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Sea-Level Extremes and Change- Example of Bangladesh

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Abstract

The effects of climate change are significant for worldwide. In future, climate will most likely continue to change dramatically. During the last 100 years sea levels has already risen globally. There will be significant impacts on several countries due to sea-level rise. However some countries such as Bangladesh which is settled on a delta will be influenced more tragically because deltas are not suitable places to be settled on as they are subsides each year. Bangladesh is in the top row of the list of countries which will be influenced by sea-level rise. That is why in this study is based on Bangladesh which is the world's biggest delta and it acquires important agriculture land. The coast of Bangladesh, meets important food requirement of Bangladesh. If sea-levels continue to rise in the future-which likely seems will- people who are living near the coast will be influenced badly. Unfortunately sea-level rise will increase salinization of ground water and that will involve water scarcity in Bangladesh. It seems the sea level rise will mostly influence humans in Bangladesh. This paper shows the impacts of sea level rise in Bangladesh such as salinity intrusion, agriculture and ecosystems. To prevent these impacts some precautions should be taken, some of these are Adaptation and Mitigation.

Keywords: *sea-level rise, Bangladesh, vulnerability, adaptation, mitigation*

1. Introduction

In the past, the main causes for climate change and sea level fluctuations were due to natural processes such as orbital variations of earth. However, today the main reason of this problem is clearly humans. Earth is getting hotter day by day due to different kinds of human activities which are lead to increase the global warming. And this rising temperature leads to raise the sea level and affect the low lying part of coastal areas of the world. Among all low lying areas, Bangladesh is the most affected by sea level rise, that's why this area has considered as our study area. Besides the global warming, sea level rise also depends on regional continental drifts. For instance, some land of river deltas has subsided by several millimeters because of sediment folding. That intensifies the existing effect of sea level rise in that region. On the other hand, some regions are remaining unnoticed because the land is also rising in the same magnitude or more. Bangladesh is one of the most populated countries in the world and it is settled just above the sea which is located in the mouth of three rivers: Brahmaputra, Ganges and Meghna [1]. About 150 million people are living around these delta regions (Houghton, 2010). Another threat for Bangladesh is impacts of cyclonic storms and monsoon. These storms causes extreme sea level rises and floods in Bangladesh and of course affects lots of people. Sea level rise will cause loss of one fifth of the land and many diseases will affect many peoples. Also another consequence of sea-level rise will be the salinization of ground water and this will affect humans negatively by causing diseases. Also there will be ecosystem lose due to the rising of sea [1]. The vulnerability of Bangladesh will be increased due to the cyclonic storms, subsidence of delta and salinization of ground water. Due to increasing carbon emission rate the atmosphere will continue to warm, as a result sea levels will continue to rise. Because of that we have to find some solutions for this important problem. Adaptation and Mitigation [2] can be some of the solutions for Bangladesh. In this study we will try to explain in what terms Bangladesh will be affected and what can be done for least damages.

2. Aim of Study

The aim of this study is to explain reasons of extreme sea level rise, rising rate and its impacts in Bangladesh. We want to mention some of the possible and current impacts of sea level rise in the coastal zone of Bangladesh

in order to suggest some solutions. We mention only some of these impacts such as; agriculture, salinity intrusion and ecosystem. But there are much more important impacts like on ground water, humans, health, economy, settlements, fisheries, security and etc. People are vulnerable especially in the coastal zone of Bangladesh and it is likely that in the future there can be disastrous impacts on all of these parameters. Because of that, some possible solutions for Bangladesh within the framework of our aim is suggested. These solutions are Adaptation and Mitigation.

3. Methodology

Our methodology is based on literature review. In order to understand the impacts of sea-level extremes it is necessary to understand underlying causes of climate changes. The reasons of climate change and its impacts on sea-levels tried to be explained in this study. Therefore it is important to express the meaning of vulnerability to understand how this country will be influenced by sea-level extremes. Hereby, it is important to focus on impact on humans to produce some solutions. Also, sea-level rise will have a dramatic impact on the agriculture land and that will cause crucial problems for humans. We mention only some of the impacts in this study but it should be considered that all of the impacts are interrelated. Further study is required to understand all these impacts thoroughly. So, some suggestions were made for providing solutions to this problem.

4. Results

4.1 Causes of sea-level rise

Both natural processes and human activities are responsible for sea level rise. In a long time period, sea level rise is mainly due to changes in Earth's orbit which has a cyclic period causes changes in incoming solar radiation. As a result of this, earth experiences glacial and interglacial periods in 400,000 years cycles. During the glacial periods, due to the cooling of the Earth, sea levels decrease and in interglacial cycles due to warming of earth sea levels increase [3]. This sea-level change is fundamentally associated with ice forming and melting [4]. During the glacial cycles, cooling led to build up of ice on land, predominantly in the Northern Hemisphere, which makes the sea levels to decrease more than 100m. However, when the atmosphere begins to warm again, the ice caps start to melt and the ultimate result is sea level rising [5]. Fig. 1shows the sea level changes over the past glacial-interglacial cycles and modern levels.

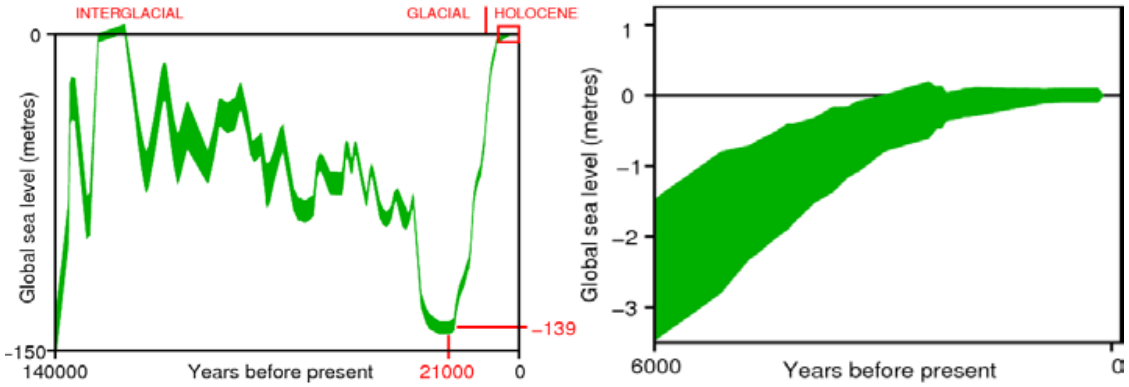

Fig. 1. Past and modern sea level changes; Source: Reference [6]

Since the last interglacial, there is a distinct global warming due to the warming of the Earth. However this warming rate is accelerated since the last century (Fig. 1). The reason of this sharp warming is strictly humans. Humans cause global warming by releasing CO_2 into the atmosphere. Concentration of CO_2 and other greenhouse gases are added to the earth's atmosphere and aggregately lead to warm up the atmosphere; the ultimate result is climate change. This rising temperature amplifies the volume of ocean water in two different manners. Such as, it causes melt of the ice in Polar Regions and thermal expansion of the ocean water. These two attributes are mainly accountable for increase the volume of ocean water of the earth as well as raise the sea level. If the earth's temperature keeps rising, the amount of ice sheet will decrease and after a certain time the total amount of ice will disappear, which will result with extreme sea level rise [9]. If the total ice sheet in Greenland and West Antarctic melt, sea level will increase 7m and 6m respectively [8], [9]. So, ice melting is the most important cause of sea level rise and the following table shown that how much sea level will rise if the ice caps on the earth's surface melt.

Another important cause of sea level rise is thermal expansion of ocean water, which is also happening because of global warming. Between the periods of 1961-2003, ocean thermal expansion contributed about 50% of total sea level rise [10] than estimated by the IPCC (2007). Beside ice melting and thermal expansion some other

regional factors also play a vital role for sea level changing process like as subsidence and uplifting of land and siltation on ocean bed [2]. Some climate models, satellite data and hydrographic observations reveal that the sea level rise is not equal all over the world. This rise is sometimes depends on regional tectonic movement, that's why some region's sea level is expected to rise slightly higher than others. For instance, because of sediment collapse, lands in some of river delta areas subside by several millimeters. In that case, sea level rise enhances the existing regional effects, meanwhile in some regions land is rising to the same rate or even more than sea level itself where sea level rise remain unnoticed [1].

4.2 Current sea level rise and future projections

From 1870 to 2004, the total global mean sea level has raised 195 mm at a rate of 1.44 mm per year, for the 20th century the sea level rise and the linear least squares trend was 160 mm and 1.7±0.3 mm per year respectively [11]. According to IPCC, the global average sea level rate was of 1.8 (1.3 to 2.3) mm per year over the period 1961 to 2003 [2]. During 1993 to 2003, the rate is increased by 3.1 (2.4 to 3.8) mm per year (IPCC, 2007). In 1990, IPCC predicted that global sea level rise will be 9 to 88 centimeters by 2100. Later on again IPCC (2007) estimates that in the next decade global sea level would be rise about 0.03m and end of this century it will rise 0.2 to 0.8 m, if the CO_2 emissions keep continue like as it is now. Based on simple statistical model, Rahmstorf (2007) suggested a sea level rise over the 1990 to 2100 periods by 0.5 to1.4 m. "A report prepared for the Dutch Delta Committee, which assesses post- Fourth Assessment Report publications on the impacts of recent warming trends on ice sheet dynamics, derives an upper bound of sea level rise of 1.1 m by 2100 [12]. In Bangladesh the average rate of sea level rise is averagely 1.0 cm per year (Milliman et al. 1998, cited in Frihy, 2003). According to SAARC Meteorology Research Center (SAARC, cited in Alam 2003, p 15) during 1977 to 1998 periods observed that sea level at Hiron Point, Char Changa and Cox's Bazar have been rising by 4 mm, 6 mm and 7.8 mm per year respectively. The rate of sea level rise is almost half in the western coast than that of the eastern coast of Bangladesh. This difference may be because of uplift or subsidence of land mass in different parts (SAARC, 2003). Although Singh (2002) noticed that this difference is mainly due to the subsidence of land.

World Bank (2002), mentioned that in 2020, 2050 and 2100 sea level will rise by 10 cm, 25 cm and 1m, which will be affected the 2%, 4% and 17% of total land mass of Bangladesh respectively. Whereas, sea level in Bangladesh coast will rise about 1.5 m by 2030, that will cause about 16% of total land mass to go under the water and affected 17 million people who are living along the coastal line [2].

4.3 Extreme sea-level rise in Bangladesh and its impacts

Due to the rapid climate change, Earth is experiencing extreme sea-level rising. Here, the word "extreme" means the unusual and unexpected sea level change and its catastrophic impacts on various regions of the world. Because Bangladesh is located on a delta where it subsides each year and lots of people are living on this delta will badly be affected by sea-level rise. Also this region is under the impact of cyclonic storms and monsoon. These factors increase the vulnerability of this country to the sea-level rise. High sea levels also changes the river flows by slowing down the drainage to the sea and causes catastrophic floods in Bangladesh.

According to SAARC Meteorological Research Council (SMRC) studies, sea level rise in Bangladesh during the last 22 years is much higher than last 100 years global trend [13]. But this sea level rise rate is not only due to the climate change it is also due to subsidence of the delta [14]. Actually most of the sea level rise in Bangladesh is due to subsidence of land [15]. But the contribution of sea level rise due to climate change in this region is non-negligible. Three different stations in different locations show different sea-level raises in Bangladesh such as; 7.88 mm, 6 mm and 4 mm [16].Global sea-level rise during the last century's 1-2 mm per year which is lower than Bangladesh rate [17].There is already significant sea-level rise in Bangladesh. Even now Bangladesh has been faced some problems because of sea level rise. But in the future all the projections predict higher sea levels which will cause more dramatic impacts in this region (Fig. 2). Based on some different reports for Bangladesh such as; IPCC and NAPA predictions are 14, 32 and 88cm sea level rise for the years 2030, 2050 and 2100, respectively [18]. Some of the impacts of sea-level rise are summarized below.

4.3.1 Salinity intrusion:

Sea level rise in the coastal zone of Bangladesh cause significant salinity increment on the water sources. This is a serious problem because it affects agriculture and ecosystems, which we also mention in the following parts.

Salinity intrusion problem in Bangladesh is not dominated at the same rate all the year. It is mostly efficient in dry season which is in winter. It has also been affected in rainy season but in this season only 10% of the land is affected. However in dry season 40% of land has been affected by salinity intrusion. Increased sea levels affect salinity by the ingression in the rivers and this decreases fresh water contamination of rivers. This increased salinity of rivers will increase ground water salinity at the same time. This is the explanation of salinity intrusion

in rivers and ground water. There is also increased salinity in the soil due to increased evaporation in dry winters. We should consider that the salinity intrusion in soil is also due to sea level rise which is mostly affected by the saline ground water in winter. The other factor that increases the intensity of saline intrusion is tidal surges [16].

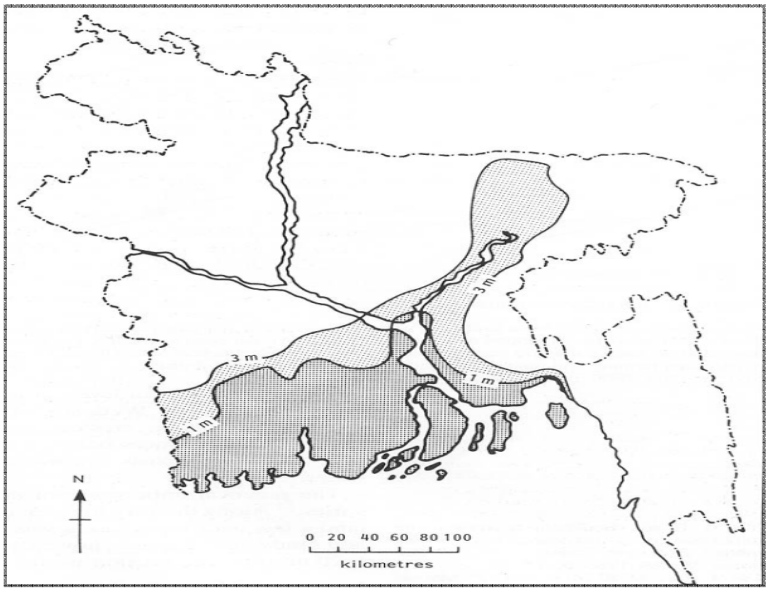

Fig. 2. Future sea-level predictions for the coastal zone of Bangladesh (1m and 3 m); Source: Reference [19]

In the coastal zone of Bangladesh there has already impact of salinity intrusion due to sea level rise which causes big problems. Especially in dry season saline water penetrates 240 km inlands of the Bangladesh [16]. Salinity intrusion has serious impacts on many areas such as agriculture, fisheries, surface water, ground water, soil, ecosystem and etc. It affects agriculture mostly in dry seasons by causing increased irrigation of products with saline ground water because of not enough rain. However, watering with saline ground water decreases the productivity. Currently there is salinity intrusion problem in the some parts of coastal zone but in the future it will be more serious where its impact will reach more inlands [16]. Salinity of ground water will influence humans negatively by causing serious drinking-water scarcity. In consequence of increased salinity on ground water, serious diseases will arise. Food productivity loss will cause nutrition disorder and will play an important role on human's health [2].

4.3.2 Impacts on agriculture:

Sea level rise impacts on agriculture are significant in Bangladesh because half of the population's economy depends on agriculture and 83% of population's livelihood comes from agriculture. With an increased climate change salt intrusion will increase significantly. If the sea level rises by 45 centimeters, it's been expected to lose up to 15,600 square kilometers of land [1]. Salinization of ground water and soil due to sea level rise will directly affect the agricultural production in the coast of Bangladesh. Rice production has already decreased in the coastal zones of Bangladesh due to decreased soil yield [2]. According to World Bank (2002) increased salinity (due to 0.3 meters sea level rise) will cause a net reduction of 0.5 million metric tons of rice production. As it mentioned before fresh water salinization will decrease rice productivity. Besides rice agriculture the coastal zone is also important for other goods such as oil seeds and vegetables. These products are also under risk of decreasing productivity because of salt intrusion [2]. Also sea level rise will increase storm frequency and more violent storms will cause catastrophic flooding.

4.3.3 Impacts on ecosystems:

Impacts of sea level rise on ecosystems can be classified in three, such as; wetland loss, salinity increment and beach erosion [19].

The coastal zone of Bangladesh has a very rich variety of species both for plants and animals such as mangrove forests, Sal forest, dipterocarp forest, bamboo bushes, freshwater swamp water forest, Bengal tiger, turtles, birds and etc. [14]. There will be lots of negative impacts on these species due to climate change but in our study we will focus on the impacts of sea level rise on these species. Salt intrusion will affect some species which can't survive from increased salinity of ground water and soil. As a result of salt intrusion these areas are being converted into saline water fields day by day. It is obvious that the salt intrusion will cause enormous loss of

biodiversity [2]. World Bank (2000) predicts that, in case of 1 meter sea level rise, Sundarban mangrove forests will be completely lost which is a very rich forest indeed. Even an increase of salt concentration in the soil and water will affect the habitat pattern of these forests [2]. Moreover, due to increased salinity in the inlands, aquatic organisms will move inlands. Sundarban is not only a simple forest at all; it includes lots of flora and fauna such as Bengal tiger which will be under threat of extinction from this forest [2]. Besides, increase of sea level will decrease photosynthetic productivity of marine corals and hence decrease the growth of corals [2].

4.3.4 Vulnerability:

It is important to explain the meaning of the word "vulnerability" in order to find out the reasons of extreme sea level rise impacts in Bangladesh. Vulnerability arises from the relationship between humans and their environments in the face of disasters [20].

Because being a low-lying country Bangladesh is highly vulnerable against the sea level raise. 80% of the country experiences flooding. Also, the economy of this country is not developed. Agrawala (2003) stated that, combination of low-level development with climate and topography causes high vulnerability in this country. It is a densely populated country and this high population rate also increases the risk of mitigation to other countries under any threats of sea level rise. $1/5^{th}$ of the country's economy is based on agriculture which will be affected by sea level rise.

4.4 Some solutions for Bangladesh

Due to the impacts of sea level rise that are mentioned above, some urgent actions should be taken to solve these problems in Bangladesh. Therefore, such solutions like adaptation and mitigation should be considered.

4.4.1 Adaptation:

Due to the global climate change sea levels will continue to increase and because of that adaptation process in Bangladesh is very important. However, it should be considered that the adaptation process requires long term and expensive studies [16]. Some of these adaptation strategies can be specified here. These are:

- Agricultural habitats can be changed. Improvements can be done in agricultural techniques.
- Crop patterns can be changed and high quality crops can be used for yield increment
- Planning can be done: embankment building to prevent flooding into the agricultural land, settlements.
- After salinity intrusion, usage of the area can be changed. For example agricultural land can be converted into fish farms.
- Settlements can be moved to safety places.
- People who are living in the coastal zone should be prepared to the disasters due to sea level rise.
- Regular surveys should be done in the fresh water to detect diseases. If some diseases germs detected in the fresh water urgent cautions should be taken to stop the epidemic of disease.
- If the capacity of country can be increased the vulnerability will decrease. This can be only done by economic recoveries. More capacity means less vulnerability [16].
- International organizations should inform people about the effects of population growth in the coastal zone and arrangements must be done to limit population growth (IPCC, 1990).
- International and national research programmes should be involved to observe impacts of sea-level rise in the coastal zone of Bangladesh (IPCC, 1990).

4.4.2 Mitigation:

It is clear to all that global warming has increased the level of ocean water and the main cause of global warming is emission of greenhouse gases to the atmosphere. IPCC Fourth Assessment Report (2007) Working Group III suggested some mitigation strategy for all country to reduce the greenhouse gas emission. Such as:

- Supply and distribution of efficiency should be improved. Switched fossil fuel to gas, nuclear power, renewable power (hydropower, solar, wind geothermal and bio-energy).
- Mode of transport system should be shifted from road transport to rail and public transport system.
- Stop deforestation by increasing more afforestation.
- Improve forest management system and produce more bio-energy by using forestry products.
- The function of lighting and day lighting can be used for electrical appliances, heating coupled with cooling devices, improved cook stoves also insulation, passive and active solar design in order to heat and cool, substitute refrigeration fluids, recovery and recycle of fluorinated gases.
- Crop and grazing land management must be improved in order to get more soil carbon storage, reestablishment of cultivated peaty land and degraded lands, improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions, improved nitrogen fertilizer application techniques to reduce N_2O emissions.

5. Conclusion

In Bangladesh the reasons of extreme sea level rise is due to subsidence of land, storm surges and flooding as well as thermal expansion and ice melting. Sea level rise rate is higher than the global trend because of its local characteristics. So, while the global trend of sea level rise is 1.8 mm per year (IPCC, 2007), it is averagely 7 mm per year in Bangladesh [16]. This extreme sea level rise in Bangladesh has serious impacts on important areas such as; salinity intrusion, agriculture and ecosystems.

Due to increased salinity intrusion 10% more land will be affected in Bangladesh (It is now 10% in rainy season and 40% in dry season). Salinity intrusion will also affect agriculture and ecosystems. It will decrease the productivity of agricultural land. Some species will disappear from ecosystems due to increased salinity and serious loss of biodiversity will be experienced. Humans will seriously be affected by water scarcity due to fresh water exiguity. Moreover, it will cause socioeconomic problems in Bangladesh [16].

It is obvious that, there will be huge economical loss due to impacts of sea level rise on agriculture. The main problems for agriculture on the coastal zone due to sea level rise can be summarized as; salt intrusion into soil and ground water, decreased soil quality, fresh water scarcity, increased flooding due to increased cyclonic storm frequency and loss of land [2]. Ecosystems will be affected in three ways. These are wetland loss, salinity increment and beach erosion [19]. Here it mentioned two solutions against these impacts. These are adaptation and mitigation.

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Group Velocity Dispersion Analysis of Rajshahi Earthquake for Studying the Crustal Thickness

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Abstract

Group velocity dispersion has computed for a light earthquake of magnitude 4.1 that occurred at Rajshahi on 5 July 2008 of 16:55:53 UTC by graphical method. Subsurface layer parameters are taken for a model construction to compute the group velocity dispersion by modified Haskell matrix method. Group velocity dispersion by graphical method is then interpreted from model parameters. Sensitivity and the statistical errors of the model are studied and presented in this research. Interpreted crustal structure of the Rajshahi area shows that there are four major subsurface layers of thickness 3.0 km, 10.0 km, 7.0 km and 22.0 km.

Keywords: C*rustal thickness, period, group velocity, earthquake data, seismic wave.*

1. Introduction

The local earthquakes Surface wave dispersion analysis can be used to study the crustal structure of the earth using simple models of continental or oceanic crust. Ewing and Press first introduced such model for the oceanic crust using rayleigh wave dispersion. The group velocity dispersion in this research has been computed and analyzed using graphical method for the up-down component seismogram of Rajshahi earthquake event, Bangladesh [1].

There are number of direct and indirect modeling techniques, which are commonly being used in determination of the earth's interior from seismic surface wave dispersion. Direct modeling determines the crustal structure from observed surface wave dispersion. On other hand, the most widely used indirect modeling techniques deal with trial-and-error procedures. Dispersion is computed for different model parameters to see how the computed dispersion matches with observed dispersion [2].

2. Material and Methods

2.1 Earthquake data

The earthquake data was recorded at Bangladesh Meteorological Department seismic station which is shown in Fig. 1. Table 1 lists the source parameters of the selected event.

Table 1: Earthquake Source parameters:

Date	Origin Time	Location	Depth (Km)	Distance of epicenter	Mw
5th July 2008	16:55:53(UTC)	24.4^0N, 88.5^0E	29.4	205.11	4.1

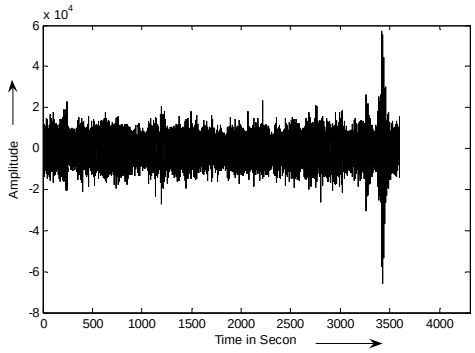

Fig.1**.** Up-down **g**round accelerated earthquake seismic wave recorded at Bangladesh Meteorological Department.

2.2 Methods

Group velocity from recorded earthquake wave and multilayered crustal model can be obtained respectively by graphical method and modified Haskell matrix method as explained below:

2.2.1 Graphical Method: Graphical method is basically a technique of group velocity dispersion determination. In this method the travel times some chosen phases along the surface wave train are measured. Usually the travel times of the wave crests and troughs are read. The group velocity, U_g of seismic surface wave can be obtained as:

$$U_g = \frac{\Delta}{t} \qquad (1)$$

Where Δ is epicenteral distance and t is the travel time.

2.2.2 Modified Haskell Matrix Method: Modified Haskell matrix method for the case of $n-1$ homogeneous, isotopic elastic layers over a half-space matrix can be written as [3]:

$$J = \hat{E}^n A^{n-1} .... A^m ... A^2 . A^1 \qquad (2)$$

Where A^m is the 4X4 Haskell matrix for the m'th layer and $\hat{E}^n$ is the half-space inversion matrix.

3. Sensitivity of Earth Model Parameters:

Dispersion data are the function of four parameters: S-wave velocity, P-wave velocity, density, and layer thickness [4]. Using given parameters an initial earth model is constructed (Table 2). The group velocity with period is also computed and shown in Fig. 2. Four parameters are changed by 1% in the model (Table 2), an average change of group velocities for each parameter are shown in Fig. 2.

Table1 2: Initial Earth model parameters.

