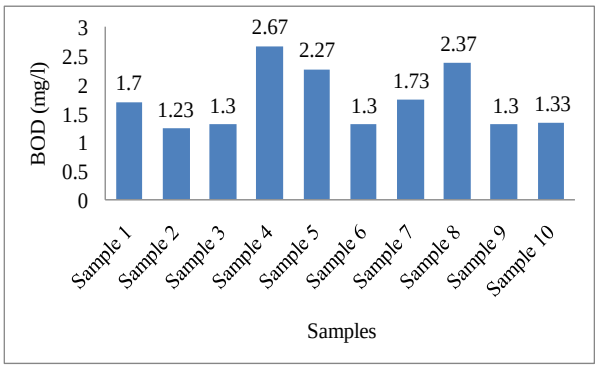

Figure 3: BOD concentration of drained out air conditioner water

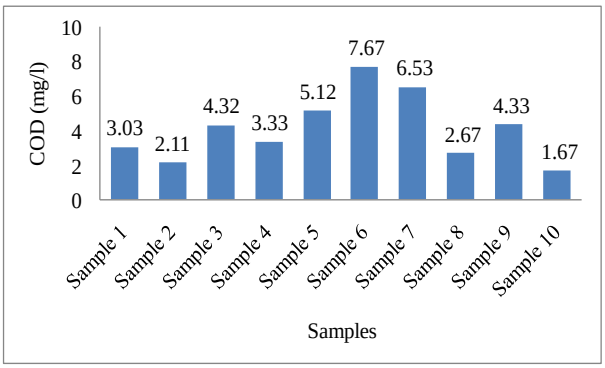

Figure 4: COD test result of drained out air conditioner water

The result ranges from 1.30 to 2.67 mg/l with the average value of 1.72 ± 0.53 mg/l (Figure 3) while the acceptable limit for drinking purpose is 0.20 mg/l according to Bangladesh Standard. The presence of BOD in condenced water in air conditioning system is might be due the presence of suspended vegetative particles in atmosphere. For the industrial use BOD level of 30-60 mg/l is acceptable and for irrigation purpose there is no standard for BOD. Therefore, this water can be used for irrigation, industrial and even drinking purpose if other parameters satisfy. The chemical oxygen demand (COD) test is commonly used to measure the amount of organic and inorganic compounds in water. The result ranges from 1.67 to 7.67 mg/l and average is 4.1 ± 1.9 mg/l (Figure 4). According to Bangladesh standard, acceptable COD level is 4 mg/l for drinking purpose. The average COD concentration is very close to the acceptable level.

Hydrogen ion concentration (p^H)

The pH indicates whether acidic or alkaline. According to WHO guideline, pH of drinking water should be within 6.5 to 8.5. The pH result is shown in Figure 5.

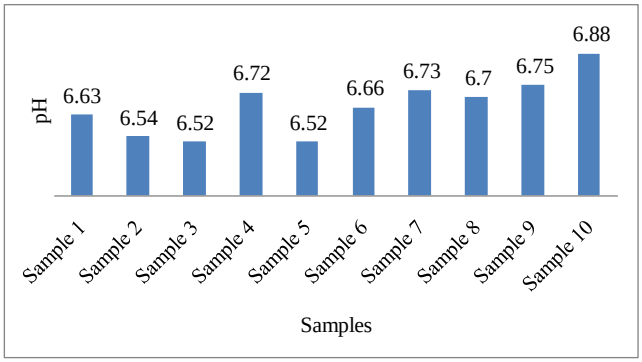

Figure 5: p^H of drained out air conditioner water

From the figure it is observed that for all samples pH is varying from 6.52 to 6.88 and average is 6.66 ± 0.11 which is slightly acidic. In case of industrial application, pH should be within 6.5-8.2 and for irrigation it should be within 5 to 10 while water with pH value of 6.5 to 7.5 can be used in acid cell battery. The obtained results of pH are satisfying the required pH value for industry, irrigation, drinking and battery use.

Corrosiveness

Corrosiveness is the characteristics of substance that can loss the materials. Water may be corrosive due to the presence of mineral that results severe corrosion (Johnson, et al., 1997). The result for corrosion is shown in Figure 6. The result ranges from 38.23 to 44.32 µm/year and the average is 41 ± 2 µm/year.

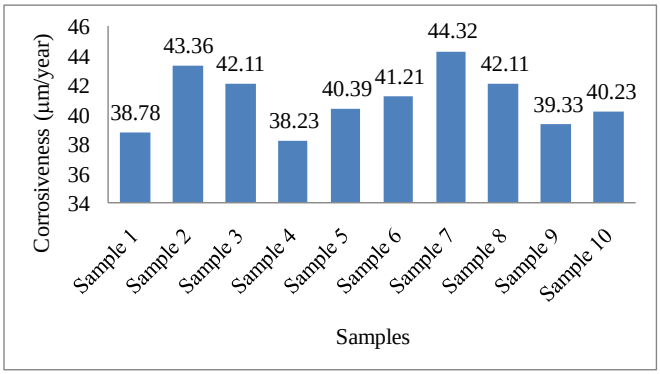

Figure 6: Corrosiveness test result of drained out air conditioner water

For corrosion velocity <50 µm/year is moderately aggressive and no anti-corrosion precaution required. For corrosion velocity from 50 to 150 µm/year is medium aggressive and considered individually; the decision about anti-corrosion actions is made with regard to required pipeline service life and based on the results of technical and economic analyses. For corrosion velocity >150 µm/ year is strongly aggressive and Anti-corrosion actions must be provided with regard to required pipeline service life. The corrosiveness of water for industrial use, use in battery and drinking purpose must be less than 6 µm/year, 50 µm/year and 48 µm/year, respectively. Allowable limit of corrosiveness of water for irrigation varies from 10 to 100 µm/year depending on the materials used for conveying the irrigation water. Therefore, it could be mentioned that this water can be used for irrigation purpose and battery use except industrial purpose.

Hardness

Hardness of water is a measure of the total concentration of the calcium and magnesium ions expressed as calcium carbonate. The result for hardness is shown in Figure 7. The result varies from 2.67 to 5 mg/l with average of 3.9 ±0.7 mg/l. Water containing hardness less than 17 mg/l is considered soft water, 17.1 – 60 mg/l is slightly hard water, 60 – 120 mg/l is moderately hard water, 120 – 180 mg/l is hard water and more than 180 mg/l is very hard water. Therefore, the drained out water from air conditioner is a soft water and can be used in all sectors.

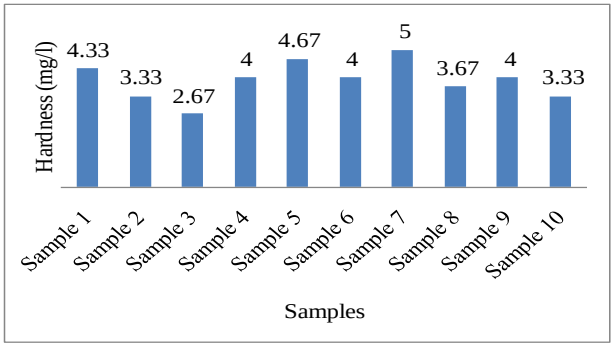

Figure 7: Result for hardness of draining out air conditioner water

Chloride

In potable water, the salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water. Chlorides associated with sodium (Sodium Chloride) exert salty taste when its concentration is more than 250 mg/L. The result for chloride test is shown in Figure 8.

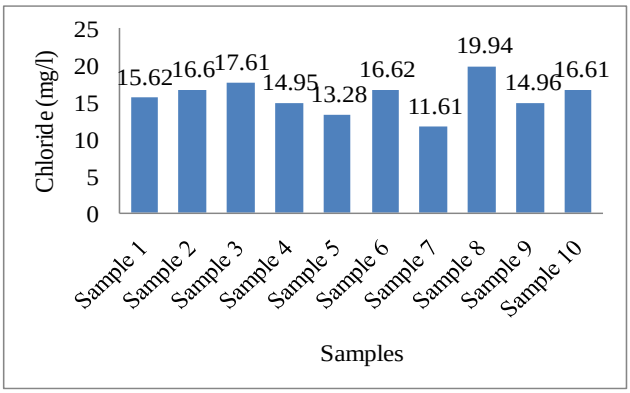

Figure 8: Chloride test result of drained out air conditioner water

The result varies from 11.61 to 19.94 mg/l and average concentration is 15.78 ± 2.3 mg/l. Allowable chloride concentration in water for industrial use varies from 25 to 200 mg/l, for drinking purpose varies from 250 to 2000 mg/l and for use in battery is 1 mg/l (IS 10500: 2012). Therefore, this water can be used in industry, irrigation and as drinking water. But it cannot be used for battery.

Acidity and Alkalinity

Usually dissolved carbon dioxide (CO_2) is the major acidic component present in atmospheric condensed waters. The acidity of water produced by air conditioning system is varying from 1.89 to 2.48 mg/l with an average of 2.2 ± 0.2 mg/l (Figure 9).

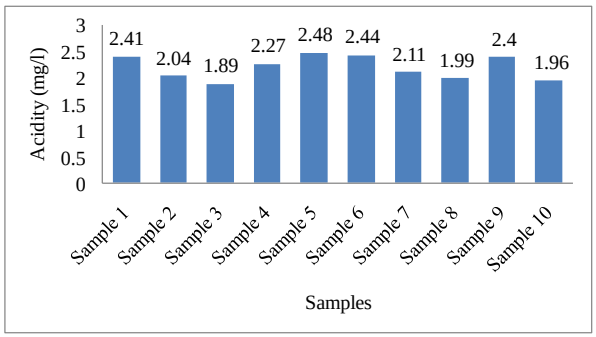

Figure 9: Acidity test result of drained out air conditioner water

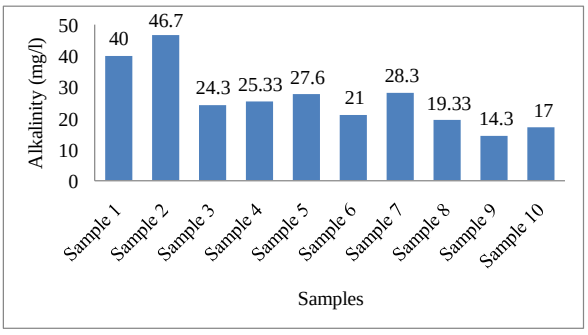

Figure 4.10: Alkalinity of draining out air conditioner water

Aquatic life is affected by high acidic of water. High acidic water is not used for construction purposes, especially in reinforced concrete construction due to the corrosive nature. Water containing mineral acidity is not fit for drinking purposes. Acidity for industrial water is 6.45 to 8.2 mg/l, irrigation water is

5 to 10 mg/l and battery water is 6.5 to 7.5 mg/l. While, the alkalinity ranges from 14.33 to 46.7 mg/l (Figure 12) with average of 26.4 ± 10.1 mg/l. Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes. Higher alkalinity levels in surface waters will buffer acid rain and other acid wastes and prevent pH changes that are harmful to aquatic life.

Iron

The presence of inorganic or organic complex-forming ions in the natural water system can enhance the solubility of both ferrous and ferric iron. The iron test result is shown in Figure 11.

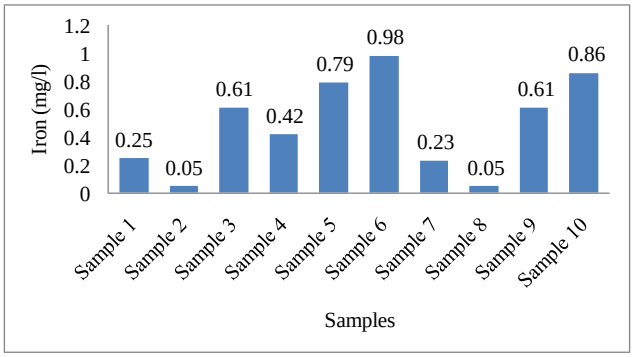

Figure 11: Iron test result of drained out air conditioner water

The possibility of iron concentration in water condensed from atmosphere is negligible. However, it is observed that the iron concentration varies from 0.05 to 0.98 mg/L (0.49 ± 0.33 mg/l). The allowable limit of iron in drinking water is varying from 0.3 to 1 mg/l. The presence of iron in excess of 0.3 mg/l in water forms colour along with associated tastes and odor can make the water undesirable for domestic use. The iron concentration should be within 0.1 to 10 mg/l for industrial use, 5 mg/l for irrigation and 3 mg/l for use in battery.

CONCLUSIONS

The quality of water produced from air conditioner is suitable for industrial and irrigational purpose without any treatment while for drinking and battery use need some treatment. If the condensation coil is kept clean, filtered the air blowing over them and captured the water immediately before it has a chance to pool and potentially grow bacteria then the water might be very clean and pure. However, the quality of water produced through air conditioning system will vary with location, surroundings, maintenance of unit and obviously the air quality in atmosphere from where moisture will be condensate.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

A REVIEW ON DESALINATION USING SOLAR STILLS AND VARIOUS PARAMETERS AFFECTING PRODUCTIVITY

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ABSTRACT
Freshwater scarcity around the world is due to the rapid increase in demand compared to potable sources of water. Seawater treatment by desalination plants is a common practice to serve drinking water which is both energy and cost intensive. The world is now seeking the use of renewable energy more than ever and solar still can be an alternative sustainable solution to the drinking water problem. Solar still is a device that harnesses solar energy to produce fresh drinking water from impure seawater. This study intends to compare various types of solar stills and the governing parameters that mostly affect the productivity. A comparison between different types of solar stills is provided considering physical features, operational features and obtained result. Design parameters, operating parameters, and environmental parameters have been studied that gives an insight of enhancing the productivity under working condition. The relationships between different parameters and production are explained to enable a better understanding of the process for future studies.

Keywords: Solar still; desalination; renewable energy; drinking water

INTRODUCTION

Solar still usually follows the same process of the water cycle in the environment but in a controlled way. The process is ideally suitable for the remote areas where the supply of freshwater by a well-established system is not possible, the places where freshwater is scarce yet provided with abundant solar energy and where desalination plants are not a viable option for drinking water supply due to poor infrastructure. Solar stills are cheap, easy to build, do not require expertise for operation and utilizes renewable solar energy, i.e., a pollution-free process. Since solar still desalination is not dependent upon the supply of external energy or any other complex process, it has drawn significant attention as a potential alternative source of drinking water across the world.

Although the history of solar desalination goes back to more than 2000 years ago, the intensive research on solar stills started during the World War II. A team from MIT developed plastic solar stills to be used in the boats (Telkes, 1943). Since then, a wide variety of materials such as galvanized iron, stainless steel, aluminum, plastic, fiber reinforced plastic, Teflon, glass, etc. have been used with different configurations like single sloped, double sloped, pyramidal, multiple basins, spherical cover, etc. to study the parameters controlling the productivity such as design parameters, operating parameters and environmental parameters.

This study aims to provide a short review of contemporary studies on different designs of solar stills, their comparative productivities and depending factors controlling freshwater production. Though the working procedure of solar stills is simple, involving simple evaporation-condensation processes, the productivity is greatly dependent on types of still, size, location and different other factors. Hence, this

study explores the parameters involved in solar still water production, i.e. design parameters (water depth, evaporation area, cover angle, gap distance, insulation), operating parameters (salt concentration, temperature difference between cover and basin water, water color) and environmental parameters (solar radiation, wind velocity, ambient temperature, dust and cloud cover). Among them, environmental parameters cannot be controlled while the other parameters are able to be controlled. A study of these parameters is therefore significant in developing a solar still to provide drinking water from saline water.

PARAMETERS AFFECTING SOLAR STILL PRODUCTIVITY

According to Ghoneyem (1995), productivity of a solar still is dependent on three conditions: ambient conditions, operating conditions and design conditions. Design parameters involve basin water depth, evaporation area, cover angle, gap distance, insulation, etc. Operating parameters refer to salt concentration, the difference between cover and basin water temperature, water color, etc. On the other hand, ambient conditions indicate the solar intensity, wind velocity, ambient temperature and dust and cloud cover which cannot be controlled directly. Table 1 provides experimental results of the studies of different parameters discussed in this study.

Design Parameters

Water depth is inversely related to the freshwater production. Increasing the basin water depth increases the heat capacity of water that decreases the yield. However, the opposite result is valid for overnight productivity since a lower amount of heat is stored in shallow water depth as mentioned by Abujazar et al. (2016). Khalifa and Hamood (2009) showed experimentally that daylight production is higher for shallow water depth and overnight production is higher for higher water depth.

There is a proportional relationship between solar still yield and evaporation area (Xiao et al., 2013). This can be accomplished by using wick materials such as cotton, cloth, felt; using additional sponges in cubic or rounded shape; using metal fins like aluminum. All these measures provide additional condensation area that can utilize solar radiation for increasing the yield.

If the cover angle is too small or too high, water droplets accumulated on the glass cover may drop back into the still. Moreover, reflective losses may hamper distillate if the angle is not maintained properly. According to Singh and Tiwari (2004), the yield of a solar still reaches maximum value and radiation losses due to reflection is minimized if the cover inclination is made equal to the latitude of the site. Aboul-Enein et al. (1998) recommended optimum tilt angle to be 10^{o} during summer and 50^{o} during winter.

Water production is increased when the gap distance between the evaporation surface and the condensing cover is decreased (Muftah et al. 2014). Ghoneyem (1995) altered the gap distance from 13 cm to 8 cm that increased the water production by 11%. When the gap distance is increased, air mass between cover and water surface increases, leading to a significant delay in saturating the air. This causes the decrease in yield.

A well-insulated solar still can eliminate heat losses from inside and increase the productivity. Insulation material and its thickness play the vital role in this respect. Khalifa and Hamood (2009) noticed 80% more yield by providing insulation of 60 mm thickness.

Operating Parameters

The distillate production is affected by the salt concentration of basin water. If the salt concentration increases up to saturation point, distillate production from a solar still decreases at a linear rate. With the increase in salt concentration, the vapor pressure is reduced at water surface resulting in slower evaporation (Al-Shammiri, 2002). Experimental investigations by Akash et al. (2000); Kalbashi and Esfahani (2010) also demonstrate the similar behavior.

The difference in cover temperature and basin water plays a controlling role in the water production. Freshwater production can be enhanced by increasing the temperature difference. Higher temperature

difference enables an increase in both convective and evaporative heat transfer between basin to cover. As a result, water condensation on the inner glass surface increases, ultimately contributing to higher yield.

The water color affects the productivity of a solar still. Rajvanshi (1981) found 29% more water production using black naphthylamine dye as compared to the still with no ink. With the addition of dye, water absorbs higher solar radiation that increase the productivity from the still (Muftah, 2014).

Table 1: Comparative study of different solar stills

Physical Features (Type; Basin material; Basin area; Cover angle; Other)	**Operational Feature**	**Obtained Result**	**Reference**
• Single slope • GI sheet (1.5 mm) • 1 m^2; 23º	• Water Depth: 1, 2, 3 cm	• Yield: 2.152, 1.931 & 0.826 Kg/m^2/day	Dev et al. (2011)
• Single slope • GI sheet (2 mm) • 1 m^2 • 9º 55’	• Five rectangular fins are used to increase the surface area • Each fin: height 35 mm, length 900 mm, breadth 1mm	• 53% higher evaporation	Velmurugan et al. (2008)
• Double slope • Stainless steel • 3 m^2	• Various cover angle: 15, 25, 35, 45, 55^0	• Optimum angle: 35º; • Yield: 2.17 L/m^2/day	Akash et al. (2000)
• Single slope • GI sheet • 0.25m^2 • 20º	• Gap distance varied from 13 cm to 8 cm	• 11% higher yield	Ghoneyem (1995)
• Galvanized steel sheet (0.8 mm) • 1 m^2 • 35º	• 30 mm, 60 mm and 100 mm insulation	• 80% increase in productivity	Khalifa and Hamood (2009)
• GI sheet • 0.32 m^2 • 3º	• Increased basin water salinity from 0% to 3.5%	• 20% decrease in yield	Kalbasi and Esfahani (2010)
• Single slope • GI sheet (1 mm) • 1 m^2 • 23º	• Additional sprinkler with a flow rate of 0.0001 Kg/sec (Increases cover-basin water temperature difference)	• Yield: 20% higher • Efficiency: 21% higher	Gupta et al. (2016)
• Hemispherical • GI sheet (14 gauge) • 0.08 m^2	• Black ink added to the basin water	• Yield: 2.8 L/m^2/day (without ink) • 17-20% yield increase with 1.25% ink • 25% yield increase with 2% ink	Solanki et al. (2014)
• Plexiglass (6 mm) • 0.12 m^2 • 40º	• Basin bottom is made black for the better absorbance of solar radiation	• Yield has a proportional relation with solar radiation	Rahbar and Esfahani (2012)
• Single slope • Galvanized steel sheet (0.8 mm) • 0.49 m^2	• A 280W fan used to change wind speed • Wind speed varied by 1.14, 2.06, 2.92, 4.01 m/s	• 61.6% higher yield for 2.92 m/s wind speed • Critical speed is found 4 m/s	Khalifa and Ali (2015)

- 33º

Environmental Parameters

Solar radiation is the most significant environmental parameter controlling the productivity since it is the only driving force that leads water to evaporate. There lies a proportional relationship between solar radiation and yield, as shown by Nafey et al. (2000), throughout their annual experimental investigation. An experimental study by Rahbar et al. (2012) also supports the claim.

Wind speed has a positive outcome on the yield of a solar still. Increase in wind speed is associated with higher convective heat transfer coefficient from glass cover to the surroundings which reduces the cover temperature and increases the condensation rate inside the still (Al-Hinai et al., 2002). Khalifa and Ali (2015) performed experimental investigations with varying wind speed from 0 to 4.01 m/s and experienced 61.6% higher yield. They also concluded that wind speed has positive impacts up to a certain limit beyond which it tends to have negative impacts.

Ambient temperature has little impact on the productivity of solar still. Nafey et al. (2000) carried out experiments by increasing the ambient temperature by 5ºC and found only 3% increase in water production from solar still.

The deposition of dust on the cover drops the level of transmittance of solar radiation and decreases the yield. A study by El-Nashar (2009) pointed out a 70% reduction in annual transmittance if the condensing cover is not properly cleaned. El Nashar (1994) also observed a drop of 10% transmittance during summer and that of 6% during winter.

Table 2 summarizes the effects of different parameters on the productivity of solar stills.

Table 2: Summary of the parameters and their effects on productivity

	Parameters	**When increased**	**When decreased**
Design Parameter	Water depth	Negative	Positive
	Evaporation area	Positive	Negative
	Cover angle	Same as latitude is recommended	
	Gap distance	Negative	Positive
	Insulation	Positive	Negative
Operating Parameter	Salt concentration	Negative	Positive
	Cover and basin water temperature difference	Positive	Negative
	Water color	Black dye increases productivity	
Environmental Parameter	Solar radiation	Positive	Negative
	Wind speed	Positive	Negative
	Ambient temperature	Slightly Positive	Slightly Negative
	Dust deposition on cover	Negative	Positive

Negative: Parameter having negative impact on productivity; Positive: Parameter having positive impact on productivity

MODIFICATIONS IN SOLAR STILLS

Over the years, numerous studies have been conducted to improve the freshwater production from solar stills. Wicks, jute fabrics, cotton cloths, sponge, black gravel, etc. have been used to increase the effective evaporation area. Internal and external reflectors are often used to amplify the incident solar radiation. Application of flat plate collector is another approach to capture additional solar radiation. Phase change materials (PCM) are being used for storing heat during sunshine hours and utilizing the heat after sunset for enhanced evaporation (Sathyamurthy et al., 2014). Solar still with evacuated tube collector is another approach to increase the thermal efficiency of the still without any external energy

supply in order to increase the productivity (Singh et al., 2013). Table 3 summarizes several studies on modified solar stills.

Table 3: Modified solar stills and their productivity

Purpose	Applied modification	Obtained Result	Reference
Increasing evaporation area	• Cubic sponge 216 m^3 • Tetrahedral sponge: 216 m^3	• Yield: 172% higher (cubes) • Yield: 219% higher (tetrahedral)	Narayana and Raju (2017)
Increasing evaporation area	• Black cloth in a corrugated shape as wick	• 34% improvement in productivity	Matrawy et al. (2015)
Increasing incident solar radiation	• Internal and external reflector	• Productivity increased by 70% to 100%	Tanaka (2009)
To store heat for better evaporation	• Paraffin wax as phase change material (PCM)	• 28.5% higher productivity	Sathyamurthy et al. (2014)
To improve the evaporation	• Evacuated tube collectors	• Increased productivity • 5.1% to 54.4% variation of energy efficiency	Singh et al. (2013)

CONCLUSION

This study provides an overall review of the parameters involved in influencing productivity in the application of solar stills. Design parameters, operating parameters and environmental parameters have been briefly discussed with relevant references to develop an understanding of the parameters. Design parameters are significantly important since they can be easily controlled in favor of better productivity. Since environmental parameters cannot be controlled, the study of these parameters is required to develop a new solar still design that can minimize their negative effects on the production. This study also presents some recent development techniques in solar still design to augment the yield. As a potential alternative to conventional desalination processes involving higher cost and energy, solar stills can be the very best alternative to drinking water supply for its cheap production cost and utilization of renewable energy. More research works are required in modifications of the stills to improve yield at considerably lower cost.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
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LOW-STRENGTH WASTE WATER TREATMENT: ANAEROBIC FLUIDIZED BED CERAMIC MEMBRANE BIOREACTOR

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ABSTRACT
For low-strength wastewater treatment aluminum dioxide ceramic membrane had been utilized in the bioreactor, called anaerobic fluidized bed ceramic membrane (single-stage) bioreactor (AFCMBR). Complete system has been functioned for 390 days using a synthetic wastewater treatment bed at 25° C, where the chemical oxygen demand was approximately 265 mg/L. Through periodic maintenance the membrane net flux height was measured approximately 15–16.5 L/m2 h, by complete 25 milligram/litter solution of sodium hypochlorite. During operation any adversative consequence of maintenance cleaning on organic subtraction has not been detected. For the smooth functioning of the entire system the projected energy requirement was almost 0.04 kWh/m3, which is almost 16.5% of the total energy, might be created with methane production.

Keywords: Wastewater treatment; Energy production; Ceramic membrane

INTRODUCTION

Anaerobic membrane bioreactor (AnMBR) is a promising technology which is now actively being pursued for treating domestic wastewater (McCarty et al., 2011; Valipour, 2016, 2015; Yannopoulos et al., 2015). However, membrane biofouling is most serious problem as it can reduce membrane lifetime and increases capital/operational costs. New approach to control membrane biofouling with much less energy expenditure than one required by conventional way in AnMBR (i.e., biogas sparging) was developed using anaerobic fluidized bed membrane bioreactor termed as AFMBR. The system produces less sludge with no aeration and electrical energy (renewable) can be produced in the arrangement of methane gas (Zeeman et al., 2008; Foresti et al., 2006; Ghauri et al., 2011). Nevertheless, the particles of GAC with other media which is alternate technique of the organic subtraction and biofouling regulator throughout the operation of the AFMBR (McCarty et al., 2011; Valipour, 2016, 2015), which has further scope of research for improvement.