Layer number	Vp (km/s)	Vs (km/s)	ρ (gm/cc)	h (km)
1	5.54	3.20	2.54	5.0
2	5.63	3.25	2.57	12.0
3	5.89	3.40	2.65	15.0
Half-space	6.10	3.53	2.72	Infinite

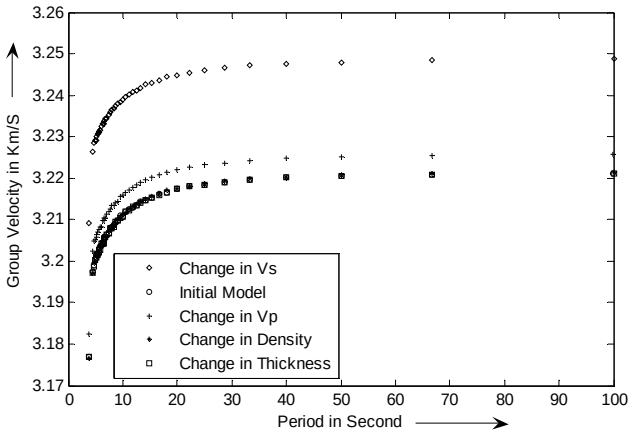

Fig.2. Sensitivity of group velocity dispersion obtained by 1% changes in each model parameter of the initial earth model as shown in Table 1.

4. Model Error Estimation:

The S-wave velocities (Vs) of the layers are free to change during the inversion. Consequently, the P-wave velocities are estimated using the Vp/Vs ratio 1.732. Poisson's ratio (σ) in each layer was assumed to be .25 and the densities (ρ) are calculated from the P-wave velocities (Vp) using the relation 0.32Vp+0.77 [5]. During the inversion, a number of criteria were adapted to calculate the goodness of fit. These criteria are the standard error of estimate (SE), mean residual (MR), average absolute residual (AR), weighted root mean square error (RMS) and the percent of signal power fit (SPF) [6].

5. Crustal Thickness Measurement:

Group velocity dispersions are estimated in this section using graphical method (Eqn.1) and Haskell modified matrix method
(Eqn. 2) as discussed below:

5.1 Group Velocity Estimation from Earthquake data: Group velocity is computed for the earthquake data (Fig. 1) and earthquake source parameters are shown in table 1.
This dispersion relation is computed by graphical method (Eqn. 1).

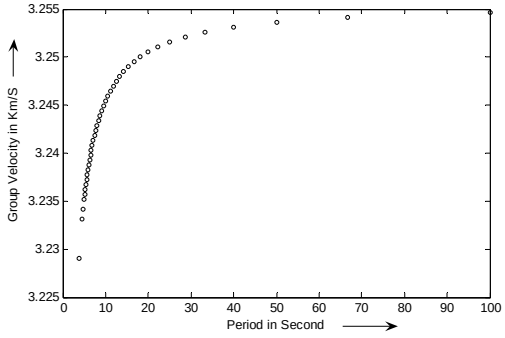

Fig.3. Group velocity dispersion curve for earthquake data

5.2 Group Velocity Estimation from Model: There are three models (A-C) are considered in this work. Model based group velocity is computed using modified Haskell matrix method
(Eqns. 2). The computed group velocity according to model parameters are shown in Figs. 4-6 also show the group velocity computed by graphical method.

5.3 Interpretation: Subsurface layers are estimated from the modeling. It has seen that (Figs. 4-6) group velocity obtained from earthquake data and from models have the similar characteristics. Therefore, interpretations are made from model parameters as shown in the rectangular box in Figs. 4-6. The computed statistical errors are shown in Table 3. According to estimated statistical errors (Table 3) the model C (Fig. 6) is found more acceptable.

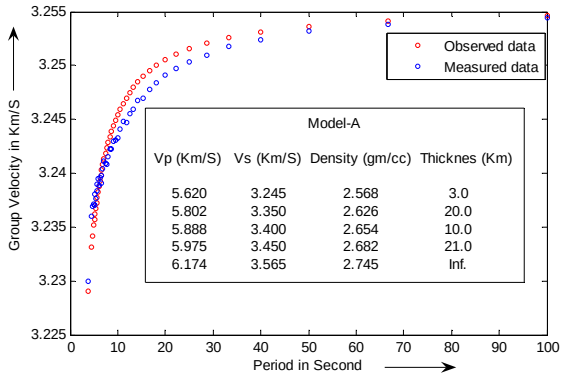

Fig.4. Group velocity dispersion obtained from earthquake data and from modeling A. Rectangular box contained the model parameters.

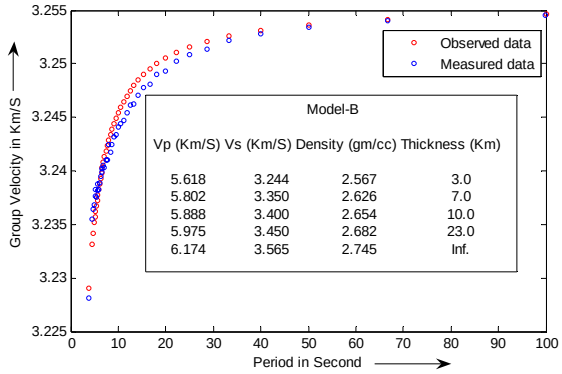

Fig.5. Group velocity dispersion obtained from earthquake data and from modeling B. Rectangular box contained the model parameters.

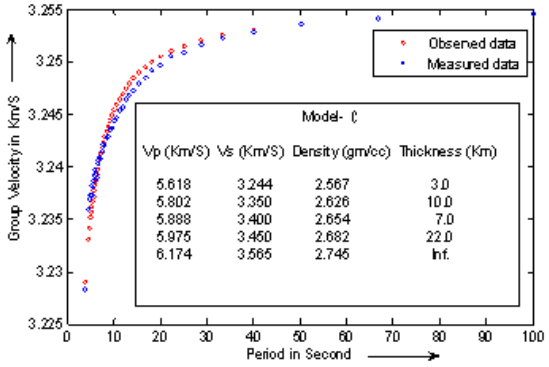

Fig.6. Group velocity dispersion obtained from earthquake data and from modeling C. Rectangular box contained the model parameters.

Table 3: Data fit criteria:

Model	SE	AR	RMS	SPF
A	0.0244938	0.0206183	0.0007436	99.99997940
B	0.0244938	0.0154489	0.0006551	99.99998614
C	0.0244938	0.0016291	0.0007201	99.99998725

6. Conclusion

There are some challenges to set up the model parameters. Most critical constraint is to consider the Poisson's ratio of 0.25. This ratio might be different for different subsurface layers in real cases. However for the computational advantages Vp/Vs ratio or Poisson's ratio were kept fixed and the value of 1.732 or 0.25 respectively. . Group velocity dispersion from the three models (A-C) (Figs. 4-6) and considering statistical error analysis (Table 3), it can be said that all the models are very nearer to an acceptable matching level though the statistical confidence level SPF should be 91.5% but our results are around 99.99998725%. Hence the interpreted subsurface layers of the studied Rajshahi earthquake data shows that there are four major subsurface layers having respectively the thickness and density of 3.0 km, 2.567 gm/cc; 10.0 km, 2.626 gm/cc; 7.0 km, 2.654 gm/cc; 22.0 km, 2.682 gm/cc.

7. Acknowledgement

Authors acknowledge Mr. Md. Mozidul Islam, Meteorologist and Mr. Md. Abdul Matin, Information Engineer of the Bangladesh Meteorological Department for providing seismological data

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Paper ID: RT-05

Analyzing Energy Drinks Effect on Respiratory and Cardiac Function by Wavelet Transforms Using Laser Doppler Flowmetry

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Abstract

Wavelet transform was used to analyze the effect of having energy drinks (ED) on respiratory and cardiac functions. Laser Doppler Flowmetry technique LDF100C (Biopac systems Inc.) was used on 12 healthy human subjects to analyze the effect of having energy drinks. After having energy drinks, by spectral analysis of LDF signal, it is observed that the amplitude of blood perfusion signal was increased. The physiological activities which include the frequency interval studied from 0.0095- 1.6 Hz was divided into five subintervals. Among them respiratory function due to 0.15-0.4 Hz and cardiac function due to 0.4-1.6 Hz, was measured in BPU2/Hz before and after having energy drinks. Discrete Wavelet transform was used for further analyzing frequency spectrum of the blood perfusion signal. A significant change was observed in these activities after having energy drinks. The amplitude of frequency spectrum of LDF signal related to respiratory activity increases around two fold. A little change was observed in cardiac function.

Keywords: AcqKnowledge software, Blood perfusion signal, Energy drinks, Laser Doppler Flowmetry, Wavelet analysis.

1. Introduction

The laser Doppler flow signal from the skin generally contains constant and oscillatory components. Cyclical flow variations have different periods (and frequencies), according to their origins. Spectral analysis has been used to identify six frequency bands, around 0.009 Hz, 0.01 Hz, 0.04 Hz, 0.1 Hz, 0.3 Hz and 1 Hz. Among them 0.3 Hz and 1 Hz, whose origins are known as respiratory and cardiac, respectively [1]. In addition, the cardiac and respiratory rhythms have been detected in the regions around 1 and 0.3 Hz in human skin [2]-[6].

Today energy drinks become the latest craze and a permanent fixture in our culture. An energy drink is a beverage that contains some form of legal stimulant and/or vitamins which are supposed to give consumers a short term boost in energy. Make a mental note that while the Food and Drug Administration (FDA) is allowing companies to sell and market their energy drink products, there is still very little research that has been done on them. It is suspected that the FDA allows them to be added simply because they do not pose any immediate danger to energy drink consumers [7].

The aim of the study is to determine the microvascular changes in the periodic oscillations of cutaneous blood perfusion after having energy drinks using Laser Doppler Flowmetry Technique. We hypothesized that having energy drinks changes in microvascular control mechanisms of the skin would result in differences in the spectral components and their corresponding amplitudes.

2. Materials and Method

Laser Doppler Flowmetry

The LDF technique takes advantage of the Doppler Effect, which is seen as a frequency shift in coherent monochromatic light waves scattered from moving red blood cells (erythrocytes) in the blood [7]. A LDF device uses two laser probes, one is the light-emitting probe and the other is the receiving probe [8]. The principle of laser Doppler Flowmetry technique is shown in Fig. 1, where low power laser light is used to illuminate tissue using a fiber optic; the light is scattered by the static tissue structures and moving blood cells; the moving blood cell impart a Doppler Shift; an adjacent fiber detects light returned from the tissue; this light contains Doppler shifted and unshifted light; the signal is processed to extract the signal related to the moving red blood cells [9].

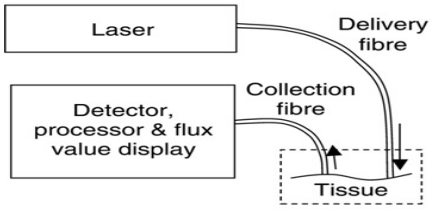


Fig. 1. Schematic of LDF

Subjects

Twelve healthy male subjects (between 24 and 32 years old) were enrolled and their Mean ±SD (range) for age (23.33±2.87yrs), weight (63.67±10.61kgs), height (165.89±8.03cms) and Body Mass Index (BMI) (22.27±3.30 kg/m^2) were taken where value (N=12)[a]. No medications were taken during the week prior to the study. The study was approved by the local Ethics Committee.

a.Values are Mean ±SD.

Energy Drinks

In this experiment we have used drinks of serving size of 250ml/can which contains caffeine 62.5mg/250ml of, 27 gm sugar per 250ml can and other ingredients e.g. water, acidity regulators: citric acid and sodium citrate, carbon dioxide, taurine (0.4%), flavor, inositol (0.02%), colours: E 150d, riboflavin, enriching substances: vitamins (niacin, panthotenic acid, vitamin B6, vitamin B12).

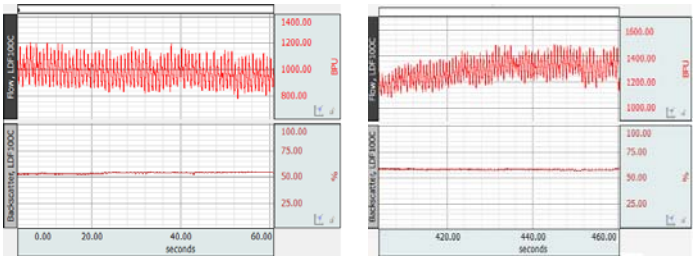
Experimental Setup & Testing Procedure

The subjects were resting in the supine position throughout the whole experimental period. A quiet room with the temperature kept at 22°C (21-23) was used for this study as well as for LDF measurements. MP150 (Biopac, USA) data acquisition unit was used in combination with universal interface module, UIM 100C (Biopac, USA). LDF measurements were performed with the Laser Doppler Flowmetry module, LDF100C (Biopac, USA).

3. Result and Discussion

Recording of LDF Signal

A typical laser Doppler Flowmetry recording of human forearm on middle finger tip at normal condition is shown in Fig. 2(a) for 60 seconds which oscillate around 1100 BPU (arbitrary unit).



(a) (b)

Fig. 2. Laser Doppler Flowmetry recording of human forearm on middle finger tip (a) normal condition (b) After having Energy drinks

Fig. 2(b) shows the LDF recording at the same position after having energy drinks. From Fig. 2(b) it is seen that the amplitude of LDF perfusion signal has been increased after consumption of energy drinks showing an increased level of oscillation of which peak touches 1500 BPU.

Wavelet Analysis of LDF Signal

The popularity of Wavelet Transform is growing because of its ability to reduce distortion in the reconstructed signal while retaining all the significant features present in the signal. The average scalogram is displaying information at frequency range, i.e., 0.15-1.6 Hz covering the respiratory and heart activities, compared with a standard PSD model. DWT which is based on sub-band coding is found to yield a fast computation of Wavelet Transform [10]. Wavelet type selected as Biorthogonal 4.4 with iterations 1 to specify the number of transforms to execute iteratively [10]. After DWT, resampling the graph and smoothing are the two processes were also done in both condition. After doing all the three processes in both condition final average scalogram was found this is shown in Fig. 3. Table 1 shows the peak values difference in the respective frequency band before and

after having energy drinks. At the interval of respiratory activity peak value is 2.83 BPU at 0.167 Hz at before whereas 5.08 BPU at 0.152 Hz at after. This says that respiratory activity increases around two fold. Also it shows that heart activity increases around a little i.e., 10.64 BPU to 12.68 BPU.

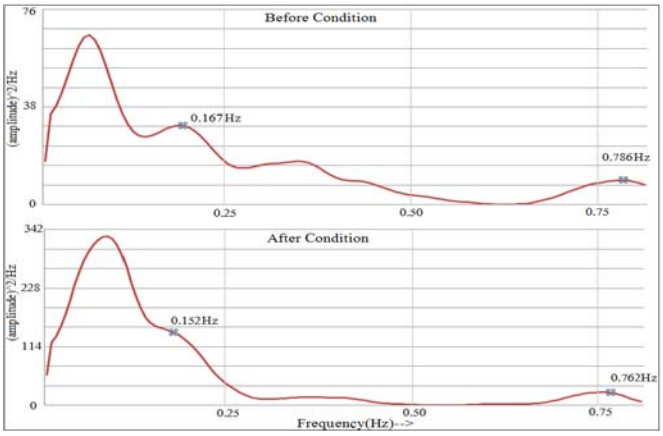


Fig. 3. Average scalogram of before and after having energy drinks

Table 1. Typical Changes in Amplitude Spectrum of LDF signal from 0.15 to 1.6 Hz

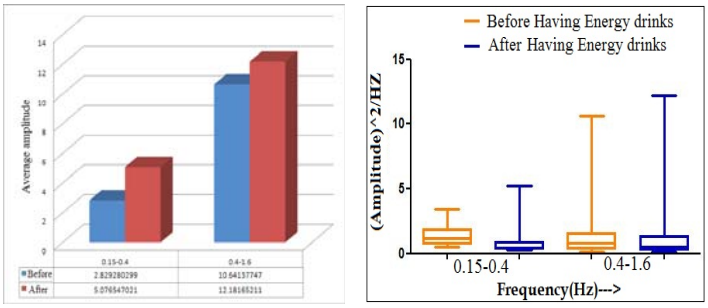
Frequency Range(Hz)	Origin of Oscillation (Activities)	Peak Spectral amplitude			
		Before Having Energy Drinks		After Having Energy Drinks	
		f_p[a] (Hz)	Peak Value (BPU)	f_p[a](Hz)	Peak Value (BPU)
0.15-0.4	Respiratory	0.167	2.83	0.152	5.08
0.4-1.6	Heart	0.786	10.64	0.762	12.18

b. Frequency of peak spectral amplitude

Statistical Analysis

The differences that can be found in average scalograms of Fig. 3 will be discussed by statistical analysis. For statistical analysis p-value measurements are done here.

- Peak spectral amplitude: The peak of the respiratory activity is detected at 0.167 Hz for the normal and at 0.152 Hz for the condition of after having energy drinks. Heart activity is detected at 0.786 Hz at normal and 0.762 Hz at after having drink condition. Respiratory and heart function also have the differences which are statistically significant.
- Average amplitude: We know the greater the amplitude of the wave, the more energy. The amplitude averaged over the whole frequency band of our interest is significantly higher for after having drink than for normal conditions [see Fig. 4(a)]. Furthermore, the energy is larger within each of the two observed frequency bands [see Fig. 4(b)].



(a) (b)

Fig. 4. The (a) average amplitude (b) average amplitude with energy- over each frequency band (Respiratory and Heart).

4. Conclusion

In peripheral blood flow signals, measured by Laser Doppler Flowmetry, oscillations on markedly different time scales are present. To analyze them, the wavelet transform was applied. It is observed that respiratory rate increases around two fold which conclude that the energy drinks have relatively effect of respiration system. Whether a little change is occurred in heart function that reflects an increased stroke volume in response to consuming energy drinks.

5. Acknowledgement

Authors wish to thank all participants in this study and cordially grateful to the Department of Biomedical Engineering, Khulna University of Engineering & Technology, Khulna, where the measurements were done.

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Paper ID: RT-06

Better Understanding of Food Material on the Basis of Water Distribution Using Thermogravimetric Analysis

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Abstract

The prime objective of dryingis to enhance shelf life of perishable food materials .As the process is very energy intensive in nature, researchers are trying to minimise energy consumption in the drying process.In order to determine the exact amount of energy needed for drying a food product,understanding the physics of moisture distribution and bond strength of water within the food material is essential. In order understand thecritical moisturecontent,moisture distribution andwater bond strength in food material,Thermogravimetric analysis (TGA) can be properly utilised. This work has been conducted to investigate moisture distribution and water bond strength in selected food materials; apple, banana and potato. It was found that moisture distribution and water bond strength influence moisture migration from the food materials. In addition, proportion of different types of water (bound, free, surface water) has been simply identified using TGA. This study provides a better understanding of water contents and its role in drying rate and energy consumption.

Keywords: *Drying, food materials, moisture distribution,energy, drying rate.*

1. Introduction

The issue of dried food quality has received considerable attention. Fruits and vegetables are important sources of essential dietary nutrients such as vitamins, minerals and fibre. Since the moisture content of fresh fruits and vegetables is more than 80%, they are classified as highly perishable commodities [1]. Food is one of the most complex materials in natural form and the fundamental understanding of food drying has not been fully established. Lack of proper processing causes considerable damage and wastage of seasonal fruits in many countries, which is estimated to be 30–40% in developing countries [2]. Drying of foodstuffs is an important and the oldest method of food processing. Many physical and chemical changes occur in foods during the drying process. The quality of dehydrated product is affected by a number of factors and is dependent on the quality of raw material, method of preparing, processing treatments and drying conditions [3]. Most of food materials contain a porous skeleton of carbohydrates or proteins, in which water and/or fat bound physically and chemically. Therefore, food structure is one of the complex arenas that are not yet comprehensively understood as it undergoes material changes, including alterations of the tissue and cell wall structure throughout growth and evenduring processes[4]. Foods, in general, can be considered hygroscopic although there are some exceptions. Although having unique molecular formula, water exists with different physiochemical properties due to variation of its surrounding molecular environments. Water inside cells is known as intracellular, which is about 90% of the total water [5], and rest of the water is intercellular which exists incapillaries as shown in the Figure 1. Water, generally in plant foods, may exist in any one of the following forms: Free water, physically bound water and chemically bound water. Pursuing this further, free water only surrounded by other water molecules or act as a solvent of crystalloids. On the other hand, physicallybounded water absorbed on the surface of cell wall or completely surrounded by other constituents of food materials. In addition, rest of the water, chemically bond water, refers to the water of hydration in the in chemical combination with different components as carbohydrates and hydrates of various salts [6]. Taken together, the obstaclesof water migration significantly depend on the compositions and structure of the plant food tissue. As food processing is very energy intensive, better understanding of water bonding in food structure will lead to huge energy saving in food processing industry [7]. Furthermore, water migration during drying processes and influence the quality attributes of plant foods [8-10]. A considerable amount of study has attempted to investigate the structure

property relationships in foods. Due to the porous nature of plant tissues,food materials show the tendency of collapsing when these are subjected to drying [11].In particular, it has been demonstrated that many desirable attributes of food such as texture, colour, or flavour, are changed depending on the way foods are structured [12].

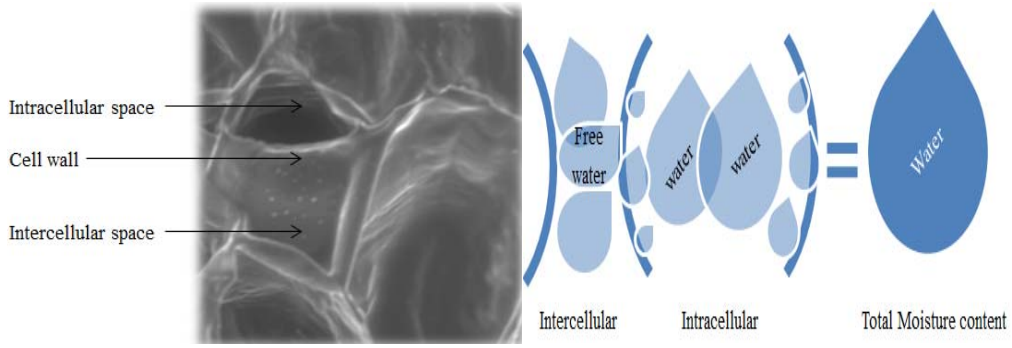

Fig.1. Water distribution in plant food tissue (Apple)

Continuing this idea, physicochemical changes eventually alter the product microstructure [13-15]. Therefore an effective method of taking away moisture from food material has always taken into attention by food researchers. As mentioned earlier, water exists within the food materials with different holding capacity throughout the tissues. It is then important to understand the distribution of water in food material in order to allow proper water migration during drying process. Thermo gravimetric analysis (TGA) deals to figure out the thermal stability of materials. TGA also can determine the distribution (proportion of different classes) of water in food materials. Thisstudy attempted to explore the water holding capacity of food by using of TGA. It would bring a better understanding of drying conditions to remove excess moisture from food materials in order to attain improved quality food.

2. Materials and Method

Proximate analysis and apparent density of three selected foodstuffs; apple, banana and potato areshown in Table1 [16-18].These foodstuff samples were prepared carefully to avoid any types of oil contamination and oxidization by air.

Table.1. Proximate analysis(weight %) of the selected fruits and vegetables

Foodstuff	Water	Fat	Protein	Carbohydrate and /or sugar	Fibre	Ash	Density (kg/m3)
Apple	83.93	0.36	0.19	12.56	2.7	0.26	723
Banana	74.26	0.48	1.03	21.03	2.4	0.8	1034
Potato	79.4	0.1	1.6	15.6	2.4	0.9	1110

All of the samples were cut into the same volume at the weight of approximately 100 mg.TGA Q500 V20.13 Build 39 was being used to assess the stability of the food material. All experiments were conducted under ultrahigh-purity or high-purity nitrogen, with the latter containing no more than 0.1% of impurities. The flow rate of nitrogen purges into the furnace was set at 15 ml/min.

3. Result and discussion

Moisture holding capacity of different food materials

Three different foodstuff; apple, banana and potato were analysed using TGA. In the system all of the food samples were kept at room temperature for 30 minutes. Surface moisture evaporation, as shown in Figure 2, depends not only on the amount of moisture content but also on the composition and structure of food material. For example, potato lost maximum amount of water 20.8% during the initial 30 minutes at room temperature although it contains less water than apple. These points refer to response of water due to higher temperature application on the foodstuffs. Beyond the temperature 85^0 C food materials shows sharp decrease of moisture content along with a higher rate of change of mass transfer as shown in Fig.3. These trends of moisture loss continueup to point where no more free water exist, where it shows almost constant moisture contends. Close investigation of the data manifests that a certain amount of water molecules are closely bonded.

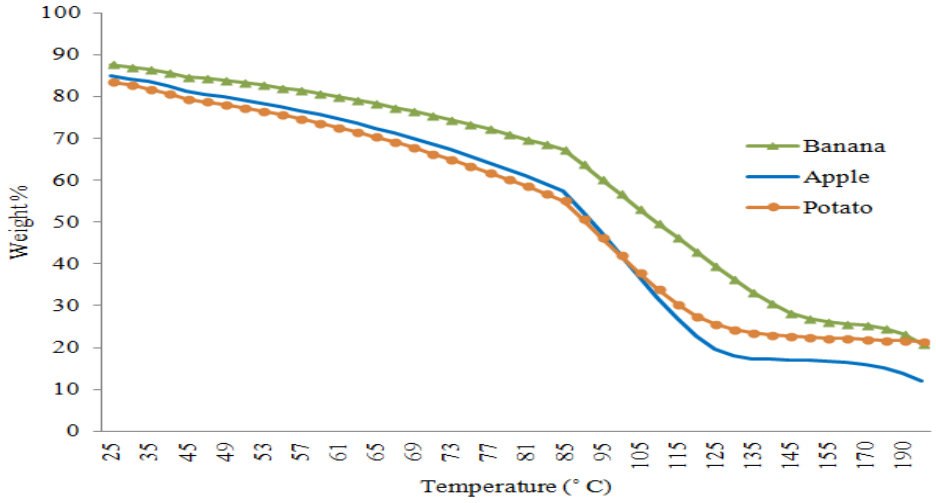

Fig. 2. Thermogravimetric analysis of different food materials

Consequently, even high temperature cannotdehydrate the sample. It seems rest of the water maintain strong Physical and chemicalbond as shown in the table 2 and it is also clearly apparent from Fig.3.