Evaluation of the different kinds of fluidized media provide the clear mechanisms of the system that might lead to the researchers for design improvements and optimization the system performance regarding organic subtraction efficiency and biofouling. In this paper, our results on comparing receptive performance, biofouling behaviour, membrane biofoulants characteristics and microbial community during the operation of the SAF-CMBR treating low-strength wastewater have been studied. Polyethylene terephthalate (PET) beads and GAC particles were utilized as fluidized membrane for relative comparison. In AnMBR process the membrane fouling is an automatic incident which enhance the fouling resistance in contradiction of hydraulic flow over the ceramic membrane (Le-Clech et al., 2006; Charfi et al., 2012). Generally, sparging of biogas was extensively used to regulate the membrane

fouling over a vital act over the membrane surface. Ceramic membranes have outstanding advantages over the polymeric membranes, in terms of thermal and chemical resistance (Ghauri et al., 2011) and hydrophilic metal oxide surface (Foresti et al., 2006).
In this study, design, fabrication and single-staged of test bench-scale AFCMBR system has been presented for low strength Wastewater treatment by using flat-tubular ceramic membrane. Evaluation of the energy requirement was also performed.

MATERIALS AND METHODS

The two identical AFCMBR systems with 1.5 L of actual volume was fabricated as a polishing compartment for the effluent treatment generated from anaerobic fluidized bed reactor (AFBR) treating low-strength wastewater and operated in parallel at constant temperature of 25° C. Fig. 1 shows the diagram of the AFCMBR system used in this study. The dimension was (25 mm wide × 120 mm long × 575 mm height) fabricated with acrylic sheets, having 1.5 L water volume including settler at the above. The feed to the AFBR contained sodium propionate and sodium acetate at equivalent SCOD concentration of 250 mg/L (approximately). Furthermore; it also contained 10 mL/L and 0.096 g/L of anaerobic digester supernatant, which was collected from a domestic wastewater facility as a resource of micronutrients and nitrogen, respectively. An alumina ceramic membrane with 0.1 m^2 surface area and 0.5 µm pore size was used for the system.
Particles of GAC were fluidized within the AFMBR through recirculating of the bulk solution using reactor. For comparison, substitute to GAC particles, PET beads were used as a fluidized media. The size of GAC and PET bead was 1-2 mm and 3±0.5 mm, respectively and specific gravity was 2.3 and 1.3; respectively. At the bottom of the reactor a diffuser was mounted to permit the recirculating bulk suspension for fluidize, both fluidized media beads to rise and cover the complete ceramic membrane surfaces. The membrane biofoulants from fouled membranes were also characterized for microbial community, extracellular polymer substances (EPS) and confocal laser scanning microscopy (CLSM) for biofouling analysis.

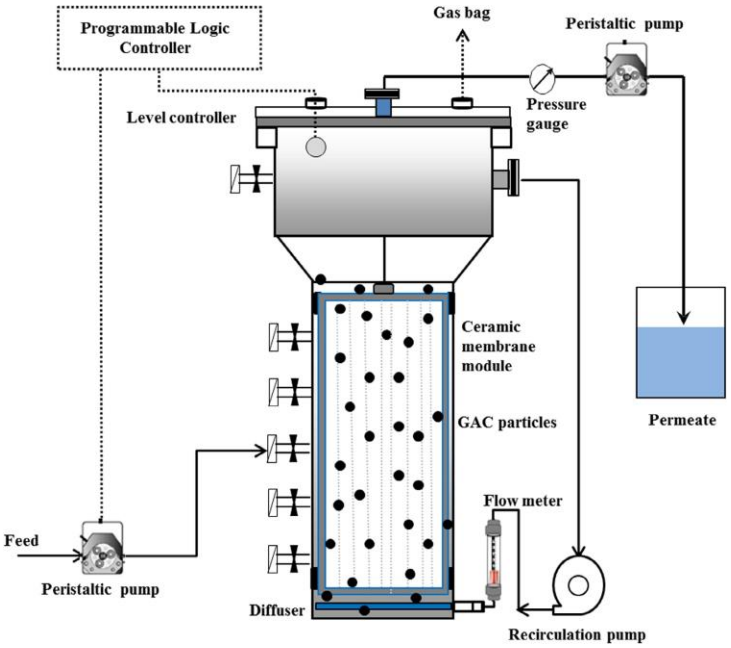

Fig. 1. Diagram of the AFCMBR system.

The membrane foulants producing cake layer and the pore blocking have been collected for further investigation. Using a plastic spatula, the cake layer was detached from the membrane surfaces and suspended in DI water. The DI water volume was 0.5 L. The foulants underwriting which creates constriction and blockage were then removed through backwashing using solution of sodium hypochlorite (5000mg/L). Darcy's law has been used to measure the fouling resistance.

RESULT AND DISCUSSIONS

In this study, plastic PET and Granular activated carbon beads (GAC) were used to evaluate the fluidized media and examine the membrane biofouling behaviour, system performance, membrane biofoulants characteristics and microbial community for long-term process of the AFCMBR polishing of the AFBR effluent. Outcomes of this study displayed that the mentioned mediums provide efficient way to control the membrane biofouling by mechanically cleaning method along the surfaces of the membrane. Hydrophilic ceramic membrane also provided synergistic effect in fouling control as compared to the hydrophobic polymeric hollow-fiber membranes. Overall COD removal was somewhat lower with PET beads than that observed with GAC particles (>90%) as fluidized media in SAF-AFCMBR at same operational condition. For complete fluidization process, considering GAC fluidization consumption of the total electrical energy was 0.024 kWh/m3, which is less than an anaerobic MBR process associated with sparging of the biogas to minimized membrane fouling.

Fig. 2 shows deviations of the carbohydrate and protein contents in the EPS and SMP throughout the various working techniques. The protein concentration was 1.5 (approximately) times higher than that of the carbohydrate concentration. In an anaerobic method the hydrolysis process is a rate-limiting stage, thus the hydrolysis of proteins is inferior than that of the carbohydrate. Figure represent that the protein accessible 65–71% of the entire EPS and SMP concentrations was (8.2–20.3 mg/L). Apparently, the range of this concentration (8.2–20.3 mg/L) is much lower than that of the biogas-sparged in the system of aerobic MBR. Production of the biosolids were within the variety of 0.005–0.021 g (approximately), which was much lower than the system of aerobic MBR. Nevertheless, production of the biosolids is mostly predictable at the time of domestic wastewater treatment which preserves the high quantity of VSS and TSS concentrations, i.e., 24–129 mg/L and 28–165 and, correspondingly, depends on the environmental variations.

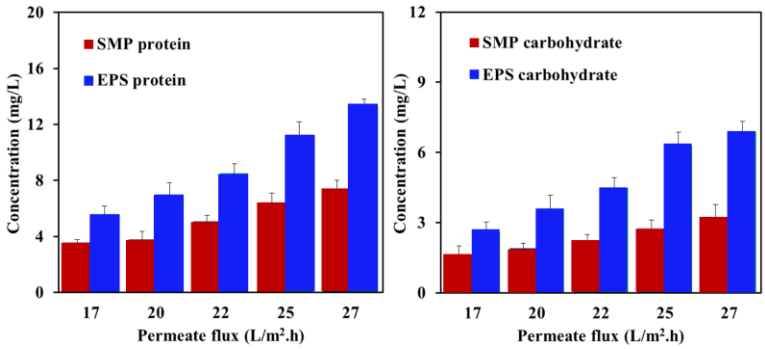

Fig. 2. Deviations of the protein and carbohydrate contents in the EPS and SMP throughout the various operational techniques.

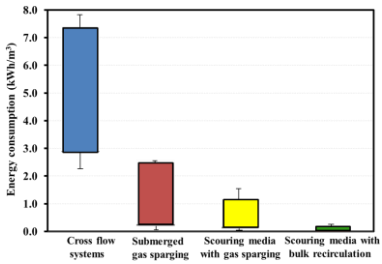

Fig. 3. Consumption of the electrical energy in different fouling control system.

Fig. 3 evaluates the energy consumption in fouling control process related to various methods of fouling. Fluidizing is one of the polishing agents, which is most energy-effective method (without gas sparing) regarding fouling regulate as compare to the other techniques (i.e., gas sparging).

Table 1 displays the necessity of the total electrical energy for the proposed method. In AFBR and AFCMBR system the electrical energy consumption was limited to 0.004 and 0.02 kWh/m3, correspondingly for permeate production and GAC fluidization. Thus, the over-all electrical energy consumption was 0.024 kWh/m3. Table also represent that the energy requirements for the AFBR

system was lower than AFCMBR system because it is necessary to fluidized the GAC over the surfaces of the membrane to regulate the membrane fouling.

Table 1: Requirements of the electrical energy, potential production through SAF-CMBR method

Electrical energy required	AFCMBR	AFBR	Total
GAC fluidization	0.013	0.004	0.017
permeate production	0.007	N/A	0.007
Total	0.020	0.004	0.024
With gaseous methane	N/A	N/A	7.15
With total methane	N/A	N/A	9.82

CONCLUSIONS

In this study, low-strength wastewater has been treated using aluminum dioxide ceramic membrane through the well-known bioreactor, called anaerobic fluidized bed ceramic membrane (single-stage) bioreactor (AFCMBR). Biofouling reduction efficiency, microbial community structure, biofoulants and bulk characteristics varied considerably depending on the fluidized media applied in SAF-CMBR system. GAC as porous fluidized media provided synergistic effect in biofouling mitigation and organic removal efficiency as compared to the PET non-porous beads as fluidized media. Carbohydrates and proteins were very vital elements of biofouling layer which is very complicated to extracted by maintenance cleaning only.

ACKNOWLEDGMENTS

This work was supported by the new faculty research fund of Sejong University in 2018.

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4thInternationalConference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
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DRINKING WATER QUALITY ASSESSMENT OF HALISHAHAR THANA IN CHITTAGONG CITY

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ABSTRACT

Assessment of drinking water quality of Halishahar Thana of Chittagong City has been performed in the study. Water samples were collected from supply systems of different residences and tubewell as ground water source from public places like shops in the area. The study revealed that most of the water quality parameters except iron and total suspended solids of the collected water samples comply with the Bangladesh drinking quality standards. It is noteworthy to mention that the studied water samples were free of total and fecal coliform which is very important finding regrading health concern. The study tried to cover the seasonal variation in water quality collecting samples in various months of the year. There is no specific trend was found during different months in water quality. However, further evaluation of the existence of micro-organisms and identification of potential seepage and leakage sources were suggested in the study.

Keywords: Assessment, Water Quality, Drinking Quality, Iron, Faecal Coliform

INTRODUCTION

Water is an essential component of natural resources and plays an important role for the purposes of drinking, irrigation and aquaculture and livestock usages. The quality of drinking water is closely associated with human health, and providing safe drinking water is one of important public health priorities (M.F.R. Zuthi et. al. 2009). Estimated 80 per cent of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water, and on an average as much as one tenth of each person's productive time is sacrificed to water-related diseases (UNCED, 1992). All biological reactions occur in water and it is the integrated system of biological metabolic reactions in an aqueous solution that is essential for the maintenance of life.

Most human activities involve the use of water in one way or other. It may be noted that man's early habitation and civilization sprang up along the banks of rivers. Although the surface of our planet is nearly 71% water, only 3% of it is fresh. Of these 3% about 75% is tied up in glaciers and polar icebergs, 24% in groundwater and 1% is available in the form of fresh water in rivers, lakes and ponds suitable for human consumption (Dugan, 1972). A drinking water system's water quality may be acceptable when the water just leaves a treatment plant. Developing countries, like Bangladesh, have suffered from a lack of access to safe drinking water from improved sources and to adequate sanitation services (WHO, 2006). As a result, people are still dependent on unprotected water sources such as rivers, streams, springs and hand dug wells. Since these sources are open, they are highly susceptible to flood and birds, animals and human contamination. In addition, most sources are found near gullies where open field defecation is common and flood-washed wastes affect the quality of water.

In this regard the study is conducted to assess the drinking water quality of supplied water and ground water of Halishahar Thana of Chittagong city, the commercial city of Bangladesh. Few recommendations are also made at the end of the study.

METHODOLOGY

The study area was Halishahar residential area of Chittagong city. Water samples from different sources were collected to assess their quality. The water samples were collected twice in every month from October 2017 to May 2018 to account the seasonal variation on water quality. The details of sample locations and their types sources are shown in table 1 and in figure 1. Necessary precautions were taken during the sample collection and the samples were analysed in the Environmental Engineering laboratory of CUET within shortest possible time.

Table 1: Sample Identifications and their sources

LOCATION	WATER SOURCE	SAMPLE ID
Godown Bazar	Supply Water (CWASA)	S-1
Block-A	Supply Water (CWASA)	S-2
Block-K	Supply Water (CWASA)	S-3
Abbaspara	Ground Water	G-1
Block-B	Ground Water	G-2

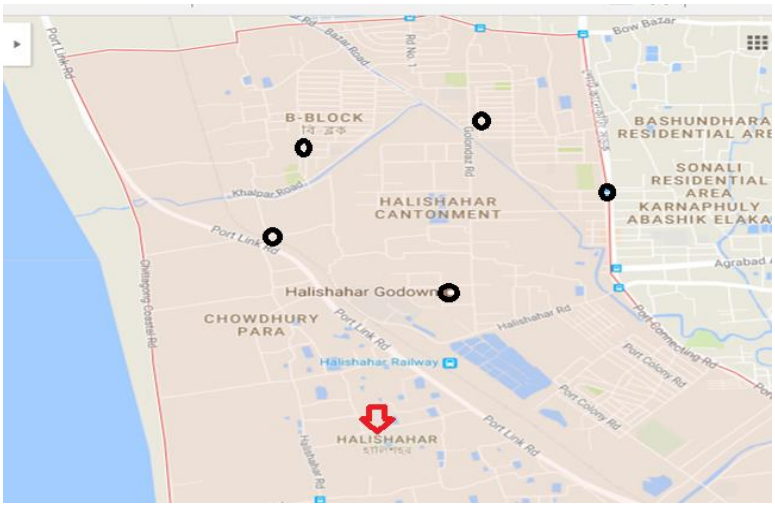

Fig 1: Location Map of Collected Samples

RESULTS AND DISCUSSIONS

The physical, chemical and biological quality of the collected water samples were assessed .The average quality of all the samples in different months are shown in Fig 2-5. It is observed from the study that most of the parameters except iron and TSS of the water are within the drinking water standards of Bangladesh (ECR, 1997). The Iron content was maximum (0.9 ppm) in the supply water collected from Block K in December. There is no specific trend was observed in different months of the year in water quality. Like supply water, all the ground water samples satisfy the drinking water quality standards except in the cases of iron content and total suspended solids. The ground water samples contain very high iron content and the maximum (3.2 ppm) was found in Abbaspara and in the early December of the studied year. Therefore it is recommended in the study that the water is needed to be treated before drinking.

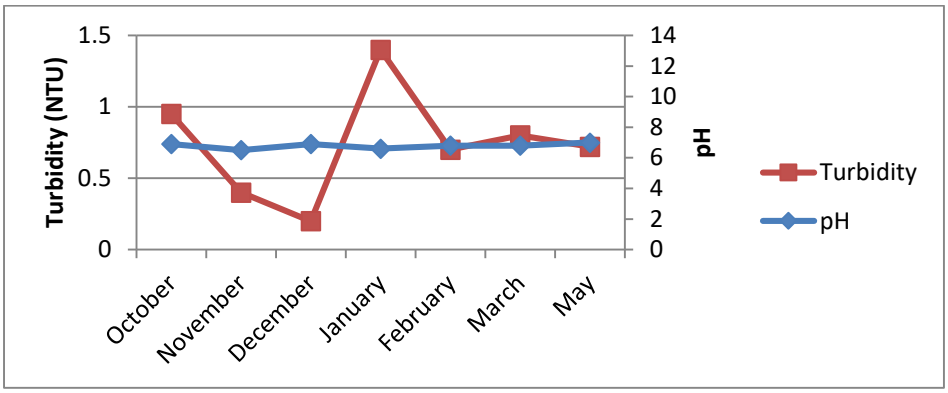

Fig. 2: Monthly variation of pH & turbidity (Average Value)

The pH value is range up to 6.6-7.0 which indicates a better range according to WHO guideline where 6.6 shows little bit acidic and 7.0 refers pure water which is satisfactory for all purpose.All the values of pH are within the range of Bangladesh standard value (6.5-8.5) and WHO standard value (6.5-8.5).The value of turbidity (NTU) of analyzed samples are under the Bangladesh standard value (<10NTU) for drinking water and also under WHO value (5NTU).Turbid water generally interferes the recreational purposes and aesthetic appearance of the water.From the analyzed sample data, it can be concluded that every sample satisfies the Bangladesh standard for drinking water.

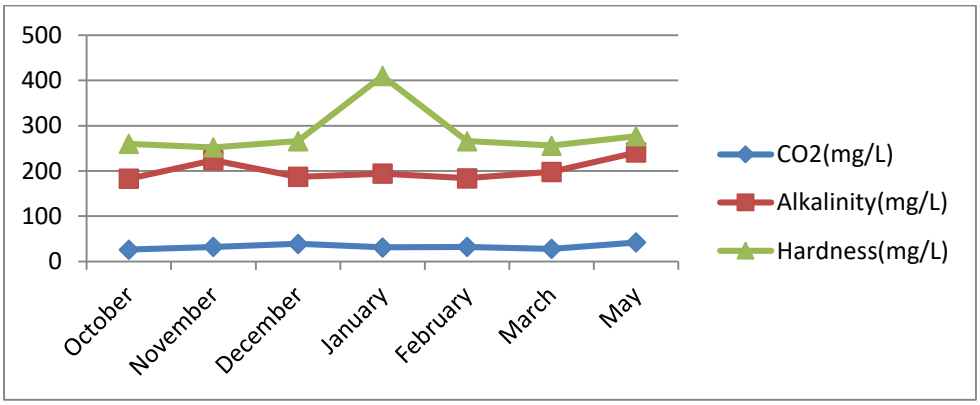

Fig. 3: Monthly variation of Hardness, alkalinity & CO_2 (Average Value)

As per chart all hardness value range up to 252-410 ppm in water. Where the hardness value of Bangladesh standard and WHO guideline is about 500ppm.so it is eligible to drink Scaling of water fixtures, soap scum at high levels, corrosion at low levels .These problems occur at high hardness. The alkalinity values of analyzed samples lie between (183-241) ppm.The alkalinity is the sum of total components in the water that tend to elevate the pH of the water above value of about 4.5. Alkalinity is a measure of buffering capacity of the water, and since pH has a direct effect on organisms as well as an indirect effect on toxity of certain other pollutant in the water. The buffering capacity is important for water quality. When the value of carbon di oxide is higher, the value of pH found in water is lower. The higher amount of carbon-di-oxide indicates the water is acidic in nature.

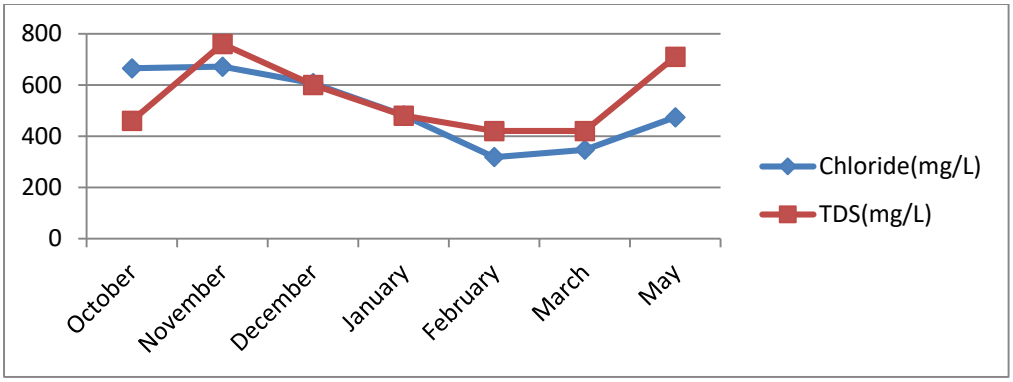

Fig. 4: Monthly variation of TDS and Chloride (Average Value)

Excess dissolved solid are objectionable in drinking water because of possible physiological effects, unpalatable mineral tastes and higher costs because of corrosion or necessity for additional treatment. From the analyzed result, it is very clear that all the results are below the maximum value of WHO standard and Bangladesh standard (1500 mg/L for TDS). High chloride concentration values may be due to saline water intrusion problem which is quite frequent in the CWASA's sources of supply now-a-days. At concentration above 250ppm chloride rich water gives a salty test, causes various diseases such as high blood pressure etc. but it depends on individual adaptability.

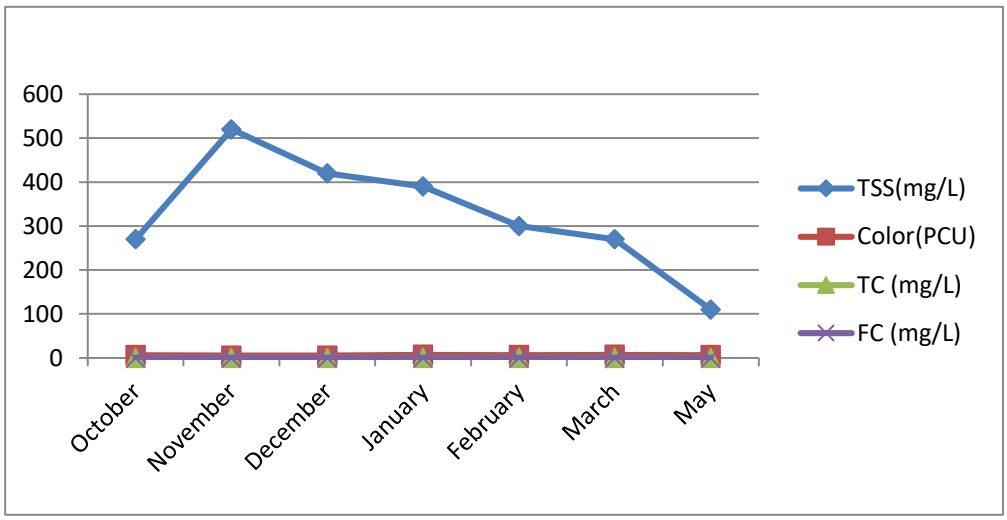

Fig 5: Monthly variation of TSS, Color ,TC & FC (Average Value)

The value of TSS (ppm) of analyzed samples of Halishahar area is higher. It can because of seepage or leakage of pipeline. The higher value of TSS means the water is more turbid. The value of TSS of Halishahar area is higher than the WHO standard value and also higher than the Bangladesh standard value (10 mg/L). However, there is widespread concern over the biological effects of the asbestos mineral fibers that occur in water, since similar fibers are known to be carcinogenic when air heavily laden with them is inhaled for many years. In view of this concern that such fibers as occur in water may be injurious to health, their occurrence, characterization, analysis, and biological effects are reviewed in some detail. No evidence has yet been discovered

that either of the other classes of common particulate contaminants of drinking water—clays and organic colloids—has any direct effect on health. Nevertheless, it is possible that both may indirectly affect the quality of drinking water because they can adsorb a variety of toxic substances, bacteria, and viruses from solution or suspension and bind them more or less strongly. By such means these materials may serve to concentrate and transport some water pollutants and protect them from removal by water treatment. The is no TC and FC is found which is very important in case of drinking purposes to avoid waterborne diseases.

COMPARISON WITH THE WATER QUALITY OF CHADGAON AREA OF CHITTAGONG CITY:

A study is found regarding the drinking water quality of Chadgaon residential area of Chittagong city (Khan 2017) . A comaparison has been made with the previus study with this study as follows:

- The pH value of Halishahar thana and Chadgaon R/A both are between Bangladesh Standard and WHO guideline (6.5-8.5).
- Turbidity value at Halishahar thana is 0.7 NTU and at Chadgaon R/A is 8.46 both are below the BD Standard value (10 NTU).
- TSS value at Halishahar Thana is 326 ppm which is above the BD Standard value (10 ppm) and at Chadgaon R/A is 2 ppm which is below the BD Standard.
- Alkalinity value at Halishahar thana is 202 ppm and at Chadgaon R/A is 72.45 ppm
- Hardness value at Halishahar thana is 284 ppm which is between BD Standard value (200-500 ppm)and at Chadgaon R/A is 65.145 ppm which is below the BD Standard value.
- TDS value at Halishahar thana is 550 ppm and at Chadgaon R/A is 234 ppm both are below the BD Standard value (1500 ppm).
- Chloride value at Halishahar Thana is 509 ppm and at Chadgaon R/A is 177.9 ppm.
- Water quality assessment of Halishahar thana and Chandgaon residential area study shows that the parameters are varying. It can be because of improving the supply-line or mechanical error of laboratory test or for seasonal variation. Contamination via cross-connection, leaky pipe joints, or pipe breaks may influence water quality. Pathogens may enter the system through contaminated raw water or breaks in pipelines error of laboratory test or for seasonal variation.

CONCLUSIONS

The concluding remarks which have been derived from the investigation are presented below:

- Water quality assessment of Halishahar thana study shows that all the quality parameters are varying which might be of improving the supply-line or for seasonal variation.
- No TC and FC is found and it is very important for following WHO guidelines for drinking water.
- Water parameters like pH, Hardness, TDS, chloride for Supply water and for Ground water pH, Chloride, Alkalinity properly follow WHO guideline and Bangladesh standard value.
- For Ground water Iron, TSS, Hardness and for supply water TSS do not follow the Bangladesh standard and WHO guideline value.
- Due to high Iron, TSS, Hardness there is such health diseases occur like Hemochromatosis, Organ failure.

Drinking water quality assessment is necessary to make sound decisions on managing water quality today and in the future. Water-quality monitoring is used to alert us to current, ongoing, and emerging problems; to determine compliance with drinking water standards, and to protect other beneficial uses of water. Assessments based on monitoring data help law makers and water managers to measure activeness of water policies, determine if water quality is getting better or worse, and formulate new policies to better protect human health and the new policies to better protect human health and environment. Drinking water quality assessment at a specific location,

help us compared to other location near that studied location and informed about the condition of that studied location drinking water quality.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
19 –21 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

PREDICTIVE MODELS FOR DISINFECTION BY-PRODUCTS (DBPS) FORMATION IN DRINKING WATER: A REVIEW

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ABSTRACT
Water disinfection processes afford a great success in eliminating harmful microorganisms and acute water-borne diseases, but they may produce unintended halogenated carcinogenic disinfection byproducts (DBPs) due to the reactions of disinfectants with natural organic matter (NOM). Worldwide the development of mathematical models that predict the formation of DBPs under different water quality and treatment conditions is of wide interest and usefulness to the drinking water field. More than 100 DBPs formation models have been published in the last 30 years. Some researchers used an entirely empirical approach and some introduced kinetics into the modelling process. This paper has reviewed various models and approaches used for predicting DBPs occurrence in drinking water necessary to evaluate the usefulness and applicability of DBPs models.

Keywords: Disinfection, Disinfection by-products, Health Risk, Predictive models

INTRODUCTION

Disinfection byproducts (DBPs) are formed upon the chemical reaction of organic and inorganic precursors present in water with chemical disinfectants. Natural organic matter (NOM) generally serves as the organic precursor, whereas bromide ion (Br-) serves as the inorganic precursor (Krasner et al., 2017; Xiamomao et al. 2014). Due to chronic exposure to DBPs through the ingestion of drinking water, inhalation and dermal contact during regular indoor activities like showering, bathing, cooking carcinogenic and non-carcinogenic risks to human health may be posed (Tradfil et al., 2016; Grellier, 2015; Health Canada, 2006). Disinfection byproducts are suspected to cause cancer, liver and kidney and human fetus damage (Health Canada, 2006; U.S. EPA, 2006).