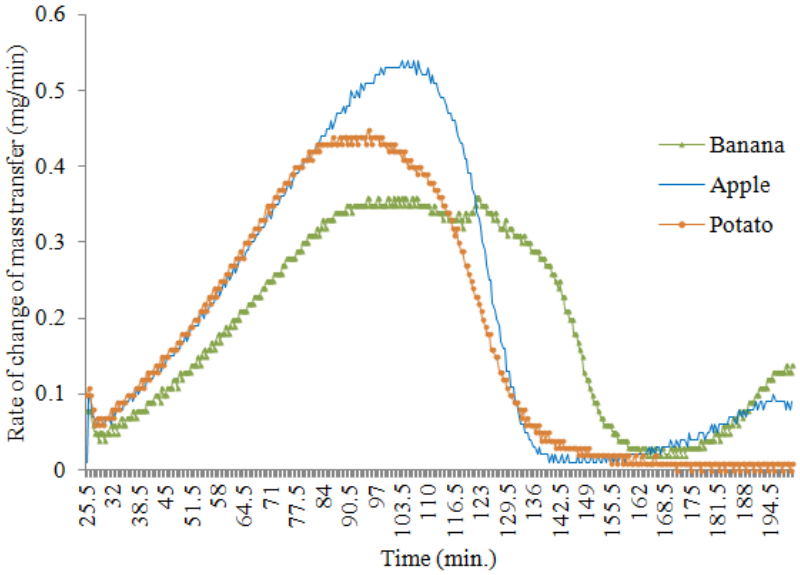

Fig. 3. Rate of moisture change of different food materials at different time

Nonetheless the TGA curve solely cannot differentiate different class of water,therefore, watermigration curve is essential. Figure 4 provides the percentage of water remains with temperature and time as well. It is apparent from Fig.4 at higher temperature approximately 150^0C all of the selected food loss whole water it contains.

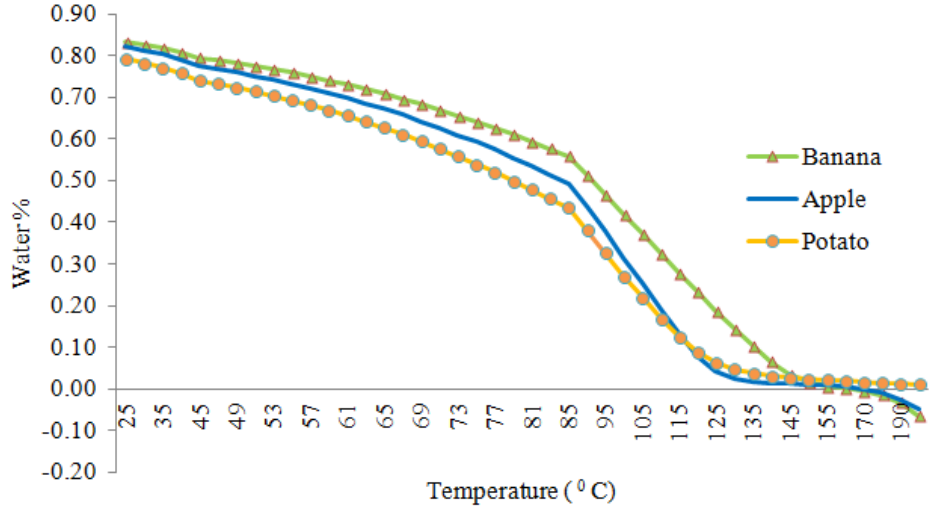

Fig.4. Water fraction retention in food materials (Negative value refers migration of other substance in respect to water percentage)

However, there may be possibility of error as TGA deals both time and temperature as variables. Therefore, two other observations for banana confirm the abovementioned findings. Different heating conditions were applied to banana sample in order to observe the thermal response. All of the three investigations allowed 1^0C/min heating rate after 60 minutes, but prior this the food samples were heated differently.

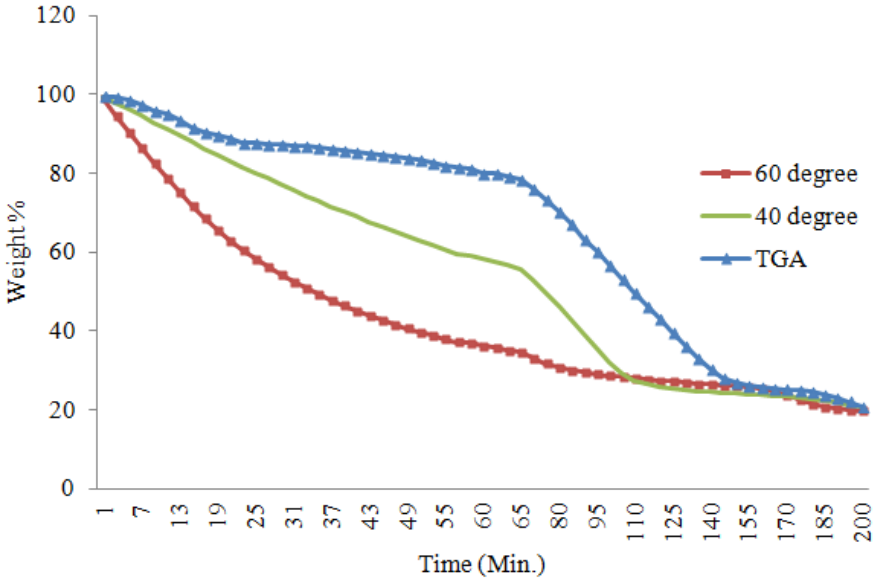

Fig. 4. Thermal response of banana in different types of heating

One of the samples was kept at 60^0C, another one was at 40^0C and one was in 1^0C heating condition in the first 60 minutes. It is clearly apparent in Fig.4 after 60 minutes that all the three samples showed same weight loss behaviour.

Analysing the nature of the curve of the selected food materials in the basis of different physicochemical properties the various kind of water has been identified as shown in the table 2.In order to find out the amount of free water, rate of change of mass transfer has been taken into consideration.

Table 2. Proportion of different class of water within selected foodstuff

Foodstuff	Solid materials	Surface Water	Free water (Including capillary water)	Physically bound water	Chemically bound water
Apple	16.07	17.9	95.7	2.7	1.6
Banana	25.74	16.5	96.6	2.6	0.8
Potato	20.60	20.8	91.2	6.4	2.4

As Table 2shows, most of the water in selected three food materials is present in water-water molecular environments and rest of the water is bounder either physically or chemically.

4. Conclusion

Achieving a better insight of the water distribution in complex food structure is vital for developing proper food processing systems. It has been an essential on-going endeavour of the researchers of the arena of food science and engineering. The water liberation from different fruits and vegetables was examined using TGA measurement in a dynamic environment. It is noticed that with the increase of the sample temperature at a steady rate of 1^0C / min a sample mass undergoes a sharp decrease which is followed by a progressive decrease in the later time of an experiment. From the results, it is apparent that water liberation from food material depends on the water holding capacity and food matrix. The most significant result to emerge from this study is that more than 90% water exists as free water. It also reveals that TGA can detect different classified water with varying holdingcapacity. Therefore, the findings of this study providea simplified approach of identification of water mobility in different food materials.

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Effects of Salinity and Sea Level Rise on Agriculture in the Coastal Area of Bangladesh

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Abstract

The impact of global climate change on agriculture has been studied extensively for various crops at different scales in many countries of the world. Bangladesh is likely to be one of the worst hit countries, being an Asian and a Third World country .Especially Coastal people are highly exposed to a range of natural hazards, from storms and cyclones to widespread flooding and coastal erosion. This study is under taken to investigate the effect of climate change on agriculture in the coastal belt of Bangladesh. The coastal zone of Bangladesh is worldwide recognized as an extremely susceptible area. Influences of climate change and sea-level rise should have real consequences on the livelihoods of the coastal people as it would be affected by salinity disturbance, flooding, drainage overcrowding, cyclones, heavy storms and erosion of the land masses .Therefore, agriculture in low-lying areas is likely to become increasingly difficult to sustain. The saline water causes the different impact on cultivable land and fisheries. The main aim of this study to identify the potential impacts and propose recommendations for agriculture to adapt to climate change. Investigation on climate change on agriculture land varies with seasonally to respect sea level, salinity flood etc.

Keywords: *Salinity,Climate Change, Agriculture, Sea Level Rise.*

Introduction

Available reports show that tropical and subtropical countries would be more vulnerable to the potential impacts of global warming. Bangladesh is likely to be one of the worst hit countries, being an Asian and a Third World country. The frugality of Bangladesh is established going on services, industry andagriculture. The agriculture segment contributes a major share in the GDP, which is about 21% and employs about 48% of the working force (Table 1).

Table 1: Occupations and GDP and sector wise contributions

Country	Occupation	GDP(At constant procedure price)
Bangladesh	Agriculture: 48.1%	Agriculture: 21.10%
	Non - Industry: 51.9%	Industry: 78.90%

Identified suitable varieties have to this study rice and non-rice crops and available adaptation measures or technologies for agriculture that have the potential to help farmers to adapt to climate change in the future.

In the past, many studies have been conducted on climate change issues by different organizations and future impact scenarios have also been developed. Different adaptation measures, technologies and strategies have already been developed by different organizations as well as by communities to adapt with climate change. As the economy is the main sector ofagriculture, it is vital to identify appropriate adaptation technologies or varieties of agricultural crops through field-testing and community awareness for sustainability. Suitable and ideal adaptation measures and varieties of crops have been identified through this study. The results will give hope and confidence to farmers in adapting their crops to climate change. The goal of this research to identify the potential impacts andpropose

recommendations for agriculture to adapt to climate change.

World sea level rise scenario:

In1990,IntergovernmentalPanelClimateChange(IPCC)estimateda3.3˚Crise intheglobal temperatureunderbusiness-as-usualconditionsby2100witharangeofuncertaintyof 2.2to4.9˚C. Suchachangeinglobaltemperatureoccurrednaturallyoverpast10,000years.IPCC'sestimation ofglobalsealevelrisewas1.0to2.0mm/yearoverthelastcentury.Increasingrate oftemperaturewiththehighglobal,sealevelwillriseatafasterrateof2-6timesthanthepresentrate[5]. Estimatedthat thegreenhouse-gas-inducedthermalexpansion contribution to sea-level rise between 1880 and 1985 was 2-5 cm and for the period 1985-2025 the estimateofgreenhouse-gas-inducedwarmingwas estimated to 0.6-1.0°C[7]. The resulting concomitantoceanicthermalexpansionwouldraisesealevelby4-8cm.[6] predictablethatbythe2080s,thelossofupto22%oftheworld'scoastal wetlands by rise of sea level.Whencombinedwithotherlossesdueto directhumanaction,upto70%oftheworld's coastalwetlandscouldbelostbythe2080s.IPCCestimatedthatsealevelrisewouldbe66cm under business-as-usual conditions by 2100 with a rangeof uncertainty of13 to 110 cm.The resulting concomitant oceanic thermal expansion would raise sea level by 4-8 cm[6].

SealevelriseinBangladesh

Sea level rise in Bangladesh is highly vulnerable, as it is a densely populated coastal country of smooth relief comprising broad and narrow ridges and depressions [2].World Bank (2000) showed 10 cm, 25cm and 1 m rise in sea level by 2020, 2050 and 2100; affecting 2%,4% and 17.5% of total land mass respectively (Table-2). [4] Reported 1.0 cm per year sea level rise in Bangladesh.

Subsidence is also a considerable factor for sea level rise in Bangladesh. The Brahmaputra and theGanges convey about 1.6 billion tons of sediment annually to the face of Bangladesh[3].So, sediment replenishment is considered to balance subsidence of the delta that results a net sea level rise [1].The rate of the tidal trend is almost double in the eastern coast than that of the western coast. This modification could be due to subsiding and uplifting of land. However, Sing (2002) mentioned that the difference is mainly due to land subsidence.

Table-2: Sealevel rise(SLR)in Bangladeshand its possible impact

Year	2020	2050	2100
sea level rise	10cm	25cm	1m(highendestimate)
Land below SLR	2 %ofland(2,500km^2)	4 %ofland(6,300km^2)	17.5%ofland(25,000km^2)
Flooding	20%increase ininundation MeghnaandGanges floodplain. Monsoonal floodsincrease	Increasefloodingin flood intensitywill increase tremendously	bothinundationareaand yield loss.
Salinityincrease		increase	increase

Methodology:

Data collection

a) Collection of secondary data

Relevant information on global warming and sea-level rising have been accumulated by consulting books, journals, periodicals, browsing internets, personal communications, attending seminars and symposia, and visiting various institutes/organizations. Climatic parameterslike temperature, humidity, rainfall, cyclones, tidal

surges etc. and geo-morphological information covering elevation, estuaries, embankments, floods, tides and projected areas of sea etc. of the coastal regions have also been composed by visiting pertinent organizations.

b) Collection of primary data

The land-use patterns, managements and socio-economic aspects of the coastal people KoyraUpazilla of khulna District in the Division of Khulna . KoyraUpazilla is bounded by paikgacha (Khulna) and Assasuni and paikgachaupazillas, Sundarbanson the northand Bay of Bengal on the south, Dakopupazillas on the east, Shyamnagar (satkhira) on the west**.** Thana Agriculture Office and directly from the local people through questionnaire.The local people in some selected areas of the coastal zones were also interviewed about theirsocio-economic aspects and livelihoods. In each location, some 10-20 farmers were randomly selected for the purposes. Khulna was also madeOn-spot observation.

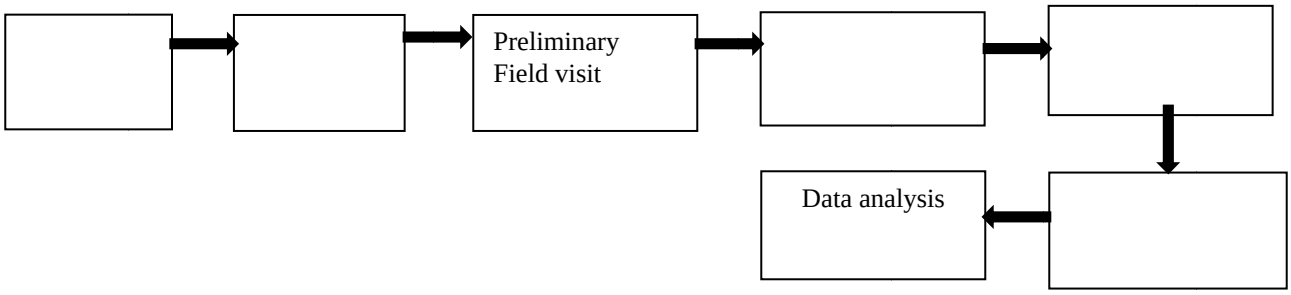

Figure 1: Flow diagram in this research work

Understanding the Geo-Physical Environment:

An attempt was made to understand the geo-physical environment of the study area. A hydrological analysis was done to understand the extent and nature of flood in the study area. The flood depth and spatial distribution of rainfall were examined during the monsoon season. Extreme temperature and soil salinity were observed for the whole season (figure 3). The effects of climate change on the geophysical environment of the study area were identified from these observations and investigate. Participation of local contributors was ensured during this process.

Field -Testing Sites Selection:

Based on previous data and information collected from a non-structured questionnaire survey from different stakeholders, such as scientists of different research organizations and local farmers, koyra to be the most suitable site for conducting the experiments. According to the suggestion of the Environment Engineering Department of Khulna University of Engineering and Technology(KUET), the proposed method for field testing has modified. It has been certain to bring out the study at KoyraUpazilla for presenting and analyzing scenarios of salinity intrusion and sea level rise as well as effect of climate change on overall agriculture. According to the some parameters of measuring the variation of agricultural data with respect to different years the experiment sites were selected at the farmers' fields at Koyra.

Results and Discussion

Sea level rising:

Sea level rise will increasefloodfrequencyandfloodingduration,affecting Aman production. Due to sea level rise, salinityofwaterandsoilwillincrease,andthis willdamageAmancultivableland. Production of T.aman and Boro is varied due to sea level rise seasonally. Damage of rice was highest in 2009-10 since due to flood and cyclone (aila) as shown in figure-2.Becauseofthe shortageoffreshwater,Bororiceproductionwillbedecreased.

Agriculturallandsinthecoastalareawill be affected by salinity; soil quality will be degraded and flooding event will loss the agricultural production of the coastal land of Bangladesh. Therefore sea levelrise will have to effect on agricultural production,most important Bangladesh to be unsuccessful, obtaining food security,especially on food production.

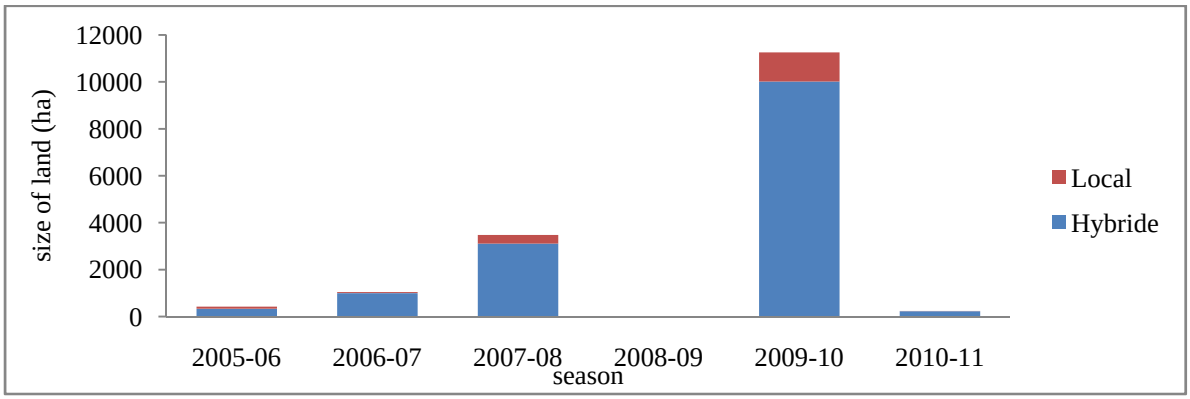

Figure 2: Damage of crops due to flood and cyclone.

Salinity:

Shrimpfarm areasintheyear2004were87fold more than that of the year 1975. It is another indicator of salinity intrusion in the coastal zone. In last thirty years' time period, salinity intrusion has degraded land quality and farmers can't grow any agricultural crops in their fields. Thus farmers becomezero productive land owners, in onesenselandlesswiththeirexisting salineland. Salinity intrusion causes loss in agriculture, loss in biodiversity, loss in fresh water and its resource. Size of land which is the firm of shrimp with Transplanted amon(rice) decrease 15294ha to 10000ha cause of salinity as in table -3 below.

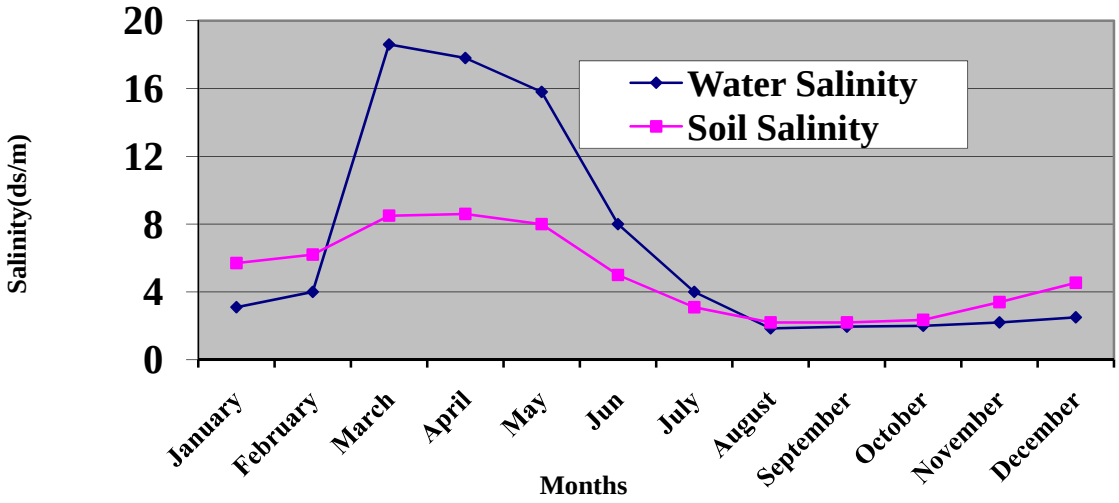

Figure 3: The soil and water salinity dynamics at koyra ,khulna during 2011-12

Salinity varies over a season with respect to month in the study area. From figure 3 it shows the salinity is large from February to July than the other month of season as resultboro rice is affected by it.

Table 3: Variation of Cultivation with respect to salinity

Types of crops	Before five years		Present status	
Transplanted amon(rice) with Prawn/Shrimp	Size of land (hector) 15294	Percentage of cultivable land 11	Size of land (hector) 10000	Percentage of cultivable land 9

Conclusion and Recommendations

Sealevelrise in Bangladeshimpactsarereally high,thoughthecountryplaysveryslightpartin greenhouse gas releases,sea level riseand climate change toleading.By affecting different livelihoodactivitiesandimportantecosystem ofthecountry,sealevelriseimposesagravethreatto theexistenceofBangladesh.Therefore,Bangladesh governmentneedtopaykeenattentiontothe issue and should develop strategy tocombat sea level rise impacts and thus safe its citizen. For comparing the impact of climate change, yields of crops under this study were generated for baseline (360 ppmv CO, temperature and precipitation of 1990) climate and with no stress condition (no stress means that optimum levels of fertilizer and irrigation).Effect of climate change on cultivable land is vary with seasonally (figure -4).

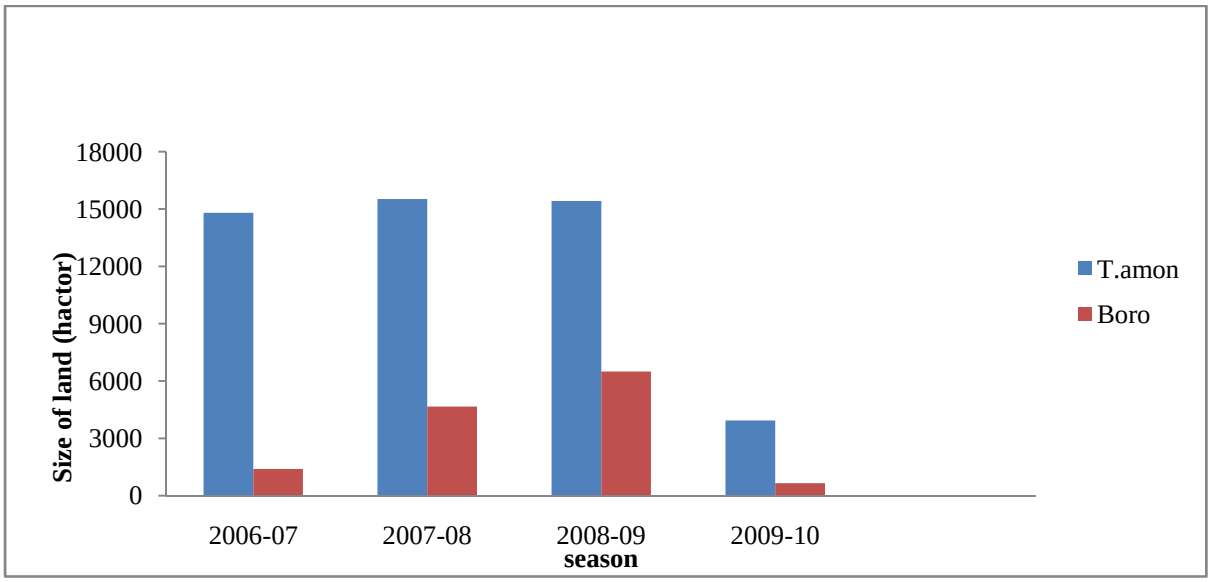

Figure 4**:** Size of cultivable land with various seasons.

It is difficult to confirm a crop as adaptive under climate change situations using only one season crop related data. At least three years of experimentation is required to conclude if a crop is adaptive under climate change situations in the coastal regions. It is necessary to find out the other way such as salinity tolerated seed distribution to the coastal farmer at boro season. The finding for rice crops cultivated in boro season and T.Aman season need to be confirmed by more trails. The findings for rabi crops need to be confirmed by more trails. The findings should be disseminated to the farmers of the whole coastal areas. Necessary inputs and technology should be provided to the farmers with a purpose to start farming practices in their respective fields with the recommended variety and technology. The finding should be expanded throughout the salt affected coastal zone of Bangladesh.
For adaptation, the government should take initiatives to improve irrigation efficiency, runoff management, and agricultural productivity and to promote risk management to compensate loss in agriculture. Government should develop and promote the use of hybrids and to develop infrastructure for post-harvest management, marketing and agribusiness (IPCC, 2001a). IRRC (2003) concluded, BRRI Hybrid Dhan-1 variety showed 0.5 to 1.0 t/ ha yielded over that of other rice varieties, produced in Bangladesh. Farmers of the coastal zone should be provided free agricultural education and necessary support for its modification to adjust with sea level rise situation. It is essential to introduce salinity tolerant species in agriculture, forestry and fisheries.