The formation of disinfection byproducts (DBPs) is a function of many factors. Different water quality parameters such as pH, temperature, ammonia, carbonate alkalinity, bromide, and treatment conditions (e.g., disinfectant dose, contact time, removal of NOM before the point of disinfectant application, prior addition of disinfectant) influenced the formation of DBPs (Xie et al., 2008; Chowdhury et al., 2009; Chowdhury and Champagne, 2008). A significant effort has been invested to develop predictive models for DBPs in drinking water (Evan et al.2014; Lu et al.,

2011). Different modelling approaches have been used to relate water quality and operational parameters with disinfection by-products (DBPs) concentrations in water. The (DBPs) models can be useful for operational purposes during water treatment and water quality management, for the evaluation of water treatment facilities, for exposure assessment in epidemiological studies and health risk assessment, and for estimating the benefits and impacts of DBP regulations. This paper has reviewed various predictive models for DBPs of different approaches with their potential use, application and limitations.

BACKGROUND OF DBPs MODELING

Models for DBPs have been developed for different purposes. In some cases, modelling is aimed at identifying the significance of diverse operational and water quality parameters controlling the formation of DBPs or at investigating the kinetics for their formation. In other cases, they are developed with predictive purposes as an alternative to monitoring in the field (Lu et al., 2016; Evan et al., 2014; Sadiq and Rodriguez, 2004). DBP models, formulated and developed in past three decades can be roughly classified into two main kinds: models based on empirical relationship and models based on kinetics involved during chlorine reaction (Chowdhury et al., 2009; Shon et al., 2004). Chowdhury et al., 2009; provides a chronological summary of existing 48 models and their advantages and limitations. The article demonstrates that several of the models were capable of generating linear correlations (R^2) > 0.90 based on results from their respective studies. Multiple linear and non-linear regression techniques are found to be the most common in developing DBPs predictive models. Other methods like ridge, logistic regression and artificial neural networks have also been employed. Most of the predictive models are based on laboratory-scaled studies, but some models have been proposed based on actual water distribution sampling as well (Al-Omari et al., 2004).

PARAMETERS OF DBPs PREDICTIVE MODELS

A number of parameters have been incorporated in the development of DBPs formation predictive models. Most of the models reported in the literature use dissolve organic carbon (DOC) or total organic carbon (TOC), disinfectant dose, pH, temperature, and reaction time as explanatory variables. (USEPA, 2001a, b; Amy et al.,1998). The TOC, DOC, UV254 and SUVA(Table2) are often used as surrogate measures representing NOM in water. TOC indicates the total mass of organic substances (suspended and dissolved fractions), while DOC indicates the mass of the dissolved fractions and UV_{254} represents the specific structure and functional groups of NOM (USEPA, 2001 a, b).

A few other studies have incorporated chlorophyll-a and fluorescence as the surrogates for NOM in water (Sadiq and Rodriguez, 2004). Some models use more than one parameter from TOC, DOC, UV_{254}, SUVA and algae to address the effects of NOM. In addition, a number of studies have reported using NH_3–N (ammonia nitrogen), seasonal variation, regional effects and ratios between HOCl and HOBr in developing DBP formation models (Hong et al., 2007)

Table: 1 List of some kinetic and empirical THMs formation models

Model	Model description	Considered parameters	Author and year
MM87	THMs = K_1. K_2.TOC.[(1/ (K_1 + K_3) (K_2 +0.19))) + (1/ (K_1+ K_3- K_2 - 0.19)) x (((1/ (K_1 + K_3) exp (- (K_1 + K_3)(tc)) – ((1/(K_2 +0.19)) exp (- (K_2 +0.19) (tc))] ; K_1 = 4.38 x 10^{-8}(D); K_2 = 11.36 x 10^{-7} (D); K_3 = 7.14 x 10^{-13} $(D)^2$THMs = 0.00309 $(TOC.UV_{254})^{0.44.}$ $D^{0.409}$ $t^{0.265}$ $T^{1.06}$ (pH -2.6) $^{0.715}$ $(Br^-+1)^{0.03}$	12	Morrow and Minear, 1987
AD91	a. THMs = 3.91+$(Br^-)^{0.15}$ + 0.23 log (D) + 0.24 +(pH) +$10^{0.009rT}$+ 0.26 (NVTOC) b. THMs = 3.94 + $(Br^-)^{0.19}$ + 0.35 log (D) + 0.24 (pH) + $10^{0.009T + 0.27}$ (NVTOC) c. THMs = 2.42 + $(Br^-)^{0.15}$ + 0.24 log (D) + 0.24 (pH)+ 10 - 204.5T + 0.25 (NVTOC)	6	Adin et al. 1991
URA83	THMs=0.00082(pH −2.8)TOC.$D^{0.25}$.$t^{0.36}$	4	Urano et al.(1983)
HAR92	THMs=0.00309 (TOC .UV254)$^{0.44}$.$D^{0.409}$ $t^{0.265}$ $T^{1.06}$ $(pH-2.6)^{0.715}$ $(Br^-+1)^{0.03}$	7	Harrington et al. (1992)
RAT96	THMs=14.6 $(pH-3.8)^{1.01}$$(D)^{0.206}$ $(UV254)^{0.849}$ $(t)^{0.306}$; R^2	4	Rathbun (1996)
CHA96	THMs=12.72 $(TOC)^{0.291}$ $(t)^{0.271}$ $(D)^{-0.072}$; R^2 = 0.97	3	Chang et al.(1996)
AMY98	THMs=0.00412$(DOC)^{1.10}$$(D)^{0.152}$$(Br^-)^{0.068}$$(T)^{0.61}$$(pH)^{1.60}$ $(t)^{0.260}$	6	Amy et al. (1998)
ROD00	THMs=0.044$(DOC)^{1.030}$$(t)^{0.262}$$(pH)^{1.149}$$(D)^{0.277}$ $(T)^{0.968}$; R^2 =0.90	5	Rodriguez et al.(2000)
ALO04	THMs=4.527$t^{0.127}$ $D^{0.595}$ $TOC^{0.596}$ $Br^{0.103}$ $pH^{0.66}$	5	Al-Omari et al. (2004)
SOH04	THMs=$10^{-1.385}$$(DOC)^{1.098}$$(D)^{0.152}$$(Br)^{0.068}$$(T)^{0.609}$$(pH)^{1.601}$$(t)^{0.263}$; R^2 =0.90	7	Sohn et al. (2004)
UYA05	THMs=0.0707$(TOC+3.2)^{1.314}$$(pH-4.0)^{1.496}$$(D-2.5)^{-0.197}$$(T+10)^{0.724}$; R^2 =0.83	4	Uyak et al. (2005)
HON07	THMs = $10^{-1:375}$$t^{0.258}$ (D/DOCÞ)0.194$pH^{1:695}$$T^{0.507}$ $(Br^-)^{0:218}$; R^2 = 0.87	6	Hong et al. (2007)

Table: 2 List of most frequently used parameters during DBPs model formulation

Key explanatory parameters of different DBPs model with unit	
Total trihalomethanes, THMs	Total organic bromide, TOBr (mg/l)
Chloroform, $CHCl_3$	chlorophyll-a , Chla (mg/m^3)
Bromodichloromethane, BDCM	hydroxide concentration, OH^-
Dibromochloromethane, DBCM	rate constant; k
Bromoform, $CHBr_3$	Rate constants for rapid and slow reactions, kr, ks
Haloacetic acids, HAAs	Outflows in the finished water reservoir, Qoutflow
Total organic carbon, TOC (mg/l)	Volume of the tank,
Dissolved organic carbon, DOC (mg/l)	Fulvic acid (mg/L), FA
pH,	Ultraviolet absorbance at 254nm, UV_{254} (cm^{-1})
Temperature, T (^{0}C or K)	Fraction of the chlorine demand attributed to rapid reactions, fs(mg/l),residual chlorine at the treatment plant after chlorination C_0 (mg/l); initial chlorine concentration Cl_1 (mg/l); residual chlorine Cl_r(mg/l)
Bromide ion concentrations, Br− (mg/l)	
Chlorine dose, D (mg/l)	
Reaction time, t (hr).	

EVALUATING THE PERFORMANCE OF MODELS

To evaluate the performance of different models, it is often required that the models be developed under similar water quality and operational conditions. It is difficult to make precise judgments regarding the performance of reported models, as these models were generally developed using different modelling approaches, parameters and pretreatments, as well as variable water quality characteristics (Evan et al., 2014; Chowdhury et al., 2009). A large number of models were evaluated using statistical techniques, where coefficients of determination, correlation coefficients, and mean absolute errors between measured and predicted data, and distributions of residuals are often considered as indicators of model performance (Sadiq and Rodriguez, 2004). However, regression models often have limitations in that these models should be used within the experimental conditions for which the models were developed. Despite the fact that most models are multiple regression models estimated from field or laboratory data, operating regions in the factors over which the models provide reliable predictions were seldom reported. In addition, most of the models did not consider actual water supply systems and/or external databases for model validation knowledge (Uyak et al. ,2005).

POTENTIAL APPLICATION OF MODELS

Predictive models for DBP formation have a wide range of applications in the design and management of drinking water supply systems, for regulatory agencies, in toxicological and epidemiological risk assessment studies, as well as in risk–cost trade-off analyses (Delpla et al., 2016; Al-Otoumet et al., 2016). These models can be employed to determine the effects of different water quality and operational parameters on DBPs formation. Based on the analyses, different water quality and/or operational parameters can be adjusted to control DBP formation in drinking waters. Managers and operators of drinking water supply systems can use these models as a decision-making tool to achieve better operational control during the treatment process (Zhu and Zhang, 2016; Richardson et al., 2011).

LIMITATIONS OF DBPs PREDICTIVE MODELS AND FUTURE RESEARCH

Many of the DBPs predicting models are not applicable to a wide range of source water because of the experimental design or methodology involved in the model formulation. There exists a significant gap with respect to the model parameter selections, as well as the characterization of model parameter correlations and interactions (Chowdhury and Champagne, 2008). Research is necessary to develop models that are more representative of real water supply systems by incorporating simultaneous variations of multiple parameters as majority of the models based on laboratory-scaled studies. Kinetics models can be effectively used only if the DBPs formation kinetics and kinetic rate constants are known. The model parameters may also vary temporally and spatially. Future research could incorporate alternative experimental techniques, such as modeling based on fundamental reaction kinetics, as well as robust modelling approaches, such as fuzzy rule-based modeling (Xie et al., 2008), adaptive neuro fuzzy inference system (ANFIS) modeling and artificial neural networks(ANN) (Milot et al., 2002).

CONCLUDING REMARKS

It appeared that a significant effort has been invested to develop predictive models for DBPs in drinking water. Models can be categorized based on methodology for data generation, the type of independent/ explanatory variables and the model usefulness. Most of the predictive models are based on laboratory-scaled studies, but some models have been proposed based on actual water

distribution sampling as well. However, research is necessary to evaluate the usefulness of DBP models and to adapt them for the purposes mentioned. More toxicological information on DBPs is available, therefore the development and use of models will be very helpful in the future to deal with these substances in drinking water.

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EVALUATION OF COMBINED PERFORMANCE OF FLY ASH AND ACTIVATED CARBON FOR TANNERY WASTEWATER TREATMENT

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ABSTRACT
A study was conducted to treat the tannery wastewater through sedimentation –coagulation –aeration - filtration. Mixed fly ash and powder activated carbon was used as a coagulant. Granular activated carbon was used as a layer of the filter bed. The objective of our work was to develop an economic treatment system which lowers the concentration of pollutants effectively in tannery wastewater to environmentally friendly and reduce the cost of discharging the effluents in the environment. The results found that 83.08% removal of Chemical Oxygen Demand, 86.61% removal of BOD5, 42.06% removal of Chloride, 93.90% removal of Chromium, 84.95% removal of TS, 92.00% removal of TSS, 83.99% removal of TDS, 90.93% removal of Turbidity. After filtration, a sample was kept for 10 days to get aerated. The significant result comes out by final effluent of BOD5, turbidity, TS, TSS, TDS as 30 mg/l, 22 NTU, 665mg/l, 45mg/l, 620mg/l respectively which is an environmentally acceptable limit which reveals that aeration is the good process for the treatment of tannery wastewater.

Keywords: Coagulation, Activated carbon, Chromium etc.

INTRODUCTION

Environmental pollution from industries in developing countries is a growing concern as it always tradeoff with economy. Although relevant rules and regulations exist to abate the pollution, the implication rarely goes beyond that margin. Among many industries, tannery industries are seen to be one of the significant polluters in relation to its effluent with high chemical oxygen demand (COD) together with elevated chrome concentration and with dyestuff. Kurt et al (2007) highlighted that the uncontrolled and untreated effluent release in natural water bodies not only increases the environmental pollution into the discharge bodies but also has serious health risks associated with aquatic and human lives that exposed to the use of this water downstream. Tannery wastewater is seen to be a strong contaminate with elevated concentration of chlorides, aliphatic sulfonates, sulfates, aromatic and aliphatic ethoxylates, acrylic acid condensates, fatty acids, dyes, proteins, soluble carbohydrates and Na2S (Murugananthan et al., 2004). The tannery industry belongs to one of the most polluting industrial sectors. Almost every tannery industry uses significant amounts of chemicals in the process of transforming animal hides into leather (Dargo and Ayalew 2014).

In Bangladesh, about 90% of tannery industries are engaged in the chrome tanning process because it is simple in operation and renders excellent properties to the leather. The tanning process is almost completely a wet process that consumes significant amounts of water and generates about 90% of the used water as effluent (Chowdhury et al. 2013). Tannery effluents carry heavy pollution loads due to a massive presence of highly colored compounds, sodium chloride and sulphate, various organic and inorganic substances, toxic metallic compounds, different types of tanning materials which are biologically oxidizable, and large quantities of putrefying suspended matter (Akan et al. 2007). The tannery effluent damages the normal life of the receiving water bodies and land surface (Cooman et al. 2002).Generally, water consumption is the highest in the pre-tanning areas, but significant amounts of

water are also consumed in the post-tanning processes. The soaking stage, the most polluting stage of the tanning process, contributes around 50–55% of the total pollution load of the tanning industry. In the liming stage protein, hair, skin and emulsified fats are removed from the hides, they are released in the effluent and increase its total solids contents (Chowdhury et al. 2003). The effluents from the tan-yard processes, de-liming and bating contain sulfides, ammonium salts, and calcium salts, and the effluent is slightly alkaline. The pickling and chrome tanning effluents contain sulphuric acid, chrome, chlorides, sodium bicarbonate and sulfates. Several reports show that beam house process effluents contain the high concentration of total solids (Gupta 2003). Only about 20% of a large number of chemicals used in the tanning process is absorbed by leather and the rest is released as wastes (Verma et al. 2008). The major pollutants of the post-tanning process are chrome salts, dyestuff residues, fat liquoring agents, syntans and other organic matter (UNEP 1991). Solvents from degreasing and finishing are a source of exposure through vapors (UNIDO 2005). Worldwide, it is estimated that discharged tannery effluent contains 300–400 million tons of heavy metals, solvents, toxic sludge and other wastes, which are dumped into water bodies each year (UNEP 1991).

METHODOLOGY

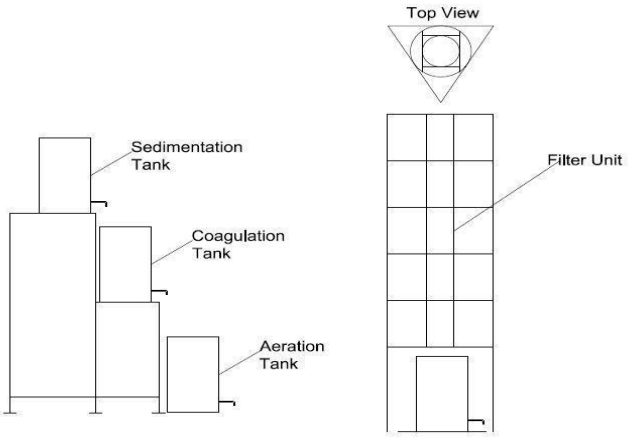
The methodology has been classified into 4 categories: (1) Selection of the sampling site, (2) Collection of wastewater, (3) Experimental set-ups carried out for research work, and (4) measurement of parameters. Riff Leather Ltd was established in 1991 which is located in CDA Noxious Industrial Area in Kalurghat of the city is just twenty minutes driving distance from the main seaport of the country. The annual capacity of Riff is 9.0 million square feet of leather. Water samples have been collected in Plastic bottles, plastic water drum with a screw cap. Well washed before collection in order to make sure that it was completely free from any kind of undesirable substances. Plastic bottles, water drum were thoroughly cleaned with detergent water. Samples have been collected manually using a bucket and rope. After the sample had been collected, the cap was locked rightly so that no air space can remain inside. The collected samples were immediately transferred to the model treatment plant (see Figs. 3 and 4) and stored in the refrigerator for further use and measurement of parameters. The samples were collected in different stages of the treatment process and then taken to the Environmental Engineering Laboratory at Chittagong University of Engineering and Technology with proper care and precautions. The fly ash was obtained from Royal Cement Factory and the activated carbon was from Water Center, Chittagong, Bangladesh.

As shown in Figures 1 and 3, there are three chambers for sedimentation, coagulation, and aeration. Each chamber is made of PVC pipe with a 19.5 cm internal diameter and 34 cm high standing on a steel frame. The capacity of each chamber is 9 liters with a 4 cm freeboard. The filter is made of PVC pipe with a 10.5 cm internal diameter and 93 cm high encased with the steel frame (see Figure 1). The freeboard above the filter bed is 42 cm. The fly ash and powdered activated carbon were placed separately after passing through 75 µm sieve (ASTM #200 sieve), and were mixed in 1:1 proportion by volume. In filter bed there are seven layers consist of gravel, coarse aggregate, coarse sand, fine sand and granular activated carbon. The initial filtration rate was found as 0.02 m^3/hr. In filter-1, activated carbon was placed in the bottom (see Fig. 2 CS2 position), while activated carbon in top (see Fig. 2 AC position).

RESULT AND DISCUSSION

OPTIMUM DOSE

Combination of fly ash and activated carbon was used as coagulant for this study. The fly ash and powdered activated carbon were passed separately 75 µm sieve (#4 sieve), and was used as such without any pretreatment and mixed in 50% proportions. Jar test was conducted to determine optimum dose using different doses, such as 500, 1000, 2000, 4000, 8000, 12000, 16000, 20000 mg/l. For each jar test, 1 liter of tannery wastewater was taken and was rapidly mixed at 55 rpm for 10 min and then allowed for setting for 3 hours before used.



Filter Details	
Slice Name	Specifications
Sand	FM=1.65
AC	#16 retaining & #12 passing
FS	FM=1.65
CS1	#16 retaining & #12 passing
CS2	#12 retaining & #8 passing
CA	$\frac{3}{8}$" retaining (9.5mm) & $\frac{3}{4}$" passing (19mm)
Gravel	$\frac{3}{4}$" retaining (19mm) & $\frac{7}{8}$" passing (22.4mm)

Figure 1: Schematic Diagram of Filter Unit and Specifications

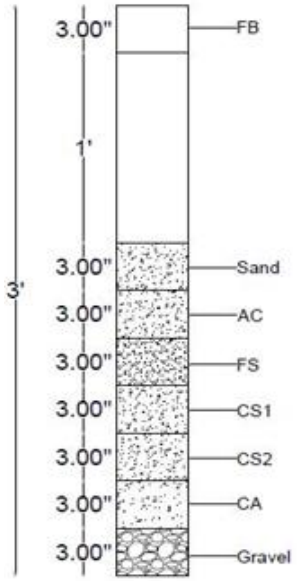


Figure 2: Filter bed configuration used in treatment train
(FB=Free Board, AC=Activated Carbon, FS=Fine Sand, CS=Coarse Sand, CA=Coarse Aggregate)

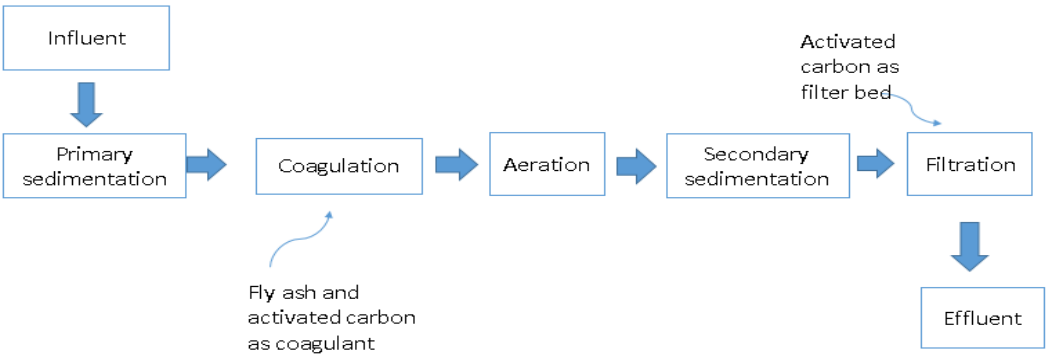


Figure 3: Treatment train diagram of the study

Figure 4: Picture showing the treatment approach used in the study

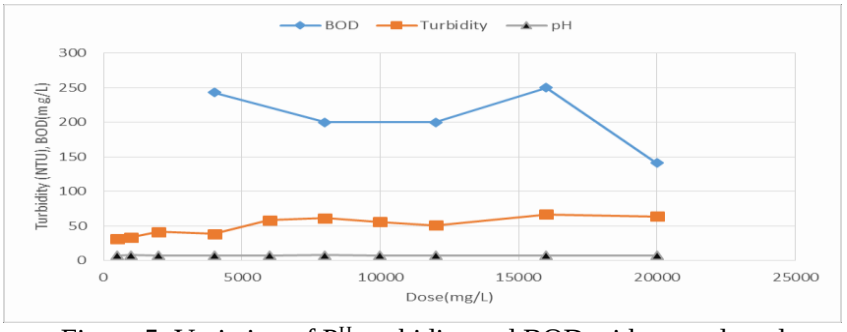


Figure 5: Variation of P^H, turbidity and BOD with coagulant doses

Fig. 5 shows the variation of P^H, turbidity and BOD with coagulant doses. There is no change in P^H with doses and a slight increment of turbidity with the increase of doses is seen. The results illustrate that coagulant doses have no acidic and alkaline effect in aqueous solution, while for slight increment of turbidity may due to the residual of coagulant after physical and chemical actions as absorbent. For BOD concentration with coagulant dosing clearly shows the downward trend except a moderate increase in the range of 12500 mg/l to 16000 mg/l prior to showing sharp reduction after approximately 1600 mg/l to 20000 mg/l. Considering the above results, the optimum dose of coagulant is set as1500 mg/l.

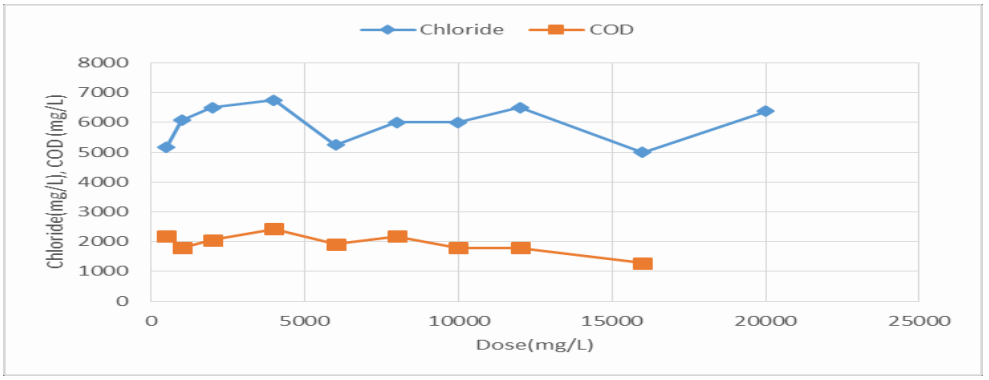


Figure 6: Variation of Chloride and COD with coagulant doses

Fig. 6 shows that the variation of chloride and COD with coagulant doses. It can be observed that the change in chloride concentration is not constant and shows up and down trend. From t h e graph, the lowest value is obtained at 1000mg/L dose and maximum at 4000mg/L dose. As dose changes, the value of COD does not change that much. After the dose value 12000 mg/L there is a decrease in COD value can be observed from the graph. Based on this discussion it is seen that the optimum doses can

be chosen as 12500 mg/l.
Fig. 7 shows that the values of Chloride, COD, TS, TDS in different treatment steps in an optimum dose of 15000 mg/l. The concentration of chloride is decreased after plain sedimentation but remain constant the consecutive steps. The lower value is found as 5230 mg/l. The COD, TS and TDS values are gradually decreasing. The slow reduction of chloride may due to the fact of residual presence. In this line, Fig. 8 shows that the values of Turbidity, BOD5, Chromium, TSS in different treatment steps in an optimum dose. As seen in Fig. the turbidity is gradually decreasing except just after the dosing time as expected, and the BOD and chromium are seen to be decreased in every step illustrating its efficiency in performance of tannery wastewater.

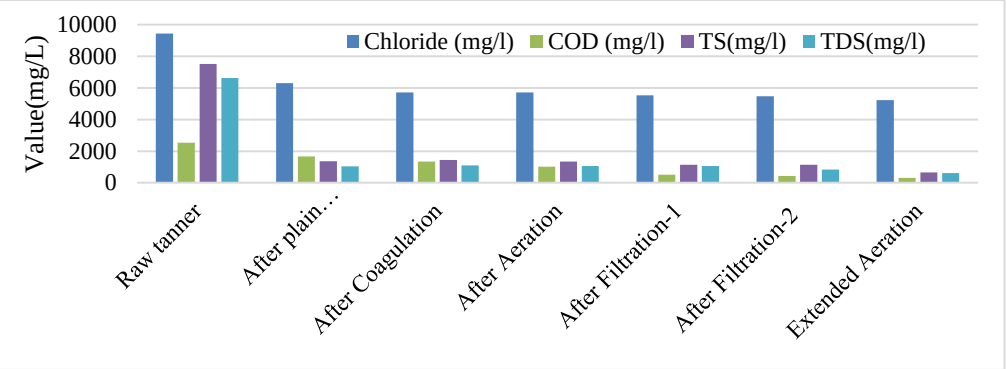


Figure 07: Chloride, COD, TS, TDS values in different treatment steps in an optimum dose

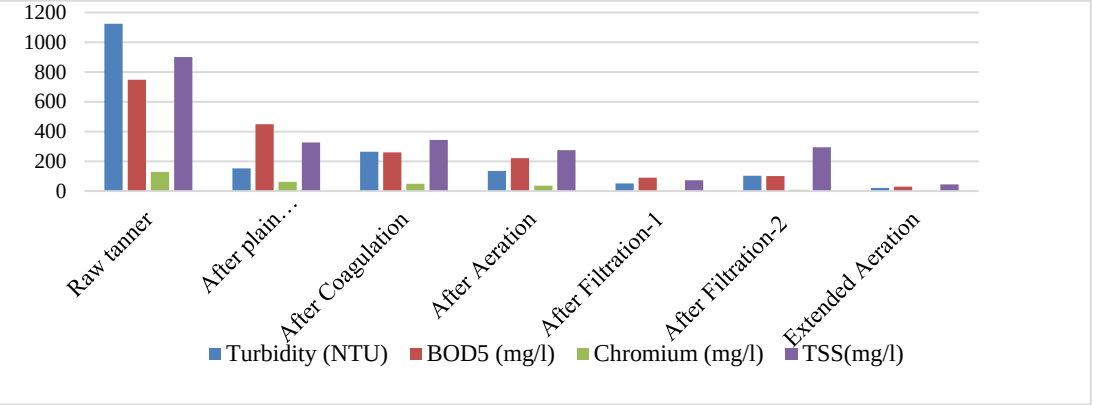


Figure 08: Turbidity, BOD5, Chromium, TSS values in different treatment steps in an optimum dose

Furthermore, Fig. 9 shows the removal efficiency in different steps with optimum dose of 15000 mg/l. With an exception of the negative efficiency of chloride after plain sedimentation because of lower retention period, the primary sedimentation (3 hrs.) contributed in 86.4% reduction of turbidity, 34.03% reduction of COD, 40% reduction of BOD_5, 52.34 % reduction of chromium, 33.16% reduction of chloride, 63.67% reduction of TSS. 15 g/l of dose showed that 47.17% reduction of COD and 65.19% reduction of BOD5, 19.7% reduction of chromium, 39.35% reduction of chloride. The value of turbidity and TSS is increased due to the finer particles from the fly ash and activated carbon in this process. 95.56% removal of Turbidity, 80.0% removal of Chemical Oxygen Demand, 87.95% removal of BOD5, 41.31% removal of Chloride, 84.95 % removal of TS, 92% removal of TSS, 83.99% removal of TDS after the treatment train with Filter-1. While with filter-2, 90.93% removal of Turbidity, 83.08% removal of chemical oxygen demand, 86.6% removal of BOD5, 42.05% removal of Chloride, 93.90 % removal of Chromium, 84.88 % removal of TS, 67.33% removal of TSS, 87.27 % removal is found. In this line, it is seen that 98.04% removal of Turbidity, 87.41% removal of chemical oxygen demand, 95.98% removal of 95.00% removal of TSS, 90.63 % removal of TDS after the treatment train with extended aeration. Among three different aspects of treatment third one with extended aeration performs better followed by second option.