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Effects of Soil Salinity on Crop Production rate of the South West Zone of Bangladesh

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Abstract

Bangladesh is a small country with total land area of 147,570 sq. km. and the major part (80%) consists of alluvial sediments deposited by the river Ganges, Brahmaputra, Tista, Jamuna, Meghna and their tributaries. The coastal region covers almost 29,000 sq. km or about 20% of the country area. Moreover, the coastal area covers more than 30% of the cultivable lands of the country. About 53% of the coastal areas are affected by salinity. Agricultural land use in these areas is very poor, which is much lower than country's an average cropping intensity. Salinity causes unfavorable environment and hydrological situation that restrict the normal crop production throughout the year. The severity of salinity problem in Bangladesh increases with the desiccation of the soil which affects crop production depending on degree of salinity at the critical stages of growth, which reduces yield and in severe cases total yield is lost. Therefore, assessment of the present scenario of soil affected by salinity on crop production of the study area namely south west zone of Bangladesh (selected four sites of four upazilas under greater Khulna district) is very important. It is found from the study area that salinity level increased in April - May and decreased in October-November in every year. It has effect on crop yield in dry season due to salinity level increased. If Ganges water supply has increased in dry season, it reduces the salinity effect in crop production in Khulna. Rainfall also reduces the surfaces soil salinity.

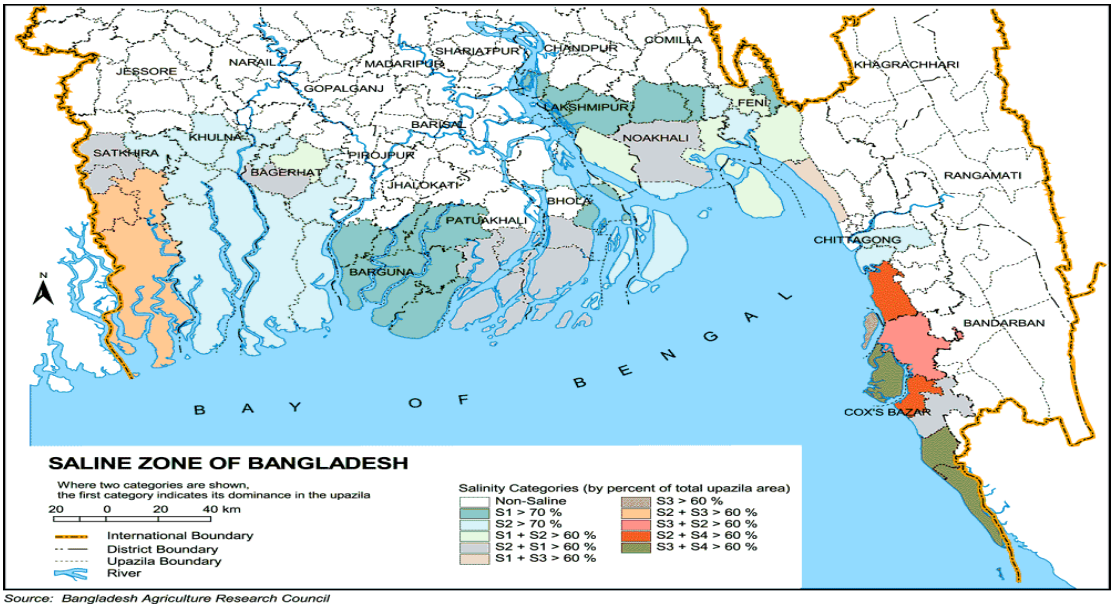
Keywords: *salinity, coastal region, cultivable lands, cropping intensity, hydrological situation, south west zone of Bangladesh.*

1. Introduction

The coastal area covers about 20% of the total area of Bangladesh is 147,570 sq. km the country and over 30% of the net is cultivable area. It extends inside up to 150 km from the coast. Out of 2.85 million hectares of the coastal and offshore areas about 0.83 million hectares are arable lands, which cover over 30% of the total cultivable lands of Bangladesh. A part of the coastal area, the Sundarbans, is a reserve natural mangrove forest covering about 4,500 sq. km. The remaining part of the coastal area is used in agricultural purpose. The cultivable areas in coastal districts are affected with varying degrees of soil and water salinity. The coastal and offshore area of Bangladesh includes tidal, estuaries and river floodplains in the south along the Bay of Bengal. Agricultural land use in these areas is very poor, which is roughly 50% of the country's average. Salinity causes unfavorable environment and hydrological situation that restrict normal crop production throughout the year. The factors which contribute significantly to the development of saline soil are, tidal flooding during wet season (June - October), direct inundation by saline water, and upward or lateral movement of saline ground water during dry season (November-May). The freshly deposited alluviums from upstream in the coastal areas of Bangladesh become saline as it comes in contact with the sea water and continues to be inundated during high tides and ingress of sea water through creeks. People in the southwest region are highly dependent on the natural resource base in sustaining their livelihoods. Agriculture and fisheries are important economic sectors, employing a large proportion of the population, and aquaculture is increasingly being pursued as an alternative livelihood option for rural households (Islam, 2003). The main aim of this study is to achieve the following specific objectives: Assessment of soil salinity condition in south-western zone of Bangladesh as well as its

effect on crop production rate. A major agricultural crop includes rice, betel leaves, fruits and vegetables, mustard and oilseeds, coconut and sugarcane. The region is densely populated, and most farm families cultivate the scarce land resources intensively, resulting in land degradation and reduced productivity. Increasing salinity and water logging are further reducing the availability of cultivable land. In addition to its contribution to the major economic sectors, the natural resource base provides coastal people with materials for building houses, cooking fuel, raw materials for handicrafts, etc. It is clear that people in this region are highly vulnerable to saline water disaster. The predicted impacts of water disaster will only increase the difficulties coastal people face in securing their livelihoods, maintaining health and safety, and achieving sustainable development.

Saline Soil: Saline soil contains an excess of soluble salts, especially sodium chloride. In other words, soils that develops under the influence of the electrolyte of sodium salts, with a nearly neutral reaction. Dominant salts are sodium sulphate and sodium chloride, but seldom sodium nitrate, magnesium sulphate, or magnesium chloride. They are non-sodic soils containing soluble salts in such quantities that they interfere with the growth of most crop plants. The pH of the saturated saline soil is usually less than 8.3. These soils are geographically associated with arid, semi-arid, sub-humid and humid areas as well. The estimates indicate that Bangladesh has about 2.8 million ha (Chanratchakool, 2007) of land affected by salinity and poor quality water. The total area includes deltaic floodplains and offshore islands. This comes to about one fifth of the total areas of Bangladesh and lies around the northern apex of the Bay of Bengal. The saline soils are mainly found in Khulna, Barisal, Patuakhali, Noakhali and Chittagong districts of the coastal and offshore lands. Due to a number of environmental factors the coastal soils are slightly too moderately saline on the surface, and highly saline in sub-surface layers and substrata.



Source: Bangladesh Agriculture Research Council

Figure 1: Saline Zone of Bangladesh

2. The study area:

2.1. South West Zone of Bangladesh:

The south western coastal zone is covered by the Sundarbans mangrove forest, covering greater Khulna and part of Patuakhali district. Greater Khulna district consists of nine upazilas. Out of them four land sites of Jalma (Batiaghata), Krisnanagar (Dumuria), Kismat (Fultola), Bajua (Dakop) selected as the study area. These areas were selected to investigate the top soil salinity and its effects on crop production. The study area is highlighted in figure 2. The area lies at 0.9 to 2.1 metre above mean sea level. Soil characteristics of the western coastal zone are silty loams or alluvium.

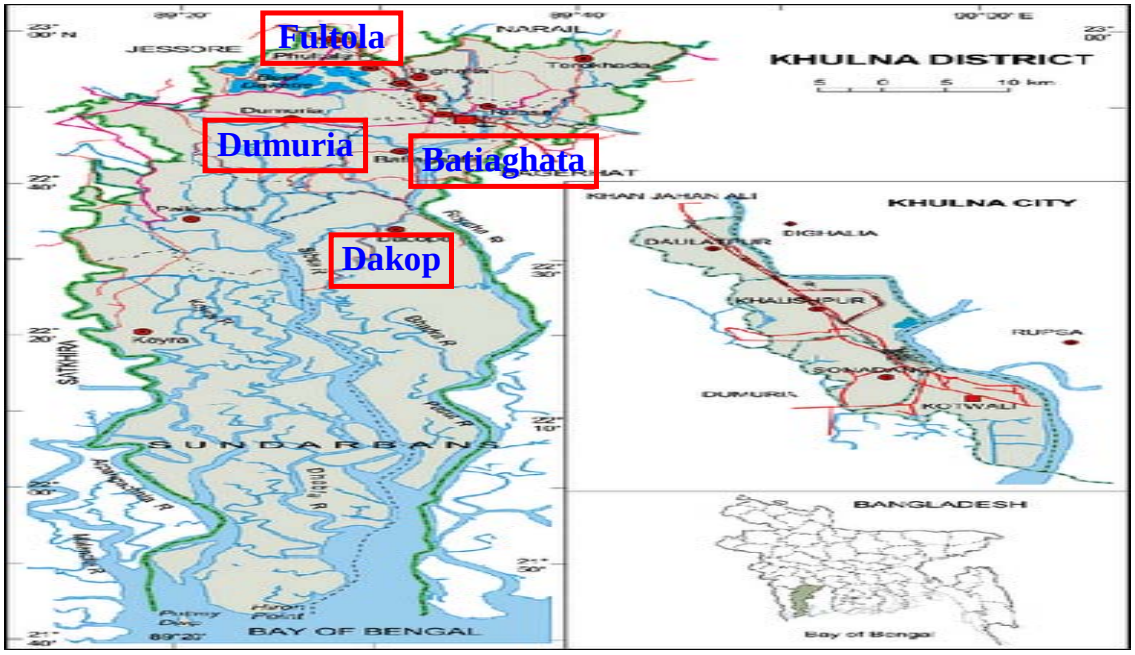


Figure 2: Map showing the study area of South West Zone of Bangladesh **(Highlighted zone)**

3. Data collection and analysis

The study area as stated above is south western part of Bangladesh. More specifically the study area is the Khulna district. In these study two types of data has been used. The soil and river water salinity data of year 2004-2009 for study site has been collected from "Soil Resources Development Institute (SRDI, 2009), Khulna". The crop yield data of 2004-2009 for Khulna has been collected from "Agricultural Extension Institute (AEI), Khulna". From the soil salinity data, monthly salinity of 2004-2009 has been calculated and used for showing graphical pattern. The graph will help to understand the top soil salinity pattern of the study area of Jalma (Batiaghata), Krisnanagar (Dumuria), Kismat (Fultola) and Bajua (Dakop), under greater khulna district.

3.1Analysis of Topsoil Salinity (ECe: ds/m) Conditions

Monthly variation of topsoil salinity of four sites within the study area in different year has been shown from figure 3 to figure 6.

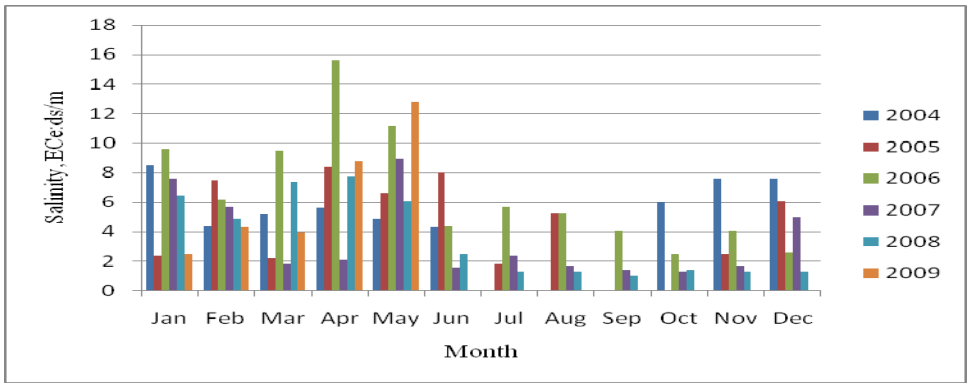


Figure 3: Monthly variation of top soil salinity rate in different year at **Jalma** (Batiaghata Upazila), Khulna.

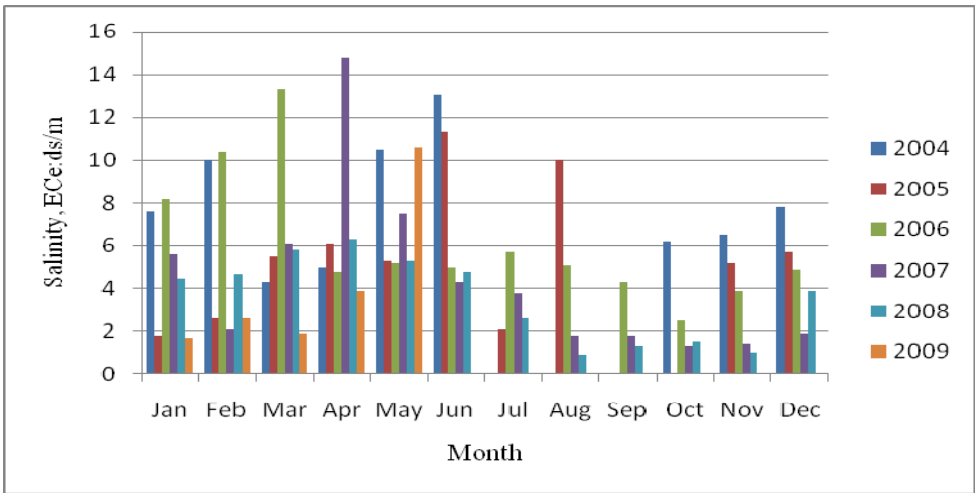


Figure 4: Monthly variation of top soil salinity rate in different year at **Krisnanagar (**Dumuria Upazila), Khulna.

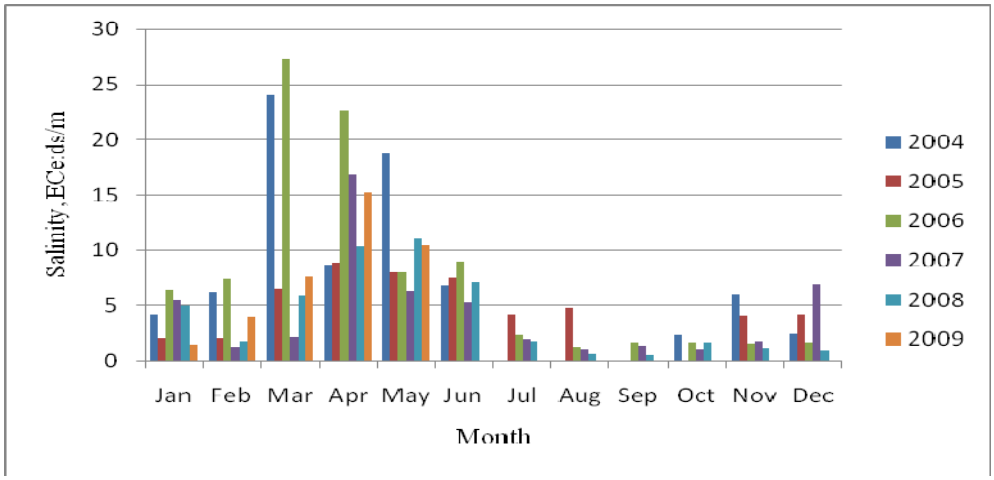


Figure 5: Monthly variation of top soil salinity rate in different year at **Kismat** (Fultola Upazila), Khulna.

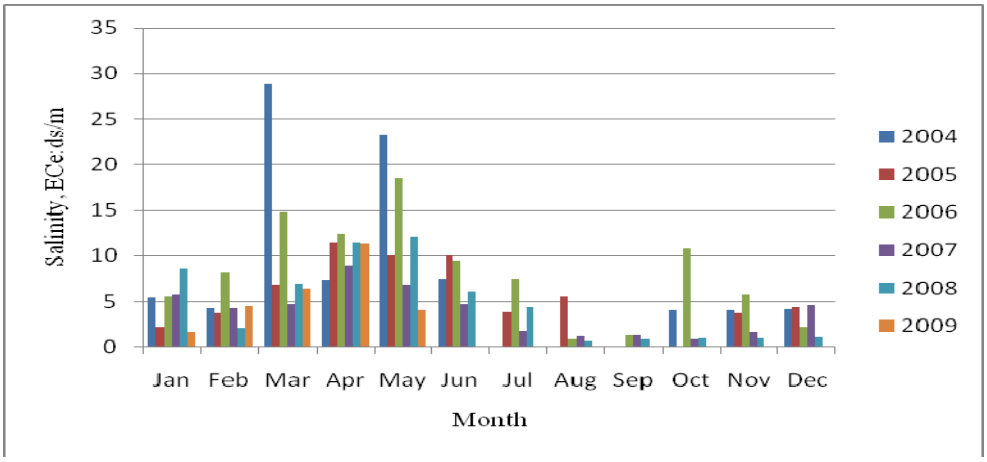


Figure 6: Monthly variation of top soil salinity rate in different year at **Bajua** (Dakop Upazila), Khulna.

4. Impact of salinity

4.1 Impact of salinity of soil on crop production

Rising of salinity level will decrease agricultural production by unavailability of fresh water and soil degradation. Salinity also decreases the terminative energy and germination rate of some plants (Rashid et al., 2004; Ashraf et al., 2002). (Ali, 2005) investigated the loss of rice production in a village of Satkhira district and found that rice production in 2003 was 1,151 metric tons less than the year 1985, corresponding to a loss of 69 percent. The production rate of different types of crops in different upazila in khulna districts is shown from figure 7 to figure 10.

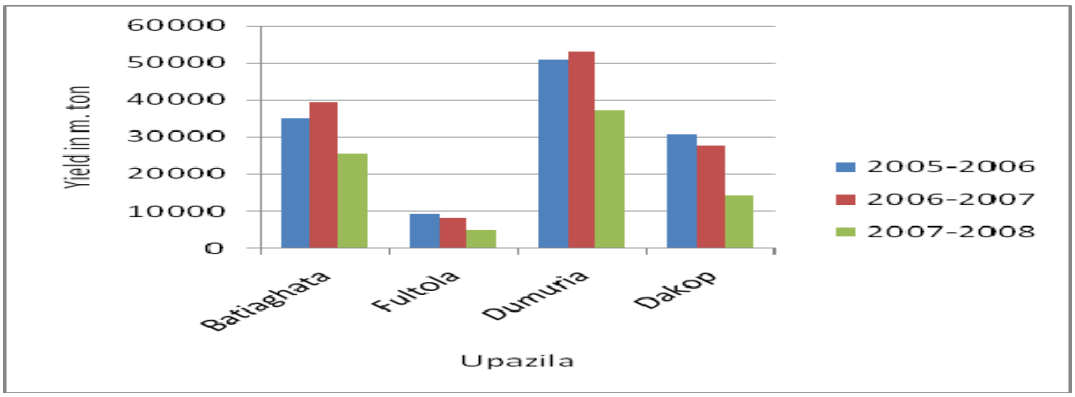


Figure 7: Rupa Aman yield rate at different upazilas in greater Khulna district (in metric ton)

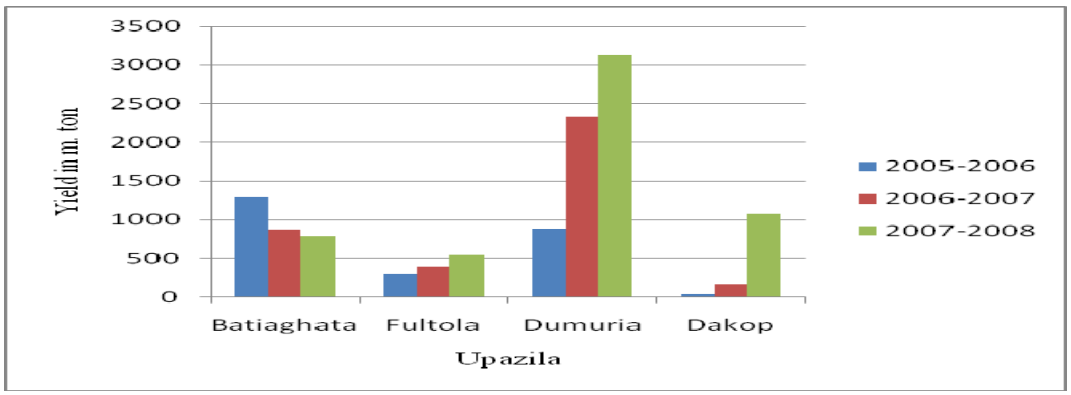


Figure 8: Aman yield rate at different upazilas in greater Khulna district (in metric ton)

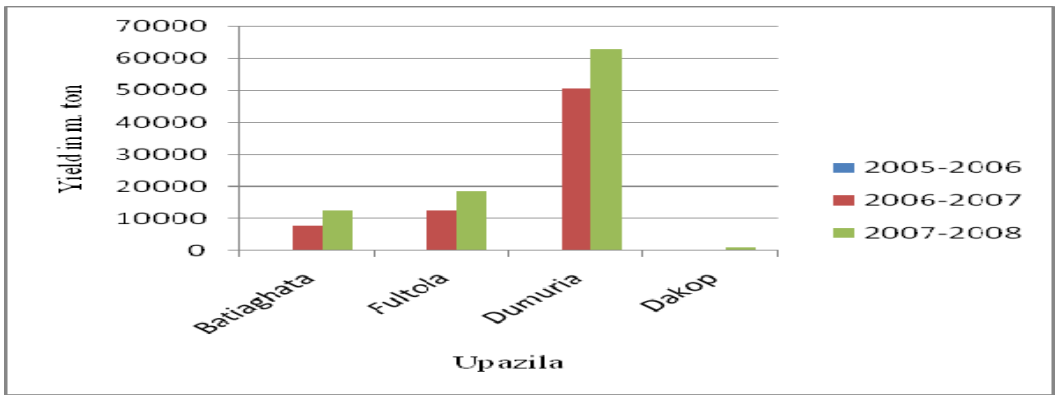


Figure 9: Boro yield rate at different upazilas in greater Khulna district (in metric ton)

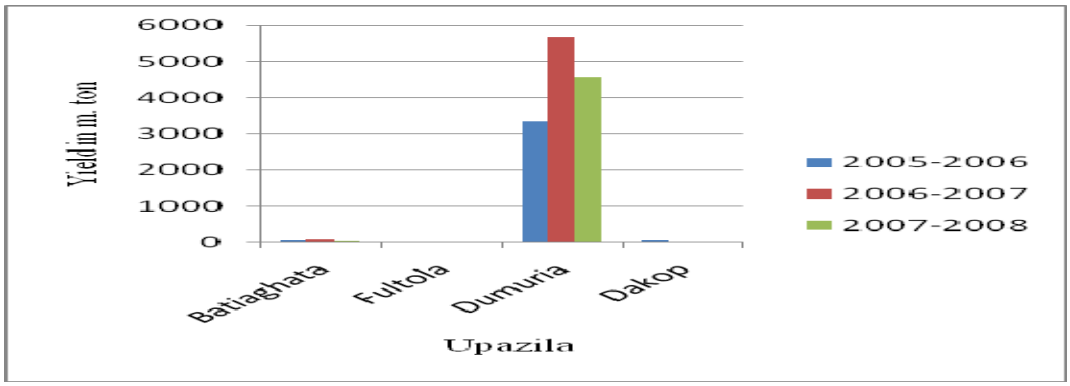


Figure 10: Jute yield rate at different upazilas in greater Khulna district (in metric ton)

5. Discussions and conclusions

5.1 Discussions

Out of 2.85 million hectares of coastal and off-shore land, about 1.5 million hectares are affected by varying degrees of salinity. The coastal saline soils are distributed unevenly in 64 thanas of 13 districts, covering portions of 8 agro-ecological zones (AEZ) of the country. The larger portions of saline land fall in the districts of Shatkhira, Khulna and Bagerhat. Large fluctuations in salinity level sever time are observed at almost all sites in these regions. The common trend is an increase in salinity with time, from November - December to March - April, until the onset of the monsoon rains. The electrical conductivities (ECs) of the soil were lowest in July - November and highest in January - May at all sites. Soil salinity, at any time, is maximum in the surface layers (0 - 15cm), the salinity gradient being vertically downwards. Subsoil salinity is usually much lower than topsoil salinity. Moderately to strongly saline underground is found within 1 - 2 meters below the soil surface at all locations in the dry season. The spatial and temporal variations in soil salinity indicate the need for crop production planning separately for different locations in the coastal areas .No generalization can be made in this regard.

5.2 Conclusions

It is found that the soil salinity, at any time, is maximum in the surface layers (0 - 15cm), the salinity gradient being vertically downwards. Subsoil salinity is usually much lower than top soil salinity. Soil salinity indicates the need for crop production planning separately for different locations in the coastal areas. Development and implementation of adaptation policies and taking initiatives for mitigation measures are the right ways to respond to salinity level rise impacts. From data analysis it is found that Dakop, Dunuria and Fultola are badly affected by soil salinity in the month of January to May. In general it is found that an increasing tendency of salinity is observed since last 5 years. The crop production rate decreases in the study area of Fultola, Batiaghata and Dakop due to the rising of salinity. In Batiaghata, the crop production rate is comparatively high due to presence of low salinity. This research gives a primary idea about the salinity condition and effect of salinity on crop production at the study area.

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Study of Soil Properties and Evaluation of Evapo-transpiration for Wheat by Soil Moisture Depletion Studies

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Abstract

Using available properties of soil an attempt has been made to estimate the evapo-transpiration of water for wheat of four samples at Regional Wheat Research Center (RWRC), Rajshahi and one sample in RUET campus. The different soil properties such as void ratio, porosity, grain size distribution has been determined. The consumptive use of water for wheat is determined by the method of soil moisture depletion studies. The Consumptive use for wheat (mm) at different location such as north, south, east, west side of the RWRC and south side of the Ladies Hall (LH) at RUET was found respectively 337, 354, 341, 417, 288, 355, 313, 452, 265, 399, 328, 449, 350, 365, 319, 396, 210, 301, 255, 346 185, 157, 218, 172 and 140mm.The estimated minimum quantity of evapo-transpiration for wheat is 140mm south side of the LH before harvesting and peak value is 452mm west side of the RWRC. The peak values are obtained after irrigation. Minimum co-efficient of curvature found 1.01 at north side of RWRC and maximum 1.19 at south side of RWRC from grain size distribution curve. The uniformity co-efficient Cu found 3.47 at the south side of the LH and south, north and west side of RWRC was found 3.93, 3.96 and 3.65 respectively. As the uniformity co-efficient Cu lies between 1 to 4 and co-efficient of curvature C_c is nearly unity indicates the soil uniformly well graded and fine grained soil. The soil samples collected from five locations are silty loam according to textural classification of soil.

Keywords: evapo-transpiration, soil property, consumptive use, co-efficient of curvature, uniformity co-efficient, soil moisture depletion studies.

1. Introduction

To grow every crops water is essential. Plant absorbs water from soil by root and this water is used in vegetative growth. Some of this water retains on plant and same of this transpires to the atmospheres. The quantity of water transpired by plants during growth and retained in the plants tissue plus the moisture evaporated from the surface of the soil and vegetation is called consumptive use or evapo-transpiration [1]. Evapo-transpiration represents one of the most important aspects of water loss in the hydrological cycle. It accounts about 75% of the annual precipitation in humid region and nearly 100% in arid region [3]. It is sum of the volumes of water entering plant roots to build plant tissue or bring passed through leaves of the plants in to atmosphere and evaporated from the surfaces of leaves of the plant. From agricultural point of view, the year is divided into two seasons, Rabi season and Kharif season. Normally Rabi start on 1st October and ends on 31st March [4]. Our studied crops wheat lies in Rabi crops. Evaporation, transpiration and consumptive use are important factors in estimating irrigation requirement and planning irrigation systems. The yield from agricultural land depends upon several factors but the most important factor in the crops to get adequate water at the stages growth of the plants. The natural supply of water to the agricultural land for the production of crop is through rain [2]. It is a consideration in irrigation project to provide optimum water to the crops. Lack of water will hampered plant growth and excessive supply will increase cost of irrigation and will bear no benefit and sometimes cause adverse effect to plant growth. So it is essential to provide optimum water supply to the crops. For estimating optimum water supply and various losses we have to know evapo-transpiration. The purpose of this study is to achieve the following specific objectives: Analysis of collected soil sample by laboratory experiment and determination of water content, grain size distribution, void ratio and porosity. Other important assessment is the type of soil in the root zone depth at different locations as well as the seasonal consumptive use and Evapo-transpiration of Wheat.

2. Research methodology

2.1 Auger boring method: Augers are used in cohesive and other soft soils, above water level. Hand augers are used for depths up to about 6m.Mechanically operated augers are used for greater depths & they can also be used in gravely soils. Samples recovered from the soil brought up by augers are badly disturbed and are useful for identification purposes only. Auger boring is fairly satisfactory for highway explorations at shallow depth and for exploring borrow pits. The soil sample has been collected by Hand augers (Post hole auger) [5].

2.2 Water content by Oven-drying method: (1) The container was cleaned and then finding its mass with lid w_1 gm. (2) putting the required quantity of the moist soil sample in the container and replace the lid. Taking the mass w_2 gm. (3). The container was kept in the oven with lid removed and maintained the temperature of oven between 105°c to 110°c, for about 24 hours. (4) Taking out the container, replacing the lid and cooling it and finally taking the mass w_3 gm of the container with lid and dried soil sample.

2.3 Grain size distribution: Grain size distribution of a soil sample can be obtained by conducting sieve analysis and hydrometer analysis. Generally sieve analysis is used for coarse-grained soil and hydrometer analysis is used for fine-grained soil. The particle size distribution for both hydrometer and sieve analysis were conducted in the laboratory. At first 500gm of the soil samples were kept submerged under water for 24 hour. After 24 hour the soil samples were sieved through 200 no. sieves (0.75mm) using water jet [6]. The soil retaining on 200 no. sieves after drying was used for sieves analysis. Soil, which passes the 200 no. sieves, was collected in a large container and was allowed to settle. These settled soils after drying was used in hydrometer analysis.

2.4 Void ratio and porosity of soil: (1) At first collecting the soil sample by using a ring. (2) Finally, take the weight of dried soil sample. (3) After collecting the soil sample is to be planed by using a straight edge. Then take the weight of soil sample (4). Then placing the soil sample into the oven at the temperature of about 105° to110°c for 24 hours.

2.5 Soil moisture studies on plots: This method is usually employed to determine the evapo-transpiration of water in irrigation field plots in which soil is fairly uniform and depth of ground water is such that it does not affect the soil moisture fluctuations within the root zones. Usually a large number of soil samples must be taken at different depths in the roots zone. The moisture content of soil samples is determined by standard laboratory methods and it is expressed as a percentage of the oven dry wt. of the soil. Thus the quantity of water in meter removes from the soil evaporation and transpiration is determined by using the formula, D=PSd/100. In which, P is the moisture percentage by wt; S is the apparent specific gravity of soil; d is depth of soil in meter; and D the depth of water in metros removed from the soil. The total quantity of water removed from the soil during each period is computed which the value of the evapo-transpiration for that period is determined. The values of the 30 days period evapo-transpiration are plotted against time and use of water curve for the crop season is obtained. The average use of water for each month is obtained directly from this curve.

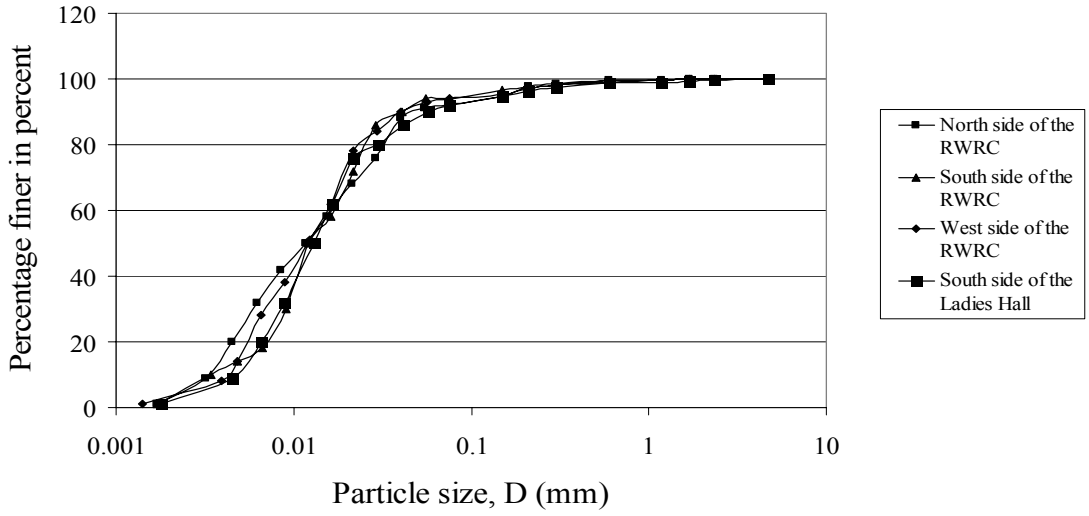

Figure 1: Grain size distribution curve (combined)

3. Results and discussions

The amount of evapo-transpiration of water for the crops of wheat is calculated in RWRC and RUET campus, Rajshahi. The consumptive use for wheat (mm) at different location shown in (Table 3.12 to Table 3.16) south, north, east, west side of the RWRC and south side of the LH, was found respectively 337, 354, 341, 417, 288, 355, 313, 452, 265, 399, 328, 449, 350, 365, 319, 396, 210, 301, 255, 346, 185, 157, 218, 172 and 140mm. The estimated minimum quantity of evapo-transpiration for wheat is 140mm at the south side of the LH before harvesting and peak value is 452mm. Water content in different depth of five locations is shown in table 4.7 to table 3.11 at different period. Porosity at the south, north, east, west side of the RWRC and south side of the LH, it was found 0.30, 0.35, 0.38, 0.37 and 0.41. Void ratio at the south, north, east, west side of the RWRC and south side of the LH, it was found 0.50, 0.55, 0.62, 0.58 and 0.70 which is shown in table 3.6. The estimated minimum quantity of evapo-transpiration for wheat is 140mm at south side of LH before harvesting [Table 3.14] and peak value is 452 mm at west side of the RWRC[Table 3.13]. After irrigation the peak values are obtained. The empirical value (Table 3.1) of consumptive use of water which is lower than the experimental value. The average value of evapo-transpiration shown in table 3.2. The evapo-transpiration curve for wheat is shown in fig. 2. Soil classification according to international soil classification range is shown in table 3.3. Textural classification of soil by using USDA chart and the value of C_u and C_c is shown in table 3.4 and table 3.5.

Table 3.1: Comparison of Consumptive use by different method

Name of the crop	Name of month	Date	Experimental method (mm)	Empirical formula	
				Blaney-Criddle method (mm)	Thornthwaite method (mm)
Wheat	December	1st to 31th December	322.4	52.10	78.80
	January	1st to 31th January	322.4	59.30	83.10
	February	1st to 29th February	361.6	83.45	90.30
	March	1st to 18th March	174.4	93.49	123.25

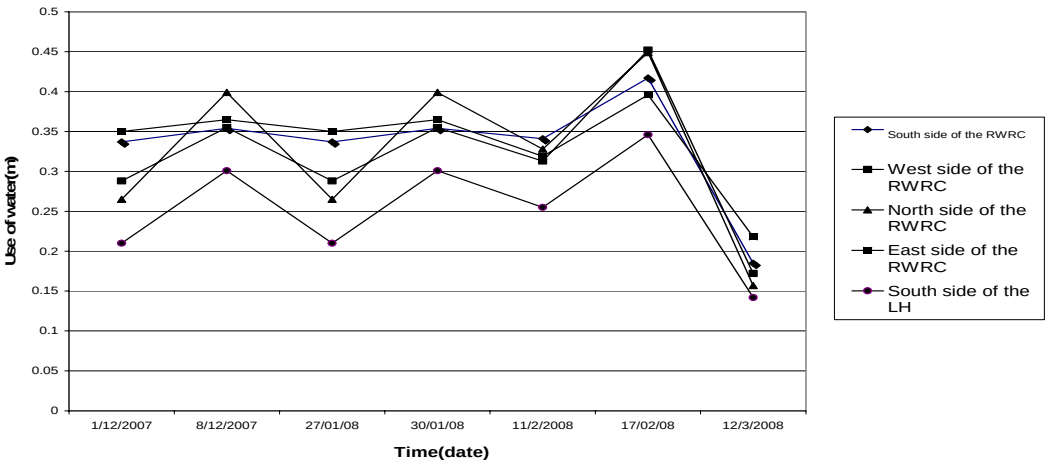

Figure 2: Evapo-transpiration curve for wheat

Table 3.2: Average values for daily, monthly seasonal evapo-transpiration

Location	Average evapo-transpiration		
	Daily (mm)	Monthly (mm)	Seasonal (mm)
South side of the RWRC	3.57	107.03	428.50
West side of the RWRC	4.31	118.83	514.90
East side of the RWRC	3.75	112.59	450.00
North side of the RWRC	4.15	124.57	497.60
South side of the LH	4.68	139.30	536.80

Table 3.3: Soil classification according to International Soil Classification Range

Type of soil	Range of particle diameter in millimeter
Course sand	2-0.2
Fine sand	0.2-0.02
Silt	0.02-0.002
Clay	Less than 0.002

Table 3.4: Textural classification of soil by using USDA chart

Location	Sand (%)	Silt (%)	Clay (%)	Type of soil
South side of the RWRC	28	63	9	Silty loam
West side of the RWRC	22	70	8	Silty loam
East side of the RWRC	26	63	11	Silty loam
North side of the RWRC	28	62	10	Silty loam
South side of the LH	24	67	9	Silty loam

Table 3.5: Soil classification by using the value of C_u and C_c

Location	Uniformity co-efficient C_u	Co-efficient of curvature C_c	Classification of soil
South side of the RWRC	3.93	1.19	Uniformly well graded& fine grained soil
North side of the RWRC	3.96	1.01	Uniformly well graded& fine grained soil
West side of the RWRC	3.65	1.04	Uniformly well graded& fine grained soil
East side of the RWRC	3.89	1.07	Uniformly well graded& fine grained soil
South side of the LH	3.47	1.14	Uniformly well graded& fine grained soil

Table 3.6: Experimental data for void ratio & porosity

Location	Mass of specimen M_1	Volume of mould	$\rho = \frac{M1}{V}$ gm/cm^3	$\gamma_d = \frac{\gamma}{1+w}$	Void ratio $e = \frac{G*\gamma w}{\gamma d} - 1$	Porosity $n = \frac{e}{1+e}$
South side of the RWRC	115.40	56.37	2.05	15.81	0.50	0.30
West side of the RWRC	118.80	56.37	2.11	17.08	0.55	0.35
North side of the RWRC	117.60	56.37	2.08	16.33	0.62	0.38
East side of the RWRC	120.20	56.37	2.13	18.7	0.58	0.37
South side of the LH	116.20	56.37	2.06	17.01	0.70	0.41

Table 3.7: Water content of soil sample at the study area (Collected on 27-01-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	28.90	28.30	27.70	33.40
North side of the RWRC	23.60	24.30	20.20	23.10
East side of the RWRC	24.20	26.170	29.80	31.70
West side of the RWRC	27.70	26.20	23.30	24.70
South side of the LH	25.55	27.72	22.32	25.55

Table 3.8: Water content of soil sample at the study area (Collected on 30-01-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	43.00	24.57	28.80	35.32
North side of the RWRC	48.30	37.72	28.85	35.32
East side of the RWRC	41.00	35.50	30.11	31.00
West side of the RWRC	38.65	33.00	29.35	29.95
South side of the LH	36.66	35.35	30.11	32.11

Table 3.9: Water content of soil sample at the study area (Collected on 11-02-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	32.30	24.00	27.10	34.35
North side of the RWRC	30.30	28.70	26.25	28.15
East side of the RWRC	31.24	27.20	26.32	28.32
West side of the RWRC	30.30	27.15	27.10	26.17
South side of the LH	31.22	28.88	25.66	25.55

Table 3.10: Water content of soil sample at the study area (Collected on 17-02-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	49.80	48.30	33.35	35.62
North side of the RWRC	52.30	48.08	39.80	43.60
East side of the RWRC	49.33	38.42	34.75	32.25
West side of the RWRC	51.33	48.08	35.25	27.50
South side of the LH	50.25	47.88	36.66	26.33

Table 3.11: Water content of soil sample at the study area (Collected on 12-03-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	15.40	16.98	16.90	21.45
North side of the RWRC	13.40	14.80	15.40	18.30
East side of the RWRC	13.00	15.35	18.39	20.19
West side of the RWRC	15.42	16.20	17.50	18.29
South side of the LH	14.44	17.78	16.58	22.23

Table 3.12: Determination of evapo-transpiration by soil moisture at the south side of the RWRC

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	28.90	2.51	0	337
	0.3	23.50	2.51	0.177	
	0.6	27.70	2.51	0.417	
	0.9	33.40	2.51	0.755	
2nd Sample					
30-01-08	0	43.00	2.51	0	354
	0.3	24.57	2.51	0.184	
	0.6	28.80	2.51	0.434	
	0.9	35.32	2.51	0.798	
3rd Sample					
11-02-08	0	32.3	2.51	0	341
	0.3	24.00	2.51	0.181	
	0.6	27.1	2.51	0.408	
	0.9	34.35	2.51	0.776	
4th Sample					
17-02-08	0	49.8	2.51	0	417
	0.3	48.3	2.51	0.364	
	0.6	33.3	2.51	0.501	
	0.9	35.62	2.51	0.805	
5th Sample					
12-03-08	0	15.4	2.51	0	185
	0.3	16.98	2.51	0.128	
	0.6	16.90	2.51	0.255	
	0.9	21.45	2.51	0.484	

Table 3.13: Determination of evapo-transpiration by soil moisture at the west side of the RWRC

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	27.70	2.61	0	288
	0.3	26.20	2.61	0.025	
	0.6	23.30	2.61	0.365	
	0.9	24.70	2.61	0.580	
2nd Sample					
30-01-08	0	35.67	2.61	0	355
	0.3	33.00	2.61	0.258	
	0.6	29.30	2.61	0.459	
	0.9	29.90	2.61	0.702	
3rd Sample					
11-02-08	0	30.30	2.61	0	313
	0.3	27.15	2.61	0.213	
	0.6	27.10	2.61	0.424	
	0.9	26.15	2.61	0.615	
4th Sample					
17-02-08	0	51.33	2.61	0	452
	0.3	48.08	2.61	0.376	
	0.6	35.25	2.61	0.552	
	0.9	27.50	2.61	0.881	
5th Sample					
12-03-08	0	13.4	2.61	0	172
	0.3	14.80	2.61	0.115	
	0.6	15.4	2.61	0..241	
	0.9	18.3	2.61	0..429	

Table 3.14: Determination of evapo-transpiration by soil moisture at the north side of the RWRC

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	23.60	2.64	0	365
	0.3	24.30	2.64	0.192	
	0.6	20.20	2.64	0.319	
	0.9	23.10	2.64	0.549	
2nd Sample					
30-01-08	0	41.50	2.64	0	399
	0.3	37.72	2.64	0.299	
	0.6	28.85	2.64	0.457	
	0.9	35.32	2.64	0.839	
3rd Sample					
11-02-08	0	30.30	2.64	0	328
	0.3	28.70	2.64	0.227	
	0.6	26.25	2.64	0.416	
	0.9	28.15	2.64	0.669	
4th Sample					
17-02-08	0	48.08	2.64	0	449
	0.3	46.90	2.64	0.371	
	0.6	34.25	2.64	0.542	
	0.9	37.13	2.64	0.881	
5th Sample					
12-03-08	0	15.42	2.64	0	157
	0.3	16.20	2.64	0.128	
	0.6	17.50	2.64	0277	
	0.9	18.30	2.64	0.435	

Table 3.15: Determination of evapo-transpiration by soil moisture at the east side of the RWRC

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	24.20	2.58	0	350
	0.3	26.17	2.58	0.203	
	0.6	29.80	2.58	0.461	
	0.9	31.70	2.58	0.736	
2nd Sample					
30-01-08	0	41.00	2.58	0	365
	0.3	35.50	2.58	0.275	
	0.6	30.11	2.58	0.466	
	0.9	31.00	2.58	0.719	
3rd Sample					
11-02-08	0	31.24	2.58	0	319
	0.3	27.20	2.58	0.211	
	0.6	26.32	2.58	0.407	
	0.9	28.32	2.58	0.658	
4th Sample					
17-02-08	0	49.33	2.58	0	396
	0.3	38.42	2.58	0.297	
	0.6	34.75	2.58	0.538	
	0.9	32.25	2.58	0.749	
5th Sample					
12-03-08	0	13	2.58	0	218
	0.3	15.35	2.58	0.118	
	0.6	18.39	2.58	0.285	
	0.9	20.19	2.58	0.469	

Table 3.16: Determination of evapo-transpiration by soil moisture at the south side of the LH

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	19.71	2.60	0	210
	0.3	15.11	2.60	0.118	
	0.6	15.27	2.60	0.238	
	0.9	20.73	2.60	0.485	
2nd Sample					
30-01-08	0	30.6	2.60	0	301
	0.3	29.05	2.60	0.227	
	0.6	23.80	2.60	0.371	
	0.9	25.45	2.60	0.605	
3rd Sample					
11-02-08	0	22.01	2.60	0	255
	0.3	17.35	2.60	0.135	
	0.6	19.54	2.60	0.305	
	0.9	24.73	2.60	0.579	
4th Sample					
17-02-08	0	28.62	2.60	0	346
	0.3	32.19	2.60	0.251	
	0.6	28.13	2.60	0.439	
	0.9	29.57	2.60	0.692	
5th Sample					
12-03-08	0	12.15	2.60	0	140
	0.3	13.25	2.60	0.103	
	0.6	15.20	2.60	0.175	
	0.9	15.35	2.60	0.256	

5. Conclusions

The minimum value of water content is found 13% and the maximum value of water content is 52.30% after irrigation. The uniformity co-efficient of five locations such as south, north, west, east side of the RWRC and south side of the LH, it was found 3.93, 3.96, 3.65, 3.89, 3.47 and the co-efficient of curvature was found 1.19, 1.01, 1.07, 1.04 and 1.14 which suggest to be uniformly well graded fine grained soil. The soil samples collected from five locations are silty loam according to textural classification of soil. Void ratio and porosity for different location varies from 0.50 to 0.70 and 0.30 to 0.41. Porosity indicates the water holding capacity of soil. Therefore, the average values of water content satisfy the porosity limits.

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Paper ID: RT-10

Wastewater Quality at Different Stages of Decentralised Wastewater Treatment Process in the Peoples Panchtala Colony at Kalishpur, Khulna

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Abstract

The main purpose of this paper is to determine wastewater quality at diferent stages of Decentralized Wastewater Treatment System (DEWATS) of the Panchtola Colony at Khalishpur, Khulna. To conduct the experiment, wastewater samples were collected from six different points such as in and out point of settler tank, middle and out of anaerobic center, out of planted filter, out of polishing pond of DEWATS at regular time interval. Different parameters such as Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), P^H, Nitrate, Phosphate, Temperature, Oil and Grease, Total Dissolve Solid (TDS), Fecal Coliform (FC), Dissolve Oxygen (DO), Total Suspended Solid (TSS) etc. were determined of collected wastewater sample. The test results show that the concentration of all harmful parameters were reduced to acceptable limit. This study was provided a clear vision that existing DEWATS can provide reliable low-cost sanitation and wastewater treatment solutions.

Keywords: *Decentralized, wastewater, compost, Fecal Coliform, Oil Grease.*

1. Introduction

Khulna is the third largest city in Bangladesh which is known to all as an industrial area. Most of its industries such as Jute mills, News print mill, and Hard board mill are situated in Khalishpur, Khulna. In the past, khalishpur was very busy and crowdie area when mills were active. To meet up the accommodation of factory workers a total of eight building were constructed at Peoples jute mill area in 1982. Every building has five floors, and for this reason it is called Peoples Panchtala Colony.

In order to address the pollution from the Peoples Panchtola Colony at Khalishpur in Khulna, the wastewater that is being discharged directly into the nearby open areas, would require proper treatment with regards to environmental conservation. Prior to the start of Nabolok EEHCO project which was funded by Water Aid Bangladesh, mostly the residential wastewaters including sewage were being disposed directly either into storm water drains or open areas without any treatment. Due to unaffordable cost of construction, most of the drains in the towns and cities are open as a result they are misused, sometimes serving as defecating sites for homes without adequate toilet facility [2]. In consequence, self-purification capacity of receiving water bodies is overloaded and it causes surface and ground water pollution, impacting directly to the health of community, reducing the value of environment [1].

To improve this dramatic situation, a new wastewater treatment plant was therefore needed. But the Municipality could not afford a centralized system for its entire area. For the circumstances, a small scale decentralized wastewater treatment system would be the most suitable to reduce the pollutant to an acceptably low level.

Nowadays, the decentralized approach is very popular system for sustainable wastewater management especially for developing countries like Bangladesh, where the water and sanitation issues are becoming a more and more important issue. To have a sustainable wastewater treatment system, an integrated assessment of each

alternative based on its economical, environmental, social, health and institutional aspects is necessary[5]. Decentralized wastewater management may be defined as the collection, treatment, and disposal or reuse of wastewater from individual homes, clusters of homes, isolated communities, industries or industrial facilities, as well as from portions of existing communities at or near the point of waste generation [3]. Up to 1,000 cubic metre of domestic and non-toxic industrial sewage can be treated by this system [6]. DEWATS applications are based on the principle of low - maintenance since most important parts of the system work without electrical energy inputs and cannot be switched off intentionally [4].

Decentralized system is the combinations of aerobic and anaerobic treatment process. The anaerobic treatment process comprise of settlers, baffle reactors and anaerobic filters. The aerobic treatment process has horizontal planted gravel filters and a polishing pond (Figure 1). The basic idea of that is to treat the wastewater (possibly together with refuses) on-site by means of low-cost treatment systems, and make direct use the treatment products (water, compost, biogas) [1]. Decentralized systems can work very well, that afford very high levels of treatment.

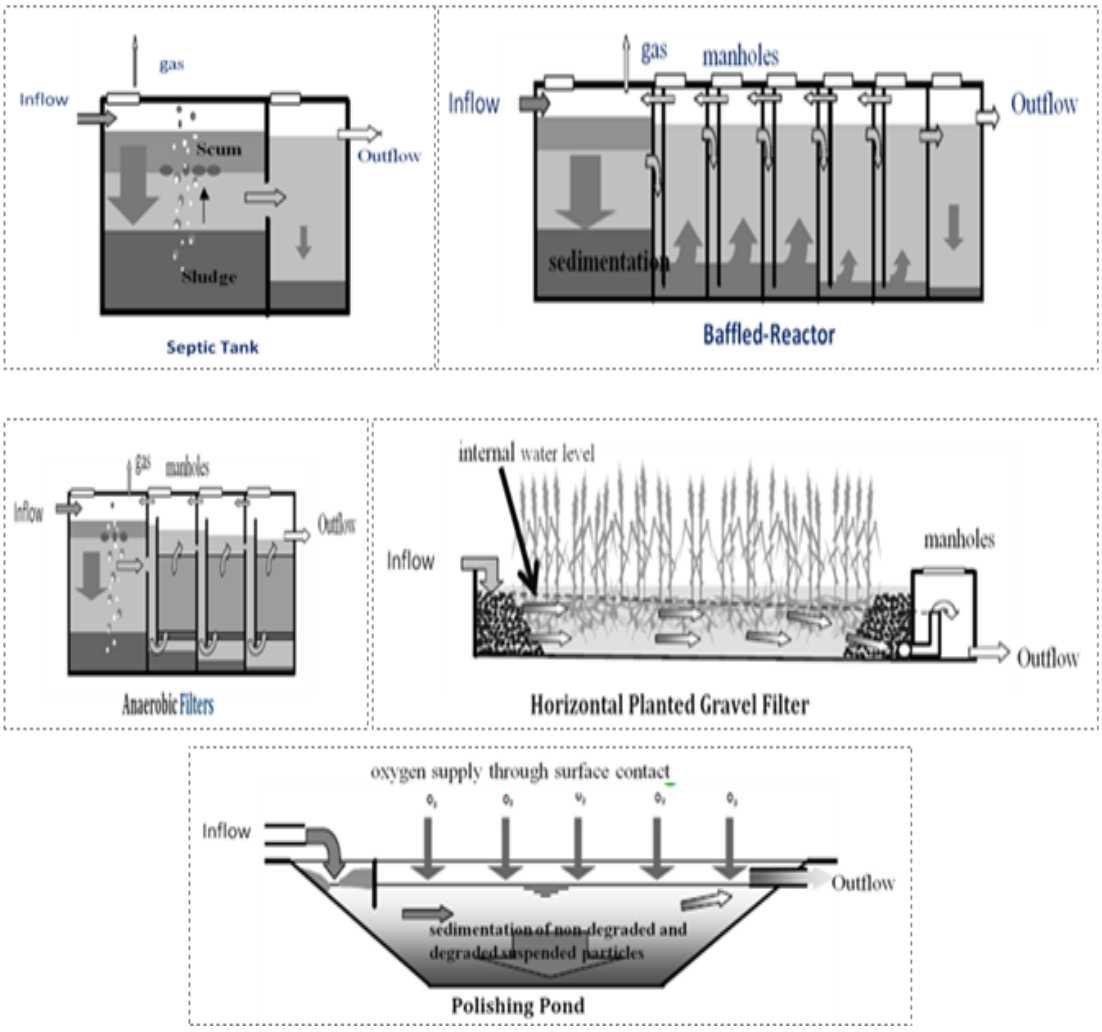

Fig.1. Schematic diagram of DEWATS

2. Before implementation of the Nabolok EEHCO project

Residential wastewater even sewage and Wastes were dumped beside their residence and near about the premises of their residence because there were not any sewerage systems or damping place (Figure 2). Thus foul odor were emitted which pollute the environment. Blockage of drainage systems occured for wastewater

overflow during rainy season. For that reason surface water bodies as well as groundwater was polluted. Moreover, wastes were spread of by scavenging birds and animals.

Fig.2. Waste and wastewater including sewage dumping practices before the Nabolok EEHCO project implementation.

3. Methodology

Collection of wastewater samples

The wastewater samples were collected from six different points such as in and out point of settler tank, middle and out of anaerobic center, out of plant filter, out of polishing pond of existing Decentralized Wastewater Treatment Systems of the Panchtola Colony at regular time interval. The wastewater samples were taken into the laboratory for examining its quality. Different parameters such as BOD, COD, P^H, Nitrate, Phosphate, Temperature, Oil Grease, Total Dissolve Solid (TDS), Fecal Coliform (FC), Dissolve Oxygen (DO), Total Suspended Solid (TSS) etc. were determined of collected wastewater sample.

Analytical methods

Laboratory determination of BOD_5 and DO were accomplished by using membrane electrode DO meter (HACH, USA). For the determination of COD, closed reflux method using $K_2Cr_2O_7$ oxidizing agent was used. The determination of pH and Temperature were done by using electrodes (HACH, USA). For TDS and TSS in wastewater sample was determined at 105^0C using laboratory oven. For determination of Nitrate (NO_3) and phosphate (PO_4), Nitrover and Phosver reagents were used [7]. For determination of Faecal Coliform, Membrane Filter procedure was used. For determination of Oil and Grease Partition-Gravimatric method was used. The calculated data of wastewater samples were compared and analyzed with Recommended Values.

The following recommended values of waste water are usually allowed for disposal in water bodies:

- BOD_5 of 40 mg/l.
- TSS of 100 mg/l.
- Faecal Coliform of 1000 No/100ml.
- Phosphate of 35 mg/l.
- Nitrate of 250 mg/l.
- Temperature of 30ºC.

4. Results and Discussion

Wastewater quality

Biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD)

A high concentration of organic matter was found in intlet of settler tank. BOD_5 values of waste water samples in Outlet of polishing pond were 33.2, 34, 28.2, 37 and 10.8 mg/l respectively. In Bangladesh Gadget,1997, BOD_5 is 40 mg/l. The DEWAT had brought BOD_5 levels down from 560 mg/l to nearly 35 mg/l. Values of COD in Outlet of polishing pond were 520, 980, 280, 820 and 340 respectively. The below graphical representations of BOD_5 and COD provided that the values were less in Outlet of polishing pond (Figure 3). So it is a clear indication that waste water Outlet of polishing pond can be mixed natural water bodies or used for irrigation purposes.

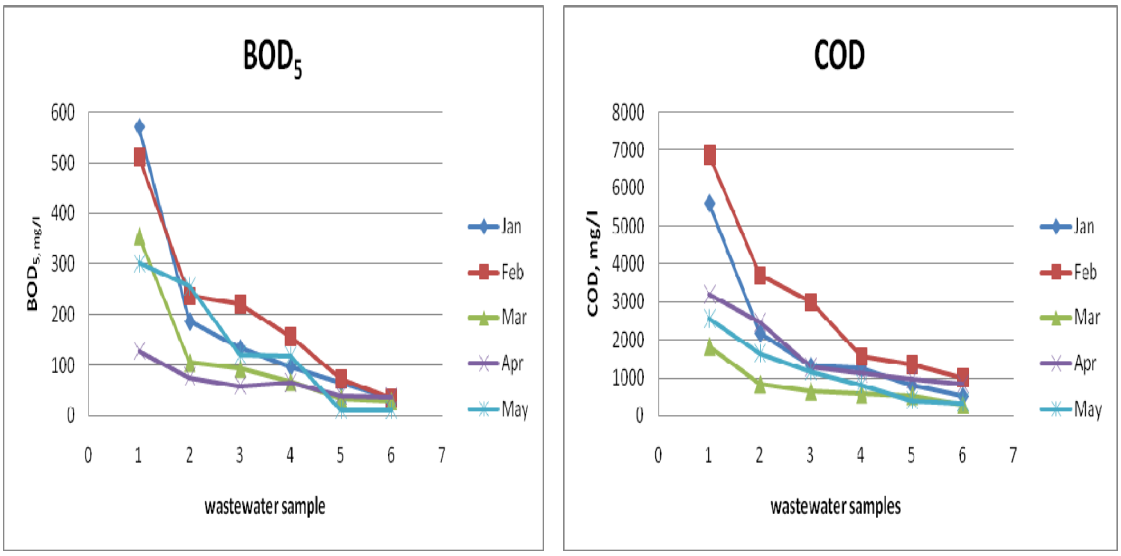

Fig.3. Graphical representation of BOD_5 and COD of waste water samples.

Nitrate and Phosphate

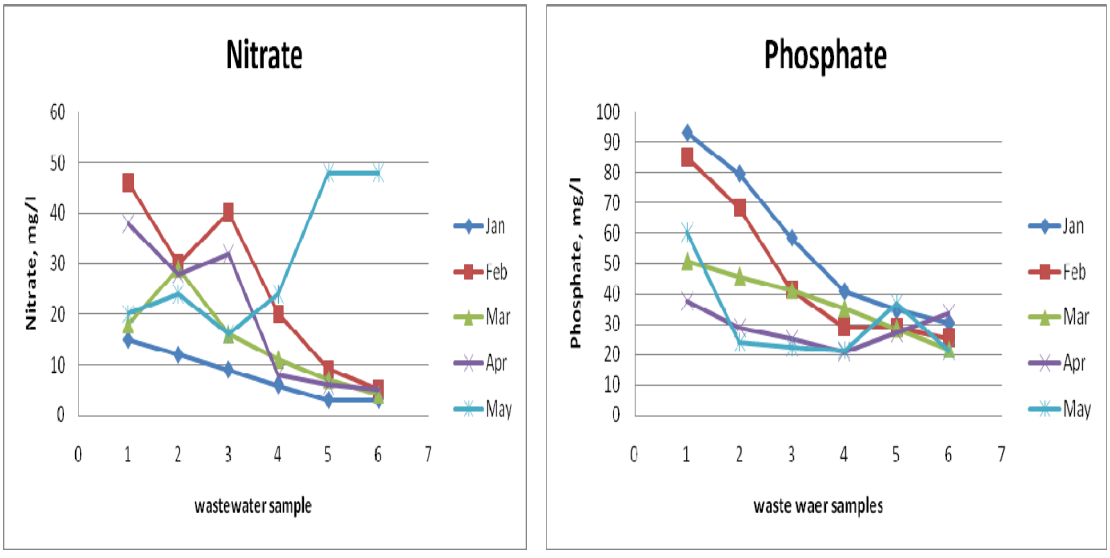

Fig.4. Graphical representation of Nitrate and Phosphate of waste water samples.

The above graph of Figure 4 also provided that Nitrate and Phosphate values were decreasing in Outlet of polishing pond which can be mixed with natural water bodies or used for irrigation purposes.

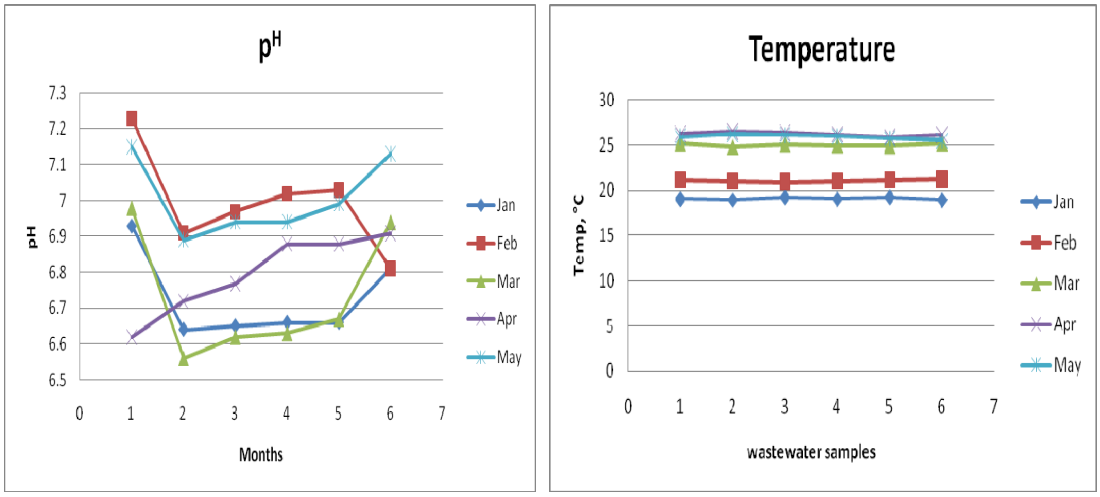

Fig.5. Graphical representation of pH and Temperature of waste water samples.

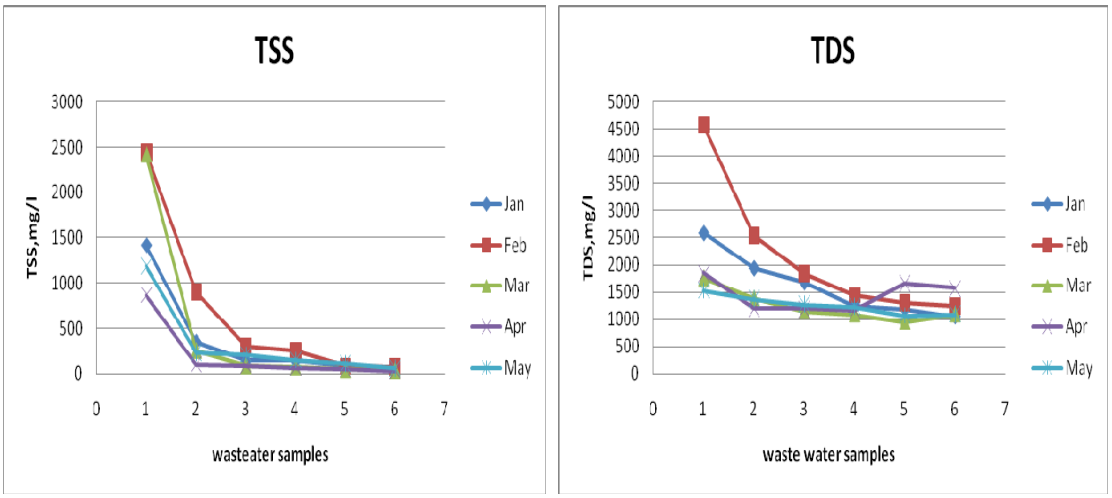

Fig.6. Graphical representation of TSS and TDS of waste water samples.

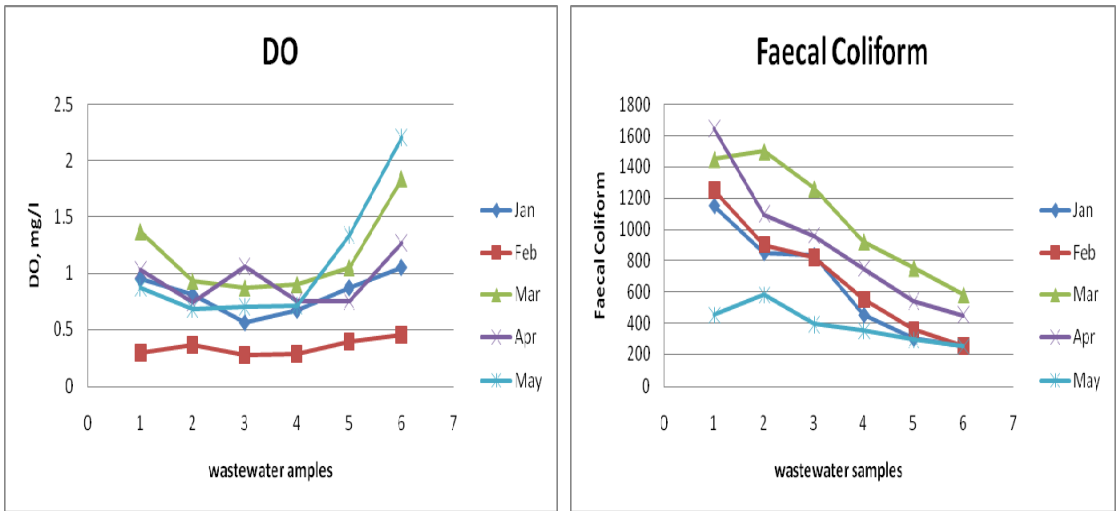

Fig.7. Graphical representation of DO and Faecal Coliform of waste water samples.

The values of Oil and Grease were zero for all collected waste water samples. Some other parameters such as pH, Total Dissolved Solid (TDS),Total Suspended Solid (TSS), Faecal Coliform, Temperature were also decreasing in Outlet of polishing pond. The values of DO were increasing which indicate that oxygen level were increased in treated wastewater sample. So,treated waste water can be mixed with natural water bodies or used for irrigation purposes.

There were some constraints in existing DEWATS system. The main Constraint was related to the operationalizing and functioning of the DEWAT which required regular supervision and community support. The rains in the monsoon affected the quality of treated wastewater which directly hampered the DEWAT operations. The main Constraint in the proper functioning of the DEWAT was to keep the water flowing through the system by screening the garbage or polythene and prevention of silting inside the chambers.

5. After implementation of the Nabolok EEHCO project

DEWAT has created clean and aesthetic environment (Figure 8). The open drain which was a breeding ground for disease germs is now safe space for colony people. For the successful functioning of the system, a community managed operation and maintenance system has been designed. A full time sweeper from the local community has been employed to look after the operation and maintenance of the system.

Fig.8. After implementation of the Nabolok EEHCO project

6. Conclusion

The wastewater quality was found to be gradually improved. The value of wastewater quality parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Oil and Grease, pH, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Faecal Coliform, Temperature Nitrate and Phosphate were also found to be gradually decreased. So, it is a clear indication that the treated wastewater can be mixed with natural water bodies or used for irrigation purposes or reused for the community toilet flushing.

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A Survey of Different Types of Mask Available in Market and Development of a New Mask to Resist Particulate Pollution

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Abstract

This paper presents the comparison of developed mask with conventional mask available in the market. In Bangladesh air pollution is a great problem. Everywhere air is polluted by dust particles, exhausts of automobiles, industries etc. This polluted air is very harmful for human being as they create various respiratory diseases. Masks are capable of providing fresh air by filtration of particulate matter. The masks used in our country are mostly providing poor filtration, uncomfortable and some are costly. These masks are not properly leak proof and cannot filter less than 10µm particles. Our developed mask is better in respect of both economy and service. It can filter up to 0.3µm diameter particles. No leakage point and better air filtration are the characteristics of our improved dust mask. It is less costly, comfortable and comparatively simple and lighter structure.

Keywords: *Air pollution, particulate matter, Human respiration, Dust mask.*

1. Introduction

Air is the life sustaining precious natural resources. Fresh air is one of the most indispensable gifts of nature without which humankind will not survive all human activities can be interfered by the pollution of this vital resource. It is only in recent times that mankind has become aware of the extent to which this interference is sustainable.The atmospheric air mainly consists of nitrogen with trace of carbon dioxide, water vapor, ozone, argon, krypton, carbon monoxide, organic matter, helium, and ammonia. Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere.

2. Particulate Matter and Human Health

Particulate matter (PM) is a complex mixture of solid and liquid particles that are suspended in air. These particles typically consist of a mixture of inorganic and organic chemicals, including carbon, sulfates, nitrates, metals, acids, and semi-volatile compounds. The size of PM in air ranges from approximately 0.005 to 100 micrometers (µm) in diameter.
When human inhale, human breathe in air along with any particles that are in the air. The air and the particles travel into human respiratory system (lungs and airway). Along the way the particles can stick to the sides of the airway or travel deeper into the lungs.

Particulate matter, especially fine particles (alone or in combination with other air pollutants), with a series of significant health problems, including: premature death, respiratory related hospital admissions and emergency room visits, aggravated asthma, acute respiratory symptoms, including aggravated coughing and difficult or painful breathing, chronic bronchitis, decreased lung function that can be experienced as shortness of breath, work and school absences etc [1].

3. Dust Mask

A dust mask is a simple, small mask that fits around the nose and mouth. It is designed to block particles in the air, usually particles like smoke or dust that can cause irritation when inhaled. Typical dust masks come with elastic bands or straps that fit over the user's head and keep the mask fastened on. Dust masks are made out of cotton and similar materials.
There are many filters available for dust masks. The ordinary cotton dust masks do not use filters at all and only block larger particles from nearing the nose and mouth, but more expensive versions can have several different filters. Carbon filters, for instance, neutralize active particles and odors, while HEPA filters block out almost all particles and are used in hospitals and industrial settings.

4. Description of Different Types of Masks

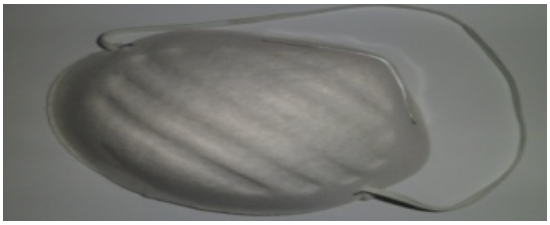

Fig. 1. Mask-1

1. Respirator style cup
2. Operation type facility safety, maintenance, repair & operations, overhaul.
3. It can filter above 5µm particulate matter.

Fig. 2. Mask-2

1. Pore size of filter paper less than 1.0µm.
2. In this mask three filter papers are used.
3. It can filter 0.3µm particulate matter.

Fig. 3. Mask-3

1. Respirator Style Cup
2. Operation Type Facility Safety, Maintenance, Repair & Operations, Overhaul
3. It cannot filter less than 0.5µm particulate matter.

Fig. 4. Mask-4

1. Respirator Style Cup
2. Costly.
3. Manufacture by 3M Company.
4. It cannot filter less than 0.5µm particulate matter.

Fig. 5. Mask-5
(Improved Mask)

Fig. 6. Mask-6

1. Pore size of filter paper 0.45 µm.
2. In this mask three filter papers are used.
3. It can filter 0.3µm particulate matter.

Fig. 7. Mask-7

1. There is used cloth as a filter paper.
2. It cannot filter less than 3µm particulate matter.

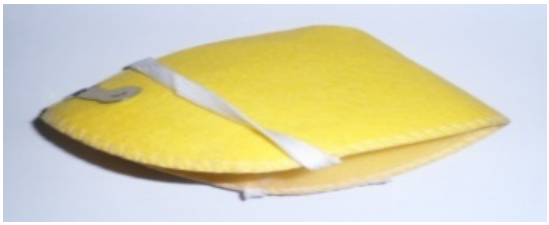

Fig. 8. Mask-8

1. There is used cloth as a filter paper.
2. It cannot filter less than 5µm particulate matter.

Fig. 9. Mask-9

1. There is used cloth and filter paper as a filter.
2. It cannot filter less than 5µm particulate matter.

Fig. 10. Mask-10

1. Respirator Style Cup
2. It cannot filter less than 3µm particulate matter.

1. There is used cloth as a filter paper
2. It cannot filter less than 10µm particulate matter.

5. Draw Backs of the Existing Mask

- The masks are not well fitted around the human face. The masks are not properly leak proof.
- The masks are not comfortable.
- The masks are not filter less than 10µm particulate matter.
- Some are costly.

6. Design and Fabrication of the Improved Mask

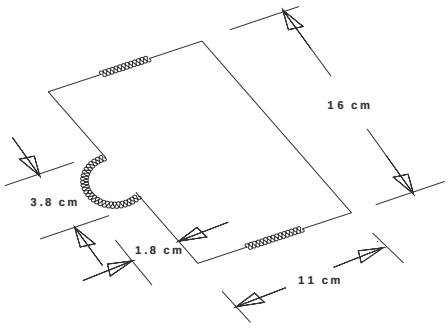

Fig. 11. Designed mask.

Fig. 12. Fabricated mask.

In design this mask our main motive was to design an improved mask of more effective whose production cost would be less and would have a light body with lees complexity and able to resist coarse particulate matter.

Mask consists of two things-

1. Frame
2. Filtering element

We selected cloth as frame materials for our mask. The pore size of the selected filter paper was 0.45µm. the filter paper are Whatman filter paper. The polluted air is allowed to pass through the filter paper. The particles of air whose diameter is above 0.3 µm cannot pass through this mask. Only sucked air can pass through these pores. The filter paper will be inactive a certain period of time. The positioning of filter paper is according to the size of the mask.
Maximum length of the mask: 16 cm
Maximum width of the mask: 11 cm
Maximum height of the mask at nose position: 1.9 cm
Maximum width of the mask at nose position: 3.7 cm

7. COST COMPARISON

Table 1: Comparison of cost of different types of mask.

Mask	Mask-1	Mask-2	Mask-3	Mask-4	Mask-5	Mask-6	Mask-7	Mask-8	Mask-9	Mask-10
Cost per piece (TK)	60	30	60	70	14.7	10	10	20	35	10

From the above table it is seen that, the highest cost is for mask-1. The cost of mask-5 is low with better quality.

8. EXPERIMENTAL SET UP

Fig. 14. Experimental set up.

1. At first the battery is charged. The charging time is approximately 260 minutes.
2. Then the battery is put into the device battery chamber.
3. The probes are connected to the terminal.
4. Then the machine is made ON.
5. Measuring mode, Particle size, Data storage, Warning beep sound, Data printing, sampling time, Frequency, Interval are set up.
6. Then a mask was set around the nose of the face of the doll.
7. Then inlet of the machine was connected to the Tracheal tube.
8. Then we gathered the data at the data book as they shown in the graphic LCD.
9. After one data was taken, then device worked again gave us data again.
10. After getting all the data we made the device set at OFF to save the battery.
11. Repeat steps 6, 7, 8, 9, 10 for different types of mask. Then data were taken for different types of masks [2].

9. Results and discussion

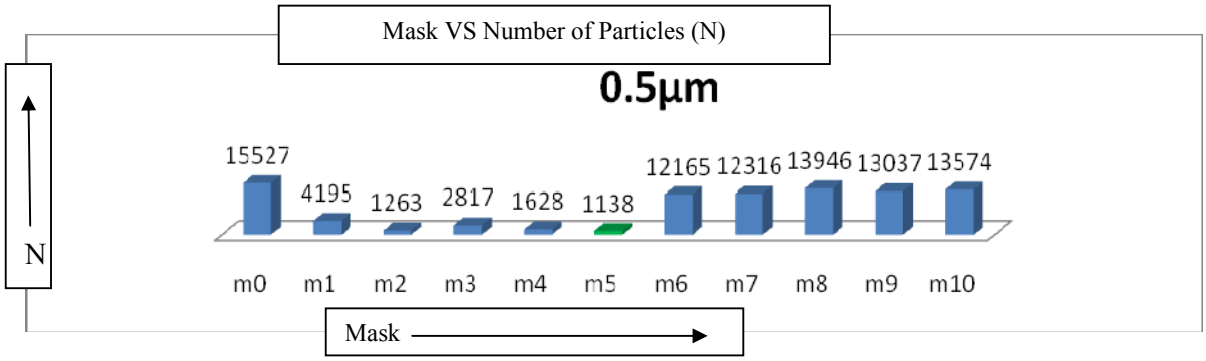

Fig. 15. Histogram of 0.5µm diameter particles passing through different types of mask tested at RUET campus.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (92.67%) than all the masks. Lowest value is 10.18%of mask- m8.

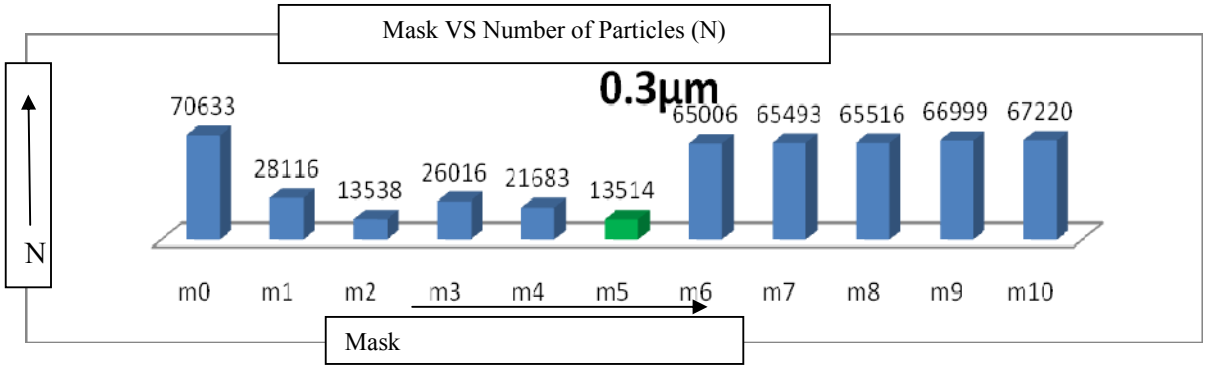

Fig. 16. Histogram of 0.3µm diameter particles passing through different types of mask tested at RUET campus.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (80.87%) than all the masks. Lowest value is 4.83% of mask- m10.

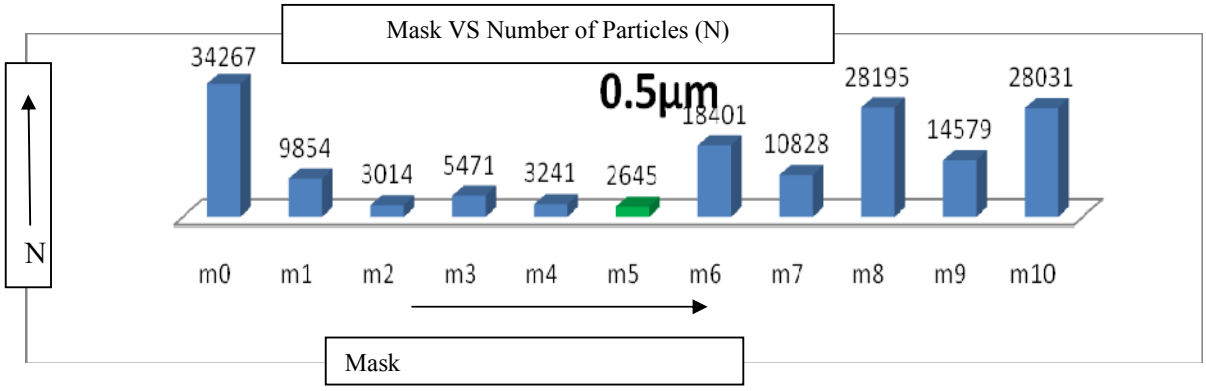

Fig. 17. Histogram of 0.5µm diameter particles passing through different types of mask tested at Rail Gate area.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (92.28%) than all the masks. Lowest value is 17.71% of mask- m8.

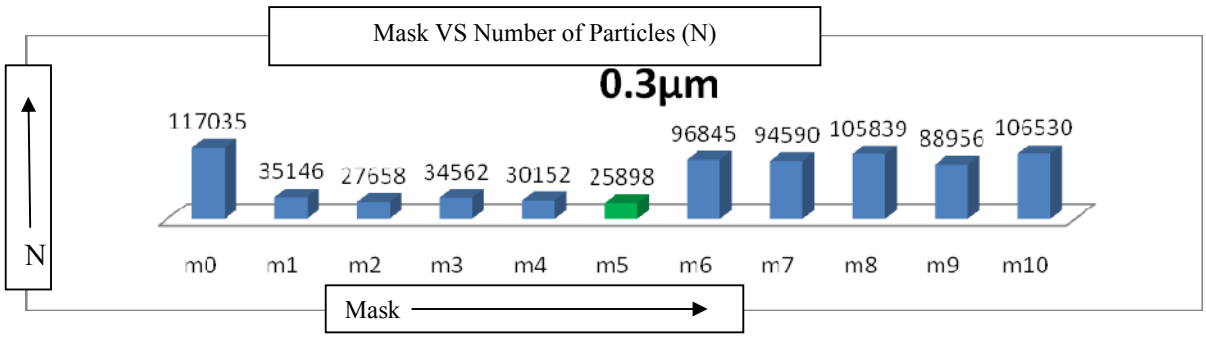

Fig. 18: Histogram of 0.3µm diameter particles passing through different types of mask tested at Rail Gate area.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (77.87%) than all the masks. Lowest value is 8.9% of mask- m10.

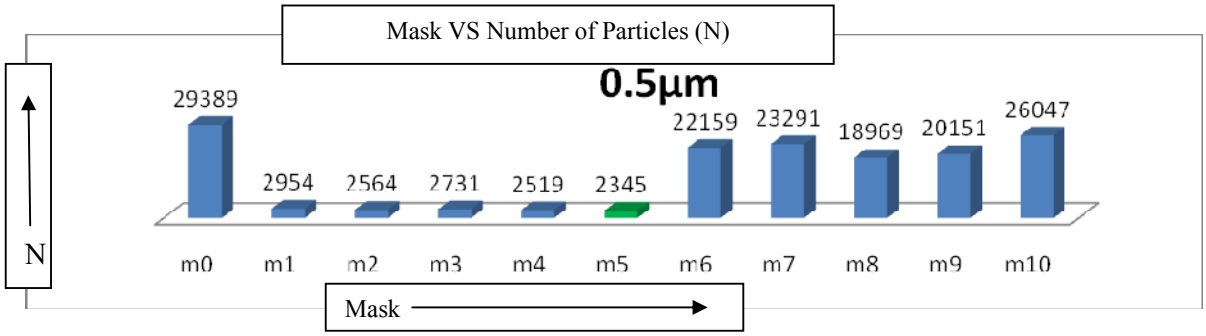

Fig. 19. Histogram of 0.5µm diameter particles passing through different types of mask tested at Saheb Bazar Zero Point.
From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (92.02%) than all the masks. Lowest value is 11.37% of mask- m10.

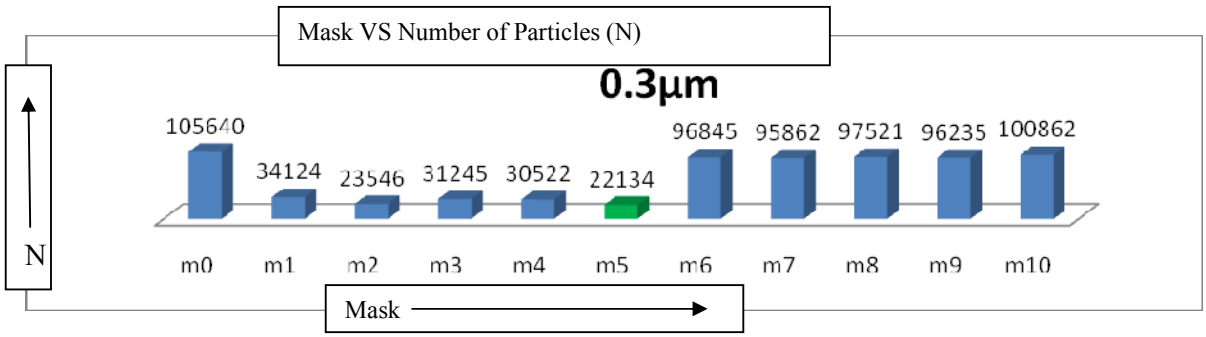

Fig. 20. Histogram of 0.3µm diameter particles passing through different types of mask tested at Saheb Bazar Zero Point.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (79.04%) than all the masks. Lowest value is 4.5% of mask- m10.
The device used for this Experiment is very sensitive. Full charged battery was used for better performance. For better result the data was taken at very dusty area but not at high heat sunlight. Also the device was kept rest after taking a data. From above chart it is said that mask-5 resist maximum amount of particulate matter. Mask-5 is the developed mask where three whatman filter paper is used which pore size is .45µm.

10. Conclusion

From this test the following conclusion can be drawn:

- Mask-1 resists about 64% particulate pollution on the basis of particle number.
- Mask-2 resists about 88% particulate pollution on the basis of particle number.
- Mask-3 resists about 71% particulate pollution on the basis of particle number.
- Mask-4 resists about 84% particulate pollution on the basis of particle number.
- Mask-5 resists about 92% particulate pollution on the basis of particle number
- Mask-6 resists about 34% particulate pollution on the basis of particle number.
- Mask-7 resists about 42% particulate pollution on the basis of particle number.
- Mask-8 resists about 24% particulate pollution on the basis of particle number.
- Mask-9 resists about 40% particulate pollution on the basis of particle number.
- Mask-10 resists about 16% particulate pollution on the basis of particle number.

To protect from particulate pollution people use different types of mask which is found in local market. But these masks cannot resist most amount of particle. From this experiment it can be said that mask-5 resist most amount of particle. Also this mask leak proof, comfortable, low cost, simple in design, easy to manufacture and lighter structure.

11. Recommendation

If High-efficiency particulate air (HEPA) filters are used as a filter paper then it gives better result than our filter paper. Pore size of a High-efficiency particulate air (HEPA) filter is 0.3μm.So it can filter coarse and fine particles. However, HEPA filters greatly restrict air flow and require special blowers and duct design. The cost of HEPA filter is very high.
Electronic air filters and electronic air cleaners are used as filter papers then these may gives better result than our filter paper. The life time of the Electronic air filters and electronic air cleaners are greater than our filter paper. Electronic air cleaners have little air flow restriction.

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Environmental Impact Assessment of Madhyapara Granite Mine, Northwest Bangladesh.

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Abstract

Madhyapara Granite Mine (MGM) is located in Dinajpur district, northwest Bangladesh between latitude 25º23´22´´ N to 25º34´43´´ N and longitude 89º03´34´´ E to 89º05´04´´ E. Estimated reserve of hard rock is about 174 million tons. Production of hard rock (1.65 million tons/year) in MGM is carried out on 5 stopes using room and pillar/sub-level stopping methods. Exploration of hard rock in MGM through full capacity, it has the potentiality to cause serious environmental impacts, mainly probability of subsidence in the mine area, ground water pollution, sound pollution as well as air pollution at the time of drilling and blasting, and lowering of ground water table due to excessive pumping of sub-surface water. Therefore, workers are facing serious health problems like skin diseases, eye diseases, ear complexity etc. The explosion of Ammonium Nitrate Fuel Oil (ANFO) in MGM produces CO_2, NO_2, and CO toxic fumes resulting suffocation, toxicity and dizziness among the workers. Proper use of water spray, water bag, ear blocker and air door during mine operation it can minimize air and sound pollutions. Extraction of hard rock in MGM helps us to save considerable amount of foreign currencies by fulfill the country demand adding to enriched Bangladesh gross national economy.

Keywords: *Environmental impact, Hard rock, Madhyapara Granite Mine, Dinajpur, Bangladesh.*

1. Introduction

Madhyapara Granite Mine (MGM) is the only one underground hard rock mine in Bangladesh under the Petrobangla and the Ministry of Power, Energy and Mineral Resources of Bangladesh. MGM is situated in Madhyapara, Dinajpur district, northwest Bangladesh, with an area of about 1.44 km², between latitude 25º23´22´´ N and 25º34´43´´ N and longitude 89º03´34´´ E and 89º05´04´´ E. In 1974, Geological Survey of Bangladesh (GSB) ran an exploration survey in Madhyapara. In the Madhyapara area, basement rock is encountered at a depth of 130 m [1]. An estimated reserve of 174 million tons of hard rock in MGM consisting of granodiorite, diorite, quartzdiorite and gneiss of the Pre-Cambrian age has been discovered. Mining is a major economic activity in many developing countries [2]. The mining method applied in MGM is room and pillar/ sub-level stoping methods. There are 5 stopes under production of which two are in the south and three are in the north. The length, height and width of each stope are 230 m, 60 m and 20 m, respectively. The long hole drilling is used in MGM and fan pattern is used for blasting operation. Ammonium Nitrate Fuel Oil (ANFO) and power gel are used for blasting purpose. The production of granite is ~1.65 million tons/yr. Mine operations, whether smaller large-scale, are inherently disruptive to the environment [3]. The environmental deterioration caused by mining occurs mainly as a result of inappropriate and wasteful working practices and rehabilitation measures. Mining has a number of common stages or activities, each of which has potentially-adverse impacts on the natural environment, society and cultural heritage, the health and safety of mine workers, and communities based in close proximity to operations [4, 5]. The objective of this study is to find out the environmental impacts caused by the exploitation of hard rock in MGM and its possible remedies and minimization to make MGM a sustainable mine.

2. Tectonic setting

Tectonic evolution of the Bengal basin is related to the orogenic phases of the Himalayas, although the Cenozoic evolutionary history of the eastern Bengal basin is mainly associated to the oblique subduction phases of the Indian plate beneath the Burma plate [6].To the northwest, the basement slopes upward and forms a prominent ridge known as the Rangpur Saddle. The Rangpur saddle and the so called Garo-Rajmahal gap comprise the most uplifted part of the basement in the country, concealed under a thin layer of alluvium. In the Madhyapara area, basement rock is encountered at a depth of 130 m. The Rangpur Saddle represents a block of the Indian shield that connects the Shillong Massif and the Mikir Hills to the Indian Shield in the southwest (Fig. 1). The Shillong Massif is considered a large thrusting block of the Indian shield. Seismic data shows that both northern and southern slopes of Rangpur Saddle are quite gentle. On the southern slope, the basement plunges gently from Madhyapara southeast to the Hinge Zone, an area known as the Bogra Shelf. The stratigraphy of Madhyapara area is listed in Table 1.

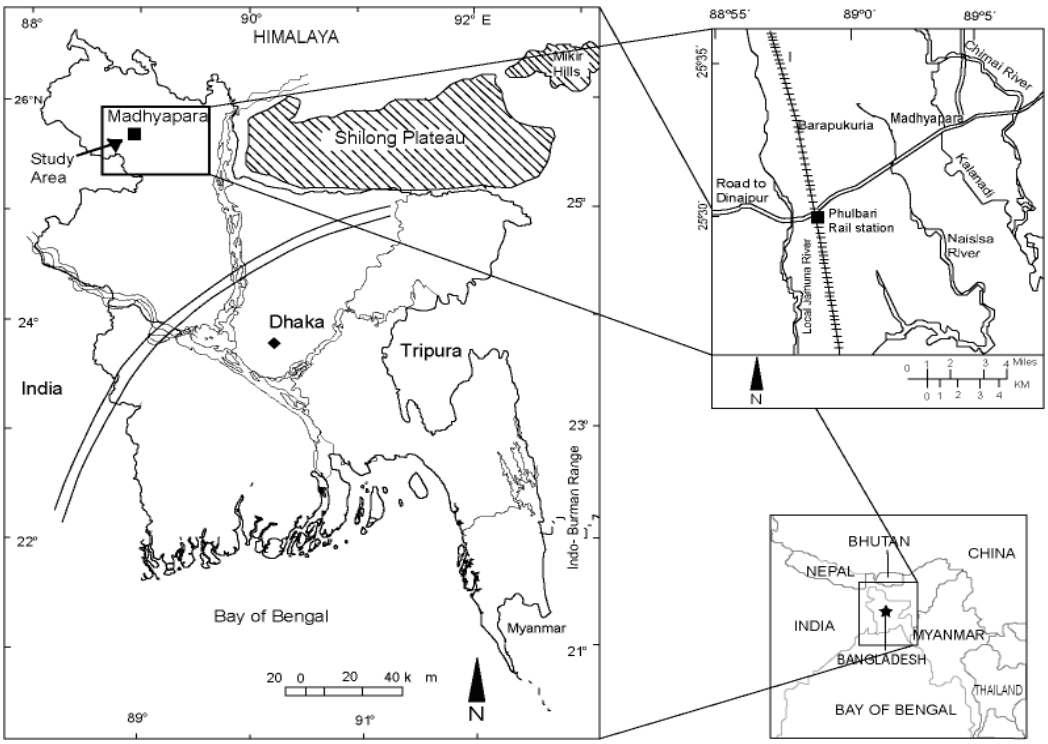

Fig. 1. Generalized map showing location of the study area and major geographic features of the Bengal Basin, Bangladesh [7].

3. Methodology

Fractures and fissures, water inrush and other parameters for the present study were conducted by field observation. Sound vibration was felt upon from the surface, and others relevant data were collected from reports and other literatures.

4. Discussion

4.1. Environmental Impacts

MGM causes several bad impacts on environment. Subsidence in the mine area, pollution of ground water, sound pollution and air pollution at the time of drilling and blasting, lowering of ground water table due to excessive pumping of sub surface water leached inside the mine during production.

4.1.1. Subsidence in the mine area

Subsidence is a natural and man-made phenomena associated with a variety of processes including compaction of natural sediments, ground water dewatering, wetting, melting of permafrost, liquefaction and crustal

deformation, withdrawal of petroleum and geothermal fluids, and mining of coal, limestone, salt, sulfur and metallic ores [9]. Subsidence in MGM is low relative to BCM (Barapukuria Coal Mine). The load bearing capacity of granite rock is very high where as coal is very low. The strength and stiffness of the overlying and surrounding rock strata, and any pillars left in the mining area are significantly reduced by the effects of water [10]. Drainage gradients may be altered by disturbance of the strata around mine area. Rocks may be weakened by saturation and erosion patterns could be changed. Where surface water is present, it may migrate more easily to fractures and fissures in the strata and into the mine area and may induce subsidence [11]. Cavities formed as a result of mining results in subsidence. Another mining-related phenomenon that also creates subsidence is the withdrawal of water to facilitate underground mining. Two common features of surface subsidence induced from room-and-pillar method such as sink-hole collapse and saucer-shaped depression following pillar failure. In the case of room-and-pillar mining, surface subsidence can occur many years after mining is done [12]. The use of room and pillar technique in hard-rock mining on a large scale is a relatively new and untested method, although it has been carried out as a part of some mining areas where larger ore deposits were encountered with varied success. Leaching water around the mine area through fractures and fissures in MGM can reduce the strength of rock. It can accelerate the rate of subsidence of MGM. Rock quality in terms of fractures or fissures is relatively good in stope-1 to stope-3 and deteriorated towards stope-4 and stope-5 in the southern stopes.

Table 1. Stratigrapic succession of the Madhyapara area, northwest Bangladesh [8].

Age	Formation		Lithology	Average thickness (m)
Recent-Pleistocene	Alluvium-Madhupur Clay		Sand, silt and clay	0.52-6.18
Pliocene to Eocene	Dupi Tila		Sandstone and pebbly sandstone, pebble bed and siltstone, fine to coarse grained sandstone and few dark minerals.	113.27
	Tura Sandstone		Medium to coarse grained sandstone with subordinate claystone and shale	20.14
Permian	Gondwana Group		Mostly feldspathic sandstone with conglomerate, fine to medium grained sandstone and minor dark minerals.	
Archean	Basement rock	Completely and highly weathered zone	Kaolinized weathered rock on the top. Fresh rock: granodiorite to quartz diorite and gneiss, pegmatite, quartz veins.	14.05
		Slightly weathered zone		23.74
		Fresh rock		Unknown

4.1.2. Lowering of ground water table and pollution of ground water

Underground mining can change not only ground water table but also ground water flow paths and the geochemical environment. Mining may increase the permeability of rock units, create fresh rock surfaces, and allow water flow between previously disconnected units or between surface and ground water. This may disturb natural geochemical systems causing dissolution/precipitation reactions and result in disturbances to ground water quality [10]. Ground water quality is affected by depletion of the aquifer when dewatering from underground mining acts as a drain and lowers the water table. When underground mines extend into saturated ground, the seeping water creates a hydraulic gradient and induces flow to the mine, which results in depressed water level. In general, water level will decline more as the mine goes deeper. Permeability increases when fractures reach the ground surface, which may lead to increase ground water recharge and surface water depletion, surface subsidence and mine dewatering and cause compaction of an aquifer unit as water is removed from pore spaces and the weight of overlying rocks causes fissures and cracks in the aquifer unit too close [13]. MGM has also caused the problem of lowering of ground water table and disturbing of water flow path and geochemical environment. The water inrush in the mine is 1200 m^3/day. It is estimated that the average water inrush in May, 2010 was 53.51 m^3/hr [14]. This huge inrush of water from surrounding water bearing formation (Dupi Tila) is responsible for lowering of the water table. Water in MGM is being polluted when mixing with different hazardous substances those are very harmful for human health. This water is pumping out from underground to surface and contamination of this water with surrounding surface water sources i.e. pond, lake, etc. can cause serious effect on drinking and irrigation water. This water contains high concentration of aluminium (Al), antimony (Sb), arsenic (As), cadmium (Cd), lead (Pb), molybdenum (Mo), selenium (Se) and

mercury (Hg) relative to WHO's standard. Physical and microbiological parameters like P^H, color, turbidity, total coliform (bacteria) and hydrogen sulphide (H_2S)/odor also have higher value than standard value [14]. Water test result for the sample MGMCL-GHS-W-01 of MGM is listed in Table 2 and the test was conducted by BRTC, BUET [14].

Table 2. Water test result of sample (MGMCL-GHS-W-01) of MGM and test was conducted by BRTC, BUET [14].

SL No.	Water Quality Parameter	Unit	Concentration Present in Sample: MGMCL-GHS-W-01	Bangladesh Standard for Drinking Water (ECR, 97)	WHO Guideline Value, 2004
01	P^H	--	9.54	6.5-8.5	6.5-8.5
02	Color	Pt-Co	242	15	15
03	Turbidity	NTU	115	10	10
04	Total Alkalinity (as $CaCO_3$)	mg/liter	…	…	…
05	Chloride (Cl^-)	mg/liter	46	150-600	250
06	Iron (Fe)	mg/liter	…	0.3-1.0	0.3
07	Nitrate- Nitrogen (NO_3-N)	mg/liter	4.8	10	50
08	Fluoride (F)	mg/liter	…	1	1.5
09	Total Dissolved Solids (TDS)	mg/liter	362	1000	1000
10	Fecal Coliform (FC)	CFU/100 ml	Nil	0	0
11	Total Coliform (TC)	CFU/100 ml	15	0	0
12	Total Hardness (as $CaCO_3$)	mg/liter	18	200-500	500
13	Electrical Conductivity (EC) at 25^0	µS/cm	510	…	…
14	Nitrite- Nitrogen (NO_3-N)	mg/liter	0.013	<1	3
15	Silica (SiO_2), Colloidal silica	mg/liter	59.9	…	…
16	Sulphate (SO_4)	mg/liter	45.4	400	250
17	Total Suspended Solids (TSS)	mg/liter	27	10	…
18	Hydrogen Sulphide (H_2S)/ Odor	mg/liter	0.03	Odorless	…
19	Mercury (Hg)	mg/liter	0.002	0.001	0.001

The chart mentioned above shows that this water contained very high p^H value and also contaminated with H_2S, Hg, suspended solids, Fe, Cl and F, inferring that it is not safe for drinking purpose.

4.1.3. Air pollution

From the environmental point of view, the various gases, which are by-products of blasting operation, are dangers to human health. These noxious gases produced in blasting operation are known as blasting fumes. The production of these noxious gases can be directly related to the type of explosive used. Carbon monoxide (CO) and oxides of nitrogen are the most important toxic products of blasting. Other gases present may be N, CO_2, water vapor, methane, H_2S etc. Oxides of nitrogen are more toxic than CO at a given concentration. Even a simple mixture of ammonium nitrate and fuel oil can produce very bad fume situations. In MGM, ANFO (oxygen balanced) is used for blasting. In ANFO, if part of the oil is lost by evaporation or settles out to accumulate at the bottom of the container, the product remaining in the top of the container will be deficient in fuel and high oxides of nitrogen will be produced. At the same time, the bottom of the container will contain excess fuel and hence will produce high quantities of CO.

$3NH_4NO_3 + CH_2 \rightarrow 3NO_2 + CO_2 + 7H_2O + 930$ KCal/kg [15]

The production of dust during the blast is directly related to the geology of the area and the charge concentration. This dust polluted air of the mine which is more hazardous to human health. The air dust can

cause eye problem, allergy and skin diseases. Besides, the polluted air is released to the atmosphere that pollutes the environment more considerably.

4.1.4. Noise pollution and vibration effect

According to DoE (Department of Environment, Bangladesh) acceptable noise level for industrial areas are 75 dB at day time and 70 dB at night. During blasting and drilling of rock in MGM, a massive noise is generated which exceeds the tolerable level of industrial areas. The pneumatic rock drill is one of the severe noise sources in mining operations. The operation of these drills produces A-weighted noise levels in range of 100 to 120 dB at the operator location [16]. There is bound to be a big sound due to two reasons- firstly, release of gases from the confinement area displacing the massive air pocket and secondly, throw/dump of the huge material on the ground from a great distance. During secondary blasting operation massive amount of noise is produced that causes acoustic pollution. Also the machines and equipment installed at the shafts, inclines, compressor houses, workshops, etc. generate noise, which tends to become ambient noise as it is generated on the surface. Sound pollution in the mine causes reduction of hearing power and ear problems to the mine workers. The ground vibrations induced by blasting are one of the fundamental problems in the mining industry and may cause severe damage to structures and plants nearby [17]. When explosives detonate in rock, energy is generated in the form of various surface and body vibration waves which can damage upper constructions and structures if the vibration wave level is too high.

4.1.5. Ecological disturbance

Mining is often a heavy industrial activity that involves road construction and the use of heavy machinery, wildlife can be dislocated and habitat can be damaged or destroyed. Birds and other wildlife can be poisoned after drinking contaminated water in tailings ponds. In MGM, the topography of the mine has a little vegetation which is not suitable habitat for wildlife and other ecological demands.

4.1.6. Soil pollution

Soil contamination or soil pollution is caused by the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste. There are several different types of waste materials produced during both the hard rock mining operation itself and the subsequent mineral processing activities which aim to concentrate the minerals of value from the surrounding waste rocks or gangue minerals. Close to an old mine site there may be spoil heaps composed of large blocks of rock. These spoil tips are commonly poorly vegetated as lack of soil, and easily drain and also have high levels of metal contamination either locked within mineral grains or through contamination of the water.

4.2. Remedy and recommendation

4.2.1. Remedy

Ore strength can be reduced by the influence of water that will results in pillar failure after mining. In MGM, a large quantity of water is leaching out from the surrounding geological formation. This can cause to collapse pillar to accelerate subsidence. So, it is necessary to investigate and determine the quantity of pillar strength reduction due to water inrush for planning of proper next stope development and counting the number of pillars necessary for the support or any other necessary of extra artificial support like bolting, wire-meshes, etc. As massive water inrushes in MGM, it creates a big problem for the working condition. Hence it is needed to be pumped out of the mine. But to prevent the harmful effect of the contaminated water, a water treatment plant has to be established and the treated water can be used for drinking and irrigation purposes. It can also be used for various underground workings i.e. water spray, water bags etc. during drilling and blasting.

Proper planning and management is essential for waste disposal or dumping yard to protect environment from being polluted by rainwater that washes the dumping yard.

Gaseous pollution that is produced by drilling and blasting can be reduced by proper ventilation system (i.e. proper implementation of air door). Water spray during drilling can reduce dust that can prevent the air pollution. Ear blocker and proper utilization of air door can be used to reduce the sound effect. Water bags can also be used to minimize the vibration (that causes noise) during blasting.

4.2.2. Recommendation

In stope-1 to stope-3, less fractures/fissures are seen. So, more drilling holes and much quantity of explosives can be used. Conversely, in the stope-4 and stope-5, more fractures and fissures are seen. More water inrush

happens in this zone than stope-1 to stope-3. So, less number of drilling holes and fewer explosives should be used. So, further extension of stopes should be towards northern part. Implementation of water treatment plant in MGM can produce vast amount of drinking water for workers and the purified water can be supplied to surrounding areas. As we know about 1200 m^3 (120000 liters) water inrushes per day, these water can be purified in the plant. Recently, there is huge demand of purified water in the country with huge population problems. So purified water can also be marketed and it may be very much profitable. This is an extra income for the company. These water can be exported and earn foreign currencies, and it also saves the environment from being polluted.

5. Conclusions

Mining is one of the major economic activities in many developing countries. MGM serves the country by providing with hard rocks which is used in various purposes. But there are some problems which cause bad impacts to the environment like subsidence in the mine area, ground water pollution and lowering of ground water table due to excessive pumping of sub-surface water, noise pollution, vibration effect and air pollution during drilling and blasting, soil pollution in the mine area, etc. Appropriate environmental policy and management can reduce these impacts. Policies and managements like adopting suitable supporting system throughout the mine, establishment a water treatment plant, proper management of dumping yard, implementation of proper ventilation system and air doors which can be taken as remedy of the impacts. By adopting these remedies this mine can be both sustainable and environment friendly. Extraction of hard rock in MGM helps us to save considerable amount of foreign currencies. So to improve socio-economic infrastructure of our country this mine can play a vital role in improving gross national economy of Bangladesh.

6. Acknowledgement

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Improved underground mine design for reducing subsidence at Barapukuria Coal Mine, NW Bangladesh

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Abstract

Barapukuria Coal Mine (BCM) is located at Dinajpur district, NW Bangladesh. Total area of the BCM is about 5.25 km^2 and coal encountered at a depth range between 118 and 509 m. Six major coal seams (seam-I to seam-VI) were identified at BCM of which greater thickness of seam-VI (~36 m). The estimated coal reserve is about 390 million tons and nearly 64 million tons are extractable. The annual production of coal is about 1 million tons. The coal is high volatile, bituminous nature and low sulphur content with calorific value is 11040 Btu/lb. Based on geological, hydrological and other technical parameters, fully mechanized underground long-wall mining method is applied for extraction of coal in BCM. Long-wall retreating mining method is also applied for extraction of coal from single face with the operational area protected by moveable hydraulic pressure roof support system. These supports are moved forward result the roof behind them collapses to form an extensive abandoned area named goaf. Using volume of the goaf area, amount of caved space is measured and how much filling materials should be required to reduce subsidence is determined. Estimated filling cost of 10 faces is about US$ 3.1 million. Coal in the BCM is extracted from seam-VI, using a multislice long-wall top coal caving mining method. The production of coal from 11 long-wall faces of 1st slice and the first face-1204 of the 2nd slice have already been completed. Recently, coal production is going on from the second face-1203 of 2nd slice. Long-wall top coal caving mining method will be applied for coal production and face-1210 will be developed in BCM. It is estimated that nearly 0.75 m ground subsidence may occur for mining of 1st slice and for 5th slice resulting ground subsidence occurs (~2.25 m). Improving underground mine design at BCM by filling process, subsidence will be reduced and production may be increased significantly.

Keywords: *Barapukuria Coal Mine, Mine development, Mining method, Subsidence, Coal production.*

1. Introduction

The Barapukuria coal deposit was discovered in 1985 by the Geological Survey of Bangladesh (GSB) over an area of 5.25km^2 at a depth ranging from 118 to 509 m under Parbatipur Upazilla in Dinajpur District, Bangladesh. Geographically, Barapukuria coal basin is lies between the longitude 88°57′E to 88°59′E and the latitude 25°31′ N to 25°35′N, respectively [Fig. 1, 1]. GSB further operate more detailed surveys to confirm the presence of approximately 390 million tons and nearly 64 million tons are extractable. The composition of coal is ash 16.2%, volatile matter 27.6%, fixed carbon 46.2% and sulfur 0.57%. The calorfic value is 10450 Btu/lb and rank of coal is high volatile bituminous [1]. There are six major coal seams encountered at BCM, and greater thickness of seam-VI about 36 m. BCM is operated to extract about 1 million tons of coal per year. At present coal is producing from seam-VI applying the fully mechanized underground long-wall mining method and long-wall top coal caving (LTCC) method [2]. The production of coal has completed from 11 long-wall faces of 1st slice and the first face-1204 of the 2nd slice has already completed [2]. The development work of second face 1203 of 2nd slice has already been completed. After completion of 1203 long-wall face coal production, face-1210 will be developed and LTCC mining method will also be applied for coal production [2]. As the mined out area in BCM is caved in, subsidence at the surface level has become a great problem. Mining of 1101 coal face initiates caving from the lowest strata in the immediate roof and propagates upward into the Gondwana Formation and up to the base of lower Dupi Tila and finally reaches up to the surface [6]. BCM subsidence zone is divided into three types: (a) Gondwana Formation zone or fractured zone (b) Lower Dupi Tila Formation or aquiclude zone and (c) Upper Dupi Tila Formation or

surface zone [6]. The present study aims to calculate the rate of subsidence, improve underground mine design for reducing subsidence, and find out the filling materials to fill the goaf area by filling method.

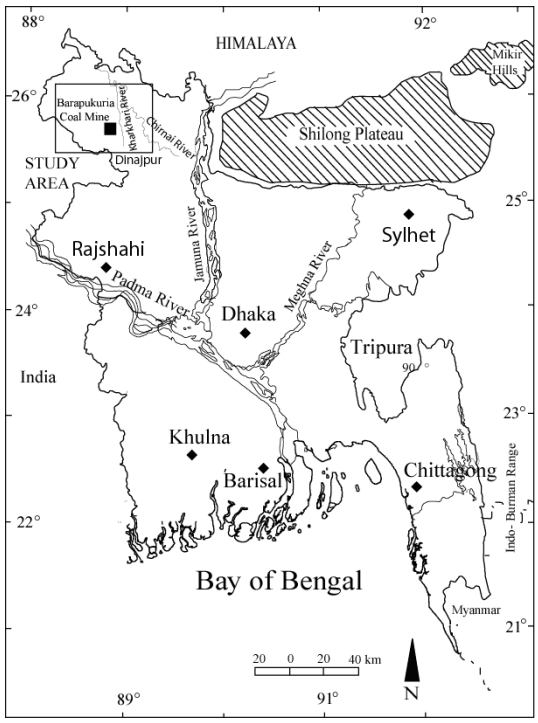

Figure 1: Generalized map showing location of the study area.

2. Stratigraphy of the Barapukuria coal basin

The stratigraphic succession of the Barapukuria coal basin is shown in Table 1. It is subdivided into Basement Complex, Gondwana Group, Dupi Tila Group, Barind Clay Formation and recent alluvium in an ascending order. The Precambrian Basement Complex consists predominantly of diorite, granodiorite, quartzdiorite, granite, schist and gneiss. The Permian Gondwana Group is mainly consists of sandstone with subordinate shale, conglomerate and thick to thin coal seam. The overlying Dupi Tila Group is sub-divided into lower Dupi Tila and upper Dupi Tila formations of Pliocene age. The lower Dupi Tila Formation is consists chiefly of mudstone with subordinate siltstone and sandstone. The upper Dupi Tila Formation consists mainly of sandstone with minor siltstone and mudstone. The Barind Clay Formation is characterized by clay and sandy or silty clay. The top of the succession is recent alluvium, consists of sand, silt and clay.

Table 1. Stratigraphy of the Barapukuria Coal Basin [7].

Age	Group/Formation	Lithology
Holocene	Alluvium	Sand, silt, clay
Pleistocene	Barind Clay Residuum	Clay and sandy clay
Pliocene	Upper Dupi Tila	Sandstone, pebbly sandstone and clay/mudstone.
	Lower Dupi Tila	Sandstone, claystone and mudstone with silica and white clay.
Permian	Gondwana	Feldspathic sandstone, carbonaceous sandstone, shale, coal beds.
Precambrian	Basement complex	Diorite, granodiorite, quartzdiorite, granite and gneiss

3. Mine design

3.1. Long-wall mining method

Long-wall mining method is an exploitation method used in flat line relatively thin tabular deposit in which a long face is established to extract the deposits Movable hydraulic roof support, a shearing machine and an

armored conveyer are used for extracting coal. This method is used when ore strength is weak to moderate, tabular deposit with low dip (<12°), large in areal extend, thin bedded (1 to 5 m) with uniform thickness and moderate ore grade [7]. Considering all these parameters being fulfilled at Barapukuria coal deposit, long-wall mining method is applied at BCM. The mining method involves removal of coal from single face, generally 80 to 200 m long with the working area protected by moveable roof support. As the coal is extracted these supports are moved forward so that the roof behind them collapses to form an extensive abandoned area called "goaf". Since coal seam VI (thickest), the only seam to be extracted at BCM, a multislice long-wall mining would be adopted. The design of long-wall mining method which is used in BCM and surface subsidence occur as result of goaf area collapsed (Fig. 2).

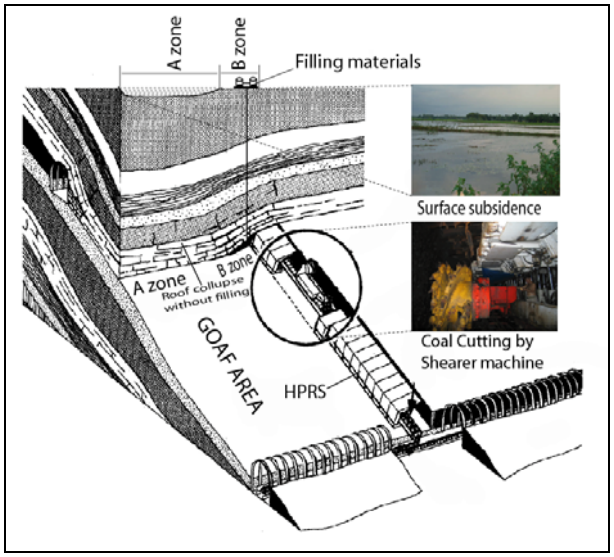

Figure 2. Long-wall mining method with surface subsidence (A zone) at BCM.

3.2. Mine development

During ore production it is needed to develop the mine with proper mine design. To access easily to or near to the coal seam a series of shafts and roadways should be excavated from surface to underground. The arrangement and the excavation engineering of main shafts and roadways, which serve for mining level stated as mine development. The main shafts and roadways excavated for mine development is called development roadways such as shafts, pit bottom, main haulage roadways, main return airway, main cross-cut etc. The arrangement methods of minefield development roadways mainly depends upon certain conditions of minefield geology and accessible mine technique.

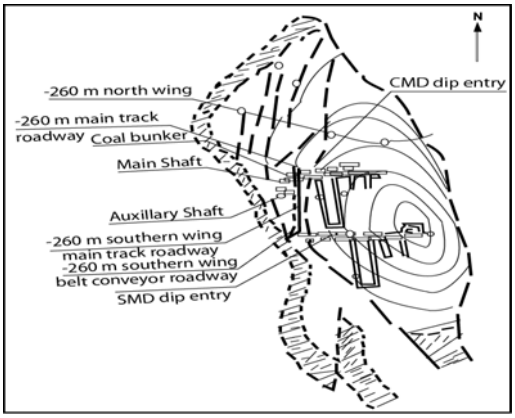

Figure 3. The development plans of Barapukuria coal mine, NW Bangladesh (CMC, 1993).

The Barapukuria coal field is divided into 3 mining areas: a northern mining area, a central mining area and a southern mining area [1]. Coal faces in BCM were primarily designed near to the vertical shafts in the central

area of the coal field. But the mine was redesigned to include southern area of the coal field due to a major water flood accident during the construction underground mining area, the whole minefield is now divided into two mining districts, as southern mining district and northern district. In 1994, a construction contract was sign between the Bangladesh government and China National Machinery Import and Export Corporation (CMC) for the development of BCM [1]. The current development works run through the No. 1 (southern) mining district by long-wall mining method and later the northern area will be mined by adopting room and pillar mining method. The proposed succession and developing plan of the Barapukuria coal mining project at a glance shown in fig. 3.

To extract the coal in BCM, access from the surface is made through two vertical shafts, diameter of each shaft is 6 m. Here one is main shaft, 326 m deep, is used for transport of coal. Another one is auxiliary shaft, 320 m deep, is used for transport of human and machineries [1]. Two shafts are also used for maintaining the proper ventilation system through the underground roadways and tunnels. Including the vertical shafts the mine has total 11 km of underground roadways and tunnels [1]. In the southern mining district, the road way arrangement pattern for the development of the Barapukuria coal mine project is shown in Fig. 4 (a).

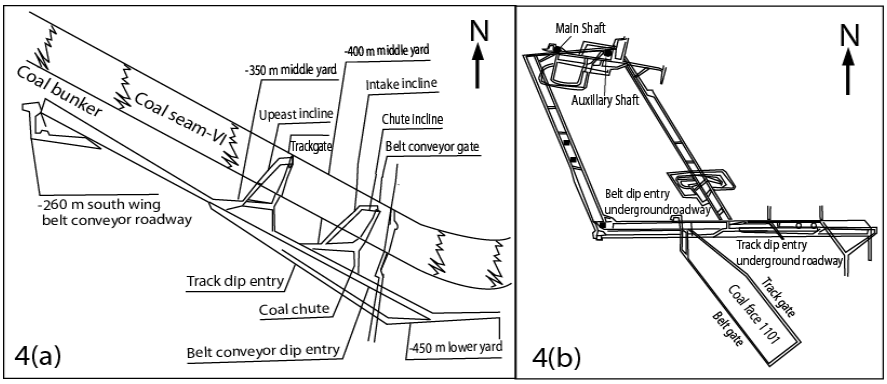

Figure 4. (a) Road way arrangement of the Barapukuria coal mine, NW Bangladesh (CMC, 1999); (b) The development plan of the road way and 1101 coal face tunnel of the BCM (CMC, 2003).

The sub-level haulage entry (belt conveyor gate) and air return entry (track gate) are laid out in parallel to the coal face. The single entry layout is adopted between two sub-levels while the double entry layout and the roadway driving along the goaf are used for the successive sub-level mining. Coal from seam-VI is extracted in multi slice method in descending order at the upper part of the seam. Each slice is separated vertically from the next one by sections of unworked coal of approximately 3 m [1]. The slice geometry and the whole mine plane at a glance is shown in Fig. 4b.

3.3. Mine subsidence

Mine subsidence is the depressions, sags and cracks in the surface above an underground mine. Subsidence happen after the coal is removed and the ceiling or roof of the mine collapses. By using a range of modern engineering techniques to design the layout and dimensions of underground mine workings, surface subsidence can be controlled. To prevent subsidence, efforts have been by drilling deep holes in the soil, rock and filling mine voids with different types of materials i.e. sands, fly ash and mine refuse material to stabilize the surface (Fig. 6). By applying National Coal Board (NBC, England, 1975) method, it is estimated that nearly 0.75 m ground subsidence may occur for mining of 1st slice and for 5th slice resulting ground subsidence occurs (~2.25 m) at BCM [6]. Mining of 1101 coal face causes caving from the lowest strata and moves upward into the Gondwana Formation and up to the Lower Dupi Tila Formation and finally to the surfaces [6]. Filling process can not eliminate subsidence but reduce it and to allow an increase in coal recovery over the caving mining methods. So underground mine design of BCM must be improved or redesigned to get rid of this phenomenon. By improving the design and applying filling process, subsidence can be reduced in minimum level. In the improved mining design there will include some other development work such as surface water reducing plant, pipeline through skip shaft and roadways and finally to the coal face (Fig. 2).

4. Filling processes

4.1. Filling methods

The hydraulic filling method can decrease the effects of subsidence at about 12 times from its total caving in a non-filling condition by hydraulic filling of voids with sand with respect to caving [8]. In the hydraulic filling method, filling materials are used for sand, gravel, concentrator tailings or slag etc. In BCM, sand from Kharkhari river bed (Fig. 1) can use as filling source materials. Pipeline hydraulic transportation is used to borrow the stope. So in improved underground mine design, the whole arrangement of filling process must be included. The advantages of filling method are good adaptability, high ore recovery rate, safe operation of filling, making use of industrial waste and protect the surface from adverse subsidence.
Hydraulic Sand Stowing (HSS) is widely in use for extraction of coal pillars from underground coal seams. For a long time, HSS has been practiced in several coal producing countries for obtaining a large recovery of coal in spite of having adverse mining conditions [5]. HSS is the mode of voids filling in which sand water mixture is prepared at surface and is allowed to gravitate to the underground voids to be filled. So improved underground mine design of BCM includes the constructions of surface plant to prepare sand water mixture and pipeline to gravitate the mixture to the underground. Without causing harmful surface subsidence, almost 100% recovery of coal from an underground mine is obtainable by the application of stowing methods in which the goaf area created by the extraction of coal is solidly filled with mine residues or cheaply obtainable solid [5]. So HSS can be implemented in the BCM, reduce the severe effect of land subsidence and at the same time increase the coal production.

4.2. Filling materials

HSS is yet an effective filling process in coal mine where sand is used as a filling material. In the case of BCM, it is recommended that the filling materials for this operation will be taken from the nearby Kharkhari river, distance of which from the mine area is about 1.8 km and the depth is about 4 to 9 m. During the dredging of the river sand is carried out by pipeline. The necessities of the river dredging are the increasing depth of the river, for sufficient irrigation water, river ecosystem will be accomplished with navigable routes and reducing potential flooding in the region. Before filling process, surface treatments have to be accomplished as the filling materials will come from the river by pipe line with >40% water as a solution form. According to the Bashundhara Dredging Company Limited (BDCL) upto 60% of the water present in sand is reduced before filling works. So a water reducing plant is needed at the surface to reduce the water from sand. Otherwise water expulsion from the wet sand will occur underground flooding. After reducing about 60% of the 40% water come with sand, the water content of sand becomes 16%. By establishing pipe line through the skip shaft, the sand water mixture will be gravitated into the underground. Then it is transported to the golf area for filling.

4.3. Filling cost calculation

Cost is the main fact in any operation associated with mining. If the whole filling process becomes very costly and economic loss happens then the process must be avoided. So it should be kept in mind that the filling process will be implemented when the overall condition, supply of filling materials, dredging and reclaimed cost are favorable. It is not possible to fill 100% voids or goaf area. Approximately 60% of total volume is possible to fill up. From the study, it is estimated that a total cost of the 60% filling of following faces is about US$ 3.082864 million. The calculations are shown in Table 2.

Table 2. Filling cost estimation for 10 coal faces (1st slice) of BCM.

Serial no:	Name of Longwall Coal Face	Coal Face Dimension (L x W x H) m^3	Coal Face Volume - $V_1(m^3)$	Fillable volume- $V_2=V_1\times 60\%$ (m^3)	Estimated cost = ($V_2 \times 2.486$) US$
1.	1101	460 × 105 × 2.7	130410	78246	194519.56
2.	1106	562 × 121 × 2.7	183605.4	110163.24	273865.81
3.	1109	558 × 106 × 2.7	159699.6	95819.76	238207.92
4.	1103	609 × 141 × 2.9	249020.1	149412.06	371438.38
5.	1104	670 × 141 × 2.9	273963	164377.8	408643.21
6.	1114	546 × 126 × 2.9	199508.4	119705.04	297589.72
7.	1105	560 × 164 × 2.9	266336	159801.6	397266.77
8.	1108	560 × 164 × 2.9	266336	159801.6	397266.77
9.	1112	537 × 116 × 2.9	180646.8	108388.08	269452.76
10.	1111	535 × 98 × 3	157290	94374	234613.76
					Total = 3082864.66 (US$ 3.082864 million)

According to the Association of River Dredging Companies Bangladesh (ARDCB) the total cost of every cubic feet is US$ 0.0704 (5.5 TK) at a distance 1.5 km to 2.00 km with filled up by hydraulic sand stowing method.

As $1ft^3 = 0.02832\ m^3$

So, the cost of per cubic meter of filling is = US$ 0.0704 ÷ 0.02832 = US$ 2.486

In the case of coal face-1101, the cost of 60% filling is = US$ (78246 × 2.486) = US$ 194519.56

Thus calculating the cost for each coal face, it is estimated that a total cost of the 60% filling of 10 faces is about US$ 3.082864 million.

In the present mine design, 0.75 m ground subsidence may occur for mining of 1st slice in non-filling condition. With the filling of 60% of each coal face, there remain 40% voids. So,

For 100% voids subsidence occur = 0.75 m

For 40% voids subsidence occur = (0.75 × 40) ÷ 100 = 0.30 m

So the reduced subsidence is about = (0.75-0.30) m = 0.45 m

Thus for improved mine design with 60% fill up of goaf area subsidence may reduce 0.45 m for mining of 1st slice and 1.35 m for 5th slice.

5. Conclusions

Long-wall retreating mining method is applied in BCM for extraction of coal from single face (80 to 200 m long) with the operational area protected by moveable HPRS system. These supports are moved forward result the roof behind them collapses to form an extensive abandoned area named goaf. Using volume of goaf area, the amount of caved space is measured and how much filling materials should be required to reduce subsidence is determined. It is estimated that ground subsidence may occur for mining of 1st slice and 5th slice are ~0.75 m and ~2.25 m, respectively. Recently, underground mine design has been faced risky subsidence. Applying the HSS filling method, the subsidence of BCM can be reduced significantly by improving underground mine design. The filling cost of each face is about US$ 3.1 million. If the HSS method is applied immediately, the subsidence will be reduced and overall surface area will be protected from such disaster. The reduction of subsidence is necessary not only saving the living people of the mine area but also increase of coal production significantly.

6. Acknowledgment

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Peoples' Perception on Environment in Urban Areas: A Case Study on Dhaka City

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Abstract

Dhaka, the capital city in Bangladesh has been going through a hasty process of urbanization and population growth since the last few decades. Some factors like rapid growth of population, unplanned urbanization and unwise industrialization have created a tremendous pressure on the changes in its land using pattern. The aim of this paper is to understand and evaluate the environmental condition from citizens' perception and various factual data. Perceptual data on series of urban environmental issues have been collected through a detail perception study for questionnaire survey, and factual data have been collected from various secondary sources. Environmental facilities in this city are under tremendous pressure due to increasing population, insufficient supply of urban facilities and the reluctance of taking proper development initiatives by the city authorities. However, in all measures to keep the city atmosphere healthy and friendly, it is significantly important to ensure and evaluate peoples' participation.

Key words: *Urban environment, environmental degradation, perception, satisfaction index, Dhaka city.*

1. Introduction

Dhaka, the capital and the most populated city of Bangladesh, is now considered one of the mega cities in the world. It is the center of all political, administrative and economic activities. High growth rate of population is the primary cause of all sorts of environmental fall down. In 2001 the population density in Dhaka has been recorded to be 7918 person per sq. km and the percent increase over preceding year is 56 [1]. The recent picture of development in the study area appears to become an alarming threat for the remaining land use change. It is important to study the loss of agricultural land, vegetation, water bodies and wet/lowlands and to see how and what changes occurred through. Most of the economic development activities are focused in and around Dhaka city. These changes have rapidly transformed Bangladesh from a subsistence agrarian economy into rapidly industrialized country. The growing urbanization in the outer periphery of Dhaka Metropolitan city has created an extra pressure on its land using pattern.

Considering with other developing countries urbanization takes place at an exceptionally rapid rate in Bangladesh. It is mainly due to rural-urban migration, as well as natural increase of native urban population [6], [8]. Increasing the landless people in villages, riverbank erosion, urban pull and socio-economic conditions are the main causes of this migration. For such reasons urban areas are naturally absorbing the poor, which is a severe challenge. The implications of such urbanization are manifested in mass poverty, gross inequality, high unemployment, under employment, over crowed housing and proliferation of slums and squatters, deteriorating environmental condition, highly inadequate supply of clean water, high incidence of diseases, overloaded public transports and increasing frequency of traffic

congestion, accidents, violence, crime and social tensions. These features are the main characteristics of nearly all urban centers in Bangladesh [10]. Serious problems of environmental degradation stemming from urbanization in Bangladesh may be evaluated in terms of land use alteration, inadequate shelter, water and sanitation facilities in slums and other urban areas, and degradation of community ambient environment [5], [7].

The major consequences of changes in land use and land cover are resource depletion, loss of rural land, land degradation, deforestation, desertification, soil loss, loss of wetlands, loss of biodiversity, and loss of cultural diversity. The key issue is the magnitude of the changes induced by the changes in land use over an extensive area. There is much concern today in Bangladesh about environmental stresses leading to environmental degradation, namely the increasing aridity being experienced in the western and northwestern zone, particularly in the districts of Rajshahi, Dinajpur, Bogra, and some areas of Kushtia and Jessore.

In recent time, importance has been given on the study of environmental perception to focus the environmental issues [7]. The study of environmental perception seeks to focus on specific aspects of the environment, which are related to human welfare [4]. In modern urban