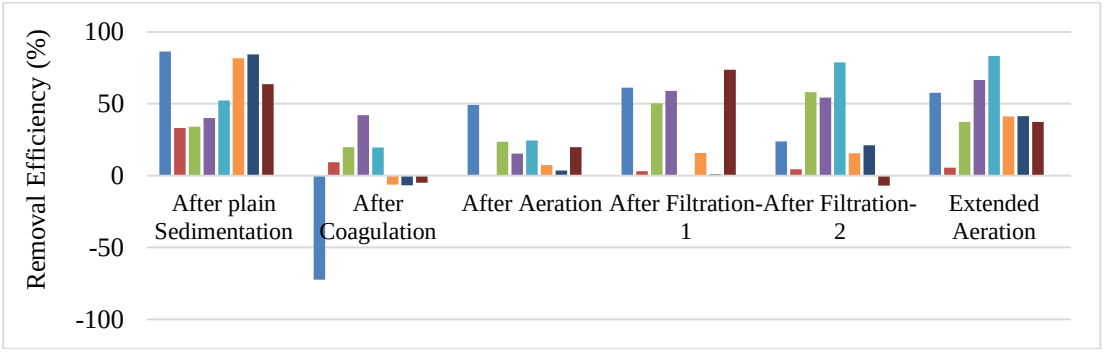


Figure 09: Removal efficiency in different steps of the treatment used in the study

Table 02: Comparison of treated waters to raw wastewater & Final Removal efficiency

Parameters	Raw tanner	After Filtration-1	After Filtration-2	Extended Aeration	**Water Quality Parameters**	**Removal Efficiency**
pH	7.6	6.7	7.2	7.2	Turbidity	90.93%
Turbidity (NTU)	1125	52	102	22	Chloride	42.06%
Chloride (mg/l)	9440	5540	5470	5230	COD	83.08%
COD (mg/l)	2542	510	430	320	BOD	86.61%
BOD_5 (mg/l)	747	90	100	30	TSS	92.00%
Chromium(mg/l)	128	-	7.8	1.3	Chromium	93.90%
TS(mg/l)	7520	1132	1137	665	TDS	83.99%
TDS(mg/l)	6620	1060	843	620		
TSS(mg/l)	900	72	294	45		

CONCLUSIONS

Tannery wastewater creates heavy pollution containing high levels of salinity, organic loading, inorganic matter, dissolved and suspended solids, chromium etc. This treatment train is suitable for removing all impurities except chloride. Another treatment required to treat chloride. Filter-1 and Filter-2 have almost the same removal efficiencies but filter-1 is preferable. Aeration process is one of the best processes to remove biodegradable substances from tannery wastewater. The more it gets aerated, the better results come out. The filter bed with a layer of granular activated carbon, have the great adsorption capacity. It's a vertical treatment train which reduces the space cost greatly.

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4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018)
18 –20 December 2018
CUET, Chittagong, Bangladesh
www.cuet.ac.bd

EVALUATION OF THERMAL POWER PLANT DISCHARGE FOR ALTERNATIVE USES, A CASE STUDY OF CHITTAGONG POWER PLANT

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ABSTRACT
Chittagong Power Plant, located in Raozan Upazila of Chittagong in Bangladesh, is a gas-fired thermal power station which requires a huge amount of water to produce steam based power. After using water for power generation, a huge quantity of water is being released to the outlet drain. From the field investigation it is seen that a portion of this release is used for different residential and agricultural purposes. The study aims to evaluate suitability of the water used for domestic uses and is used for irrigational activities. To achieve this aims samples were collected from various points of discharge at Chittagong Power Plant and a few selected water quality tests, such as pH, turbidity, alkalinity, chloride, salinity, iron, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO) and hardness were performed. By comparing the results with the permissible standard values water seems suitable for designated purposes with a few exceptions for iron, hardness, and suspended solids for the supplied water, make it little concern and need attention for low cost natural treatments. The study helps to evaluate the water quality before and after power plant use and its potential.

Keywords: Chittagong Thermal Power Station; Water quality; Uses; Chittagong

INTRODUCTION
Chittagong Power Plant, a gas-fired thermal power station, located in Raozan Upazila of Chittagong District is approximately 25 kilometers (16 mi) north-east from Chittagong on the south side of the Chittagong–Kaptai Highway. The power station consists of two identical gas-fired units of 210 MW with a present generation capacity 180 MW. It is such kind of power station in which heat energy is converted to electric power. The turbine is steam driven. Water is heated, turns into steam and spins the turbine by steam which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated. As the main sources of energy is derived from water, a large quantity of water is key to generate electricity of desired capacity. In this plant, 990 ton/hour water is being taken up at Godwaon Ghat which is 6 km upstream site in the river. This water is housed by two reservoirs which possess a capacity of 5000 ton of each. Then the water is treated in different stages by using different chemicals to make water suitable for the generation of steam power along with residential uses except drinking. Firstly the river water is taken to a coagulation tank from the reservoir, and then the water is treated by using poly aluminum chloride (PAC). After the pretreatment process, this water is taken to the clarified tank, and finally passed through the sand filter before pumped into the clear water tank. From the clear water tank a portion of water is supplied to the residential area while a major share to the demi water tank after a chemical treatment using hydrochloric acid (HCL) and sodium hydroxide (NaOH) for ion balance

passing through a series of anion filter bed, cation filter bed and mix filter bed. Then the water is used to produce steam and this steam drives the turbine to generate power. The steam is condensed by cooling tower and again used for the cycle to generate steam. In these sequences, a huge amount of water is discharged through drains after use in a continuous basis.

The power plant has two drains for water disposal. One of them is located at the north side of the plant and the other is on the south. This water mixes with the surface water sources and local people use this water for various purposes mainly irrigation and bathing. A residential area is grown up centering the power plant. About 30 ton/hour water is supplied to the residential area after a pre-treatment process in the initial stage. The people who are living in that residential area use this water for the purpose of domestic uses like bathing, cooking, washing and other non-potable uses. A flow chart of the thermal power generation showing water mass balance is presented in Fig. 1.

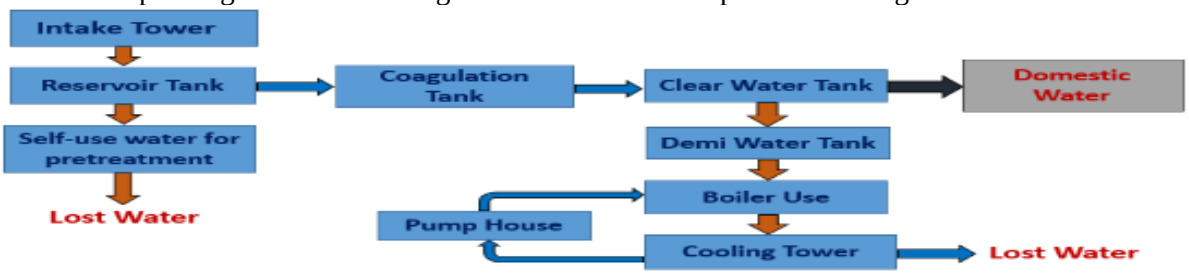

Fig 1: Water Flow In and Out

Within the above context, it is seen that a huge potential already been identified for the release of water after treatment fit for power generation towards domestic, agricultural and fish culture. However, a detail study is needed for evaluating the suitability of the informal uses considering the fact that after using chemical treatment along with significant temperature rise, water is fit for the designated uses. Unless or otherwise the water being contaminated with chemicals used for treatment may pose a serious threat to the fisheries and aquatic life when it mixes with surface water sources along with irrigation uses. This study may also help to address water use efficiency to a certain specific purposes rather than being discharge back to the river or drain if it really worth to use.

METHODOLOGY

After site investigation, few sampling sites at the power plant premises were selected. Sampling and preservations of the collected samples were done using standard protocol before testing. The testing of the samples collected was carried out in the Environmental Engineering Laboratory at CUET using standard procedure to obtain desired concentrations for the selected parameters. The cross contamination and analytical protocol were maintained as per laboratory requirement. The quality control and assurance have also been made as per laboratory testing procedure for accuracy. The selected sampling points are as follows: 1. Reservoir Tank (River water) [see Fig 2: (a)], 2. Coagulation/Sedimentation tank (Clarified Water) [Fig 2: (b)], 3. Clear water Tank (Clear water) [Fig 2: (c)], 4. Demi water Tank (Demi water) [Fig 2: (d)], 5. Drain water 1 (North side) [Fig 2: (e)]
6. Drain water 2 (South side) [Fig 2: (f)]. The water suitability has been assessed comparing guidelines available for designated purposes. For ease of identification and presentation of results the following symbol is given for each sampling site, as also seen in the Fig. 2 (a) to (f).

[Fig 2]: (a) **[Fig 2]: (b)** **[Fig 2]: (c)**

[Fig 2]: (d) **[Fig 2]: (e)** **[Fig 2]: (f)**

Fig.2: Sampling points at Thermal Power Plant, Chittagong

RESULT AND DISCUSSION

Water quality, its suitability and concerns for designated purposes

In this study, it is mentioned earlier that the effluent water from the power plant falls to the surface sources through drains. Permissible pH for drinking water is 6.5-8.5 and so for fishing and aquaculture. As seen in Fig. 3, the pH values at different sampling locations are seen as 6.0 to 6.4 illustrating suitable for designated uses in general without significant concerns.

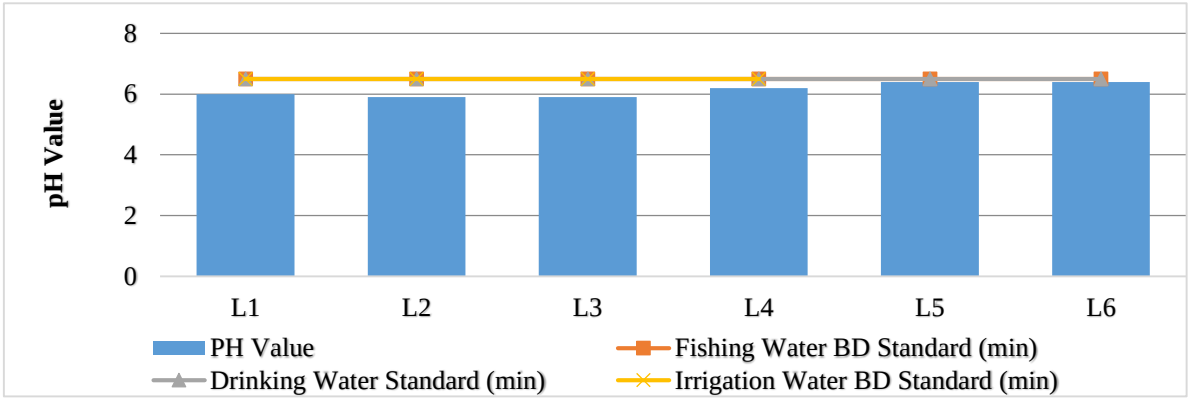

Fig 3: pH values for different samples

*[*L1=River water Reservoir Tank; L2=Coagulation Tank; L3= Clear Water Tank; L4= Demi Water Tank; L5= Drain Water 1 (NS); L6= Drain Water 2 (SS)]

Fig. 4 represents the variation of turbidity at different sampling positions of the power plant, as discussed in Fig. 3. The turbidity of river water and drain water exceed the limit for all designated purposes. However, with the various internal measures turbidity at coagulation tank, clear water tank and demi water tank appears nil and indeed fond suitable for even drinking and other thermal power plant related uses. The drain water and river water turbidity is expected to be higher in magnitude, as it collects lot of sediment. However, the concern matter with high turbidity for river and drain water is that excess turbidity over guideline values may affect fish and aquatic life by interference with sunlight penetration, which is essential for photosynthesis that demands attention. It is important to note that the reduction in photosynthesis in plant result in lower oxygen concentrations and large carbon dioxide concentrations in the atmosphere too.

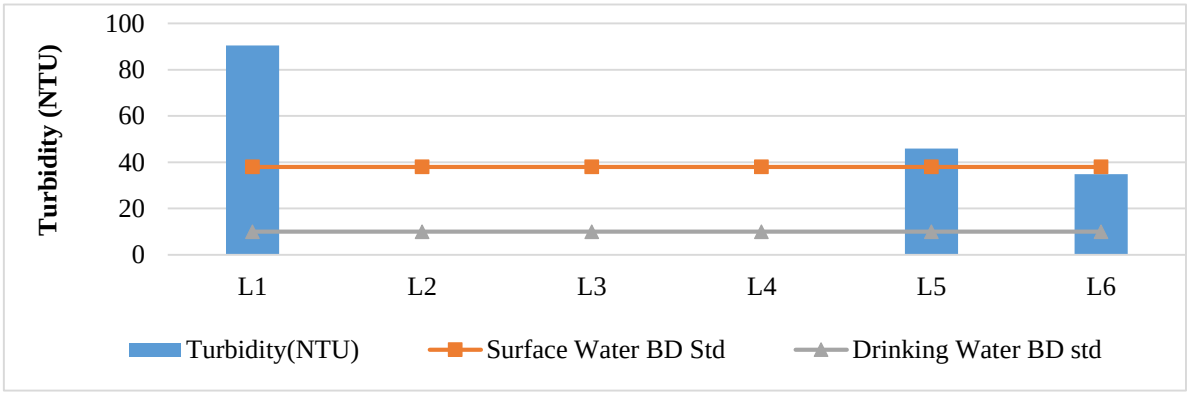

Fig 4: Turbidity values for different samples

As seen in Figs. 5 and 6, the alkalinity and chloride concentrations are well below the guidelines and hence, suitable for designated uses in general without significant concerns. However, as seen in Fig. 3, the iron concentrations for the drain water (L5, L6) which mix with the surface water sources are 1 and 1 respectively. The value is reasonable for irrigation and fishing. According to Bangladesh Environment Conservation Rules (1997), drinking water standard for iron is 0.3-1.0 ppm. The clear

water has the value of iron is 2 ppm. According to the standard value of iron this water is not satisfactory for drinking purpose. It causes taste and odor- Organism whose life process depends on compounds of iron causes taste and odor, such organisms are sometimes known as 'iron bacteria'.

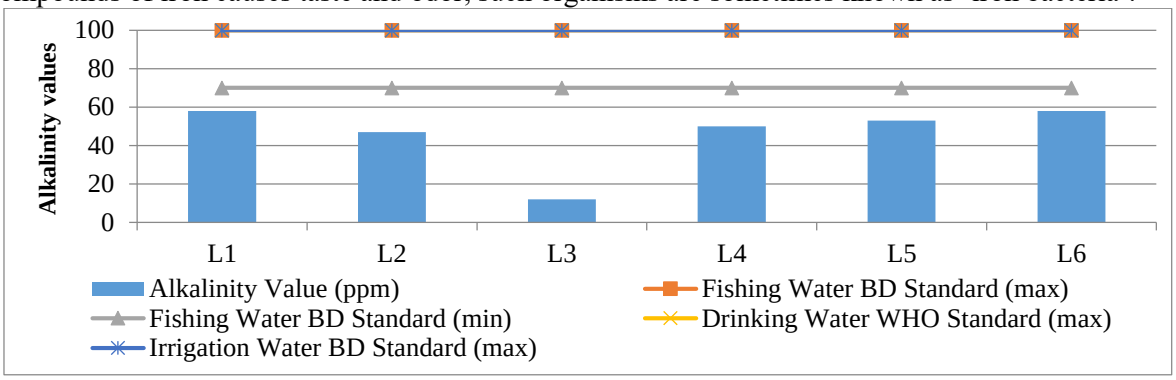

Fig 5: Alkalinity values for different samples

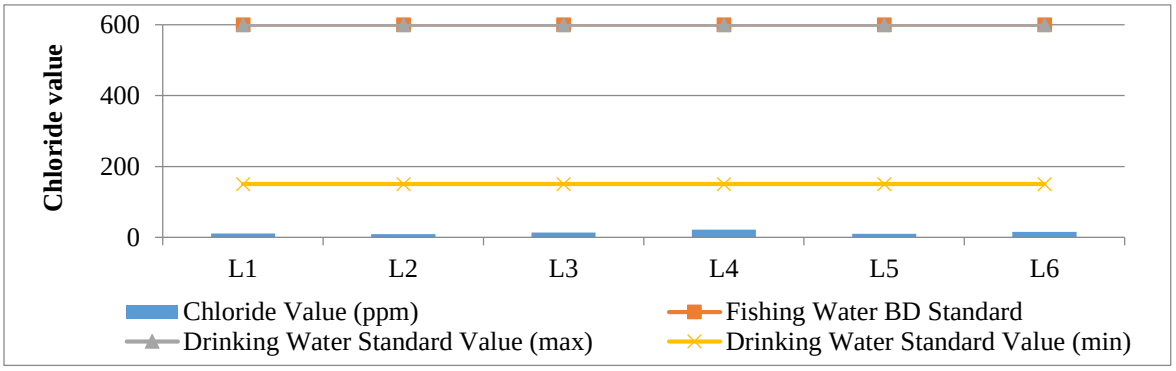

Fig 6: Chloride values for different samples

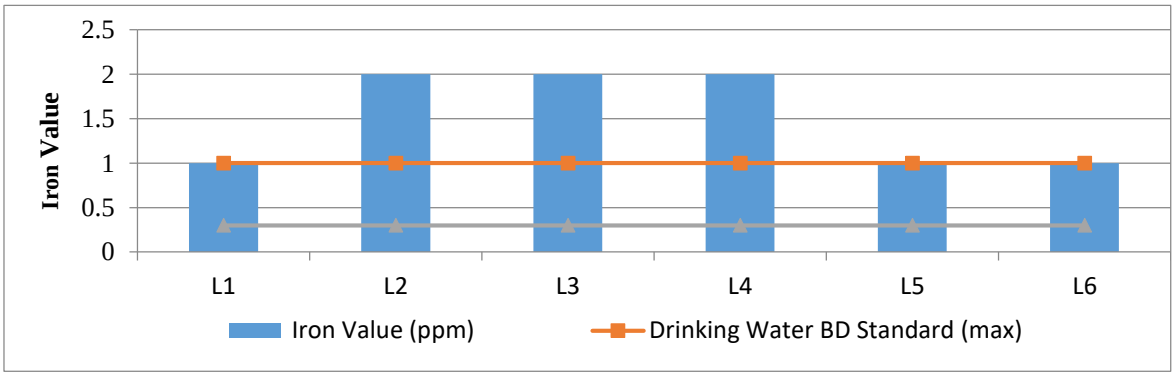

Fig 7: Iron values for different samples

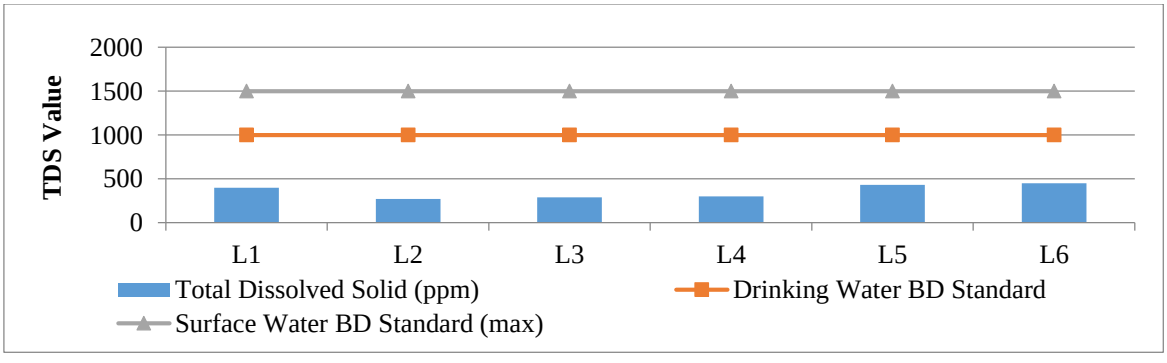

Fig 8: Dissolved solid values for different samples

Suspended solid and dissolved solid concentrations are found to be well below the designated uses, as seen in Figs. 8 and 9, indicating that in general water is suitable for uses. It is however advisable that more screening for suspended solids prior release may be taken to avoid settling in absence of proper slope in the drainage system, unless otherwise, can suffocate plant life and purifying microorganisms, causing serious damage to aquatic ecosystems. Purifying of microorganisms enables pathogens to live longer, raising the risk of disease. When organic solids are part of the sludge, their progressive decomposition will also deplete oxygen in the water and generate noxious gases. The Bangladesh standard value of suspended solids for irrigable land is 200 ppm and the value of the drains water is in the range of the permissible value. The value of suspended solids in the clear water is 120 ppm. Water high in suspended solids may be aesthetically unsatisfactory for such purposes as cooking and bathing.

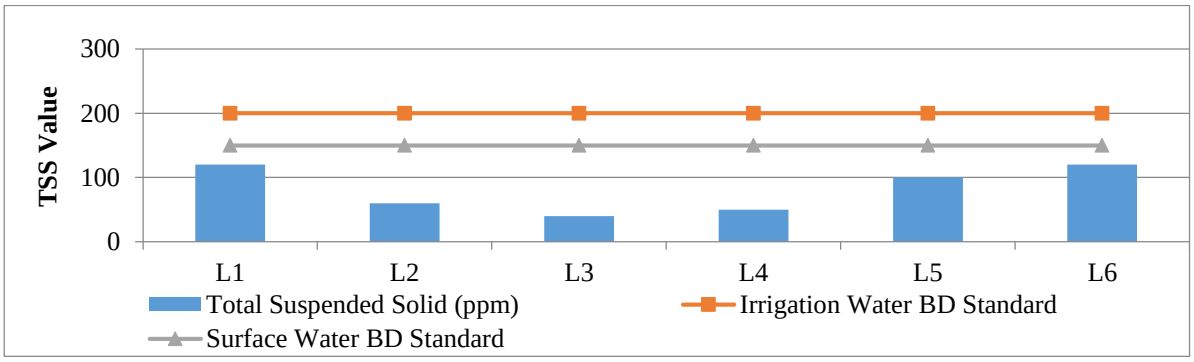

Fig 9: Suspended Solid values for different samples

The values of hardness for the drain water (L5, L6), as seen in Fig. 10, are 50 ppm and 45 ppm respectively. The standard (for fish) given by DOE, Bangladesh, for hardness of water is 80-120 ppm. So the hardness values of the drain water are suitable for fish culture, while on the other hand hardness of the clear water is 110 ppm, that is slightly higher that the guideline for drinking water. As this water is supplied for drinking to the nearby water area, it is a slight concern for day to day uses and may need attention.

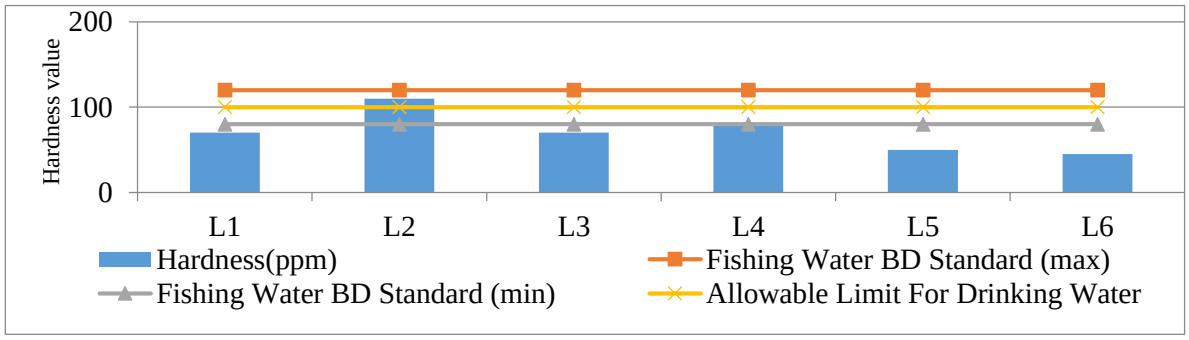

Fig 10: Hardness values for different samples

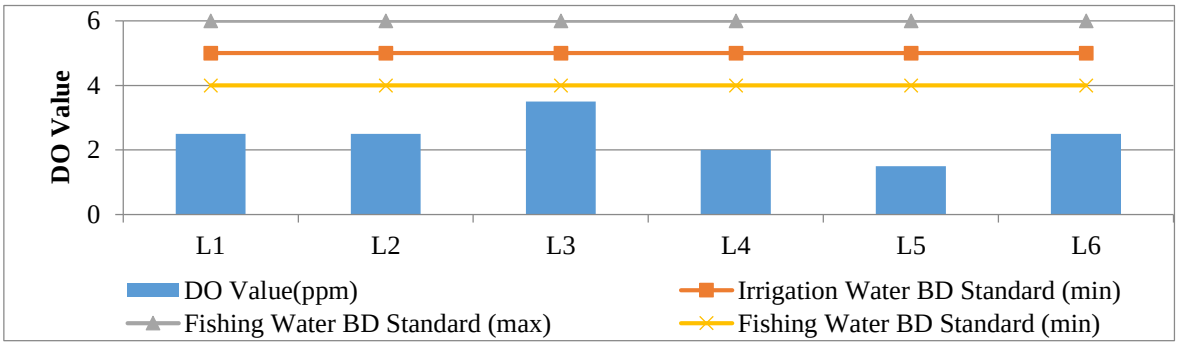

Fig 11: DO values for different samples

As seen in Fig. 11 the DO level is significantly below the desired minimum level for designated uses, indicating that for aquatic life it is a concern. It may primarily because of high temperature and high turbidity (see Fig. 4), which may be improved by natural cooling with aeration before release.

Conclusion

Based on the analyses and results obtained it is seen that there is a potential for water used after thermal power generation from the studied plant. With a few exceptions, water from the power plant which mixes with the surface water sources through drains is suitable for aquatic life, irrigation and domestic uses. High value of pH, iron, CO2, salinity, hardness of clear water reservoir makes it little concern regarding aesthetically unacceptable for drinking. The parameters of the clear water can be controlled by taking suitable steps to make it potable. If it is possible, the clear water can be used not only for domestic uses but also for drinking purposes. Those values of different parameters of the drain water can be reduced by adoption of natural treatment system before discharging it to surface sources to ensure a safe environment for fishes and aquatic life for their survival and to maintain ecological balance.

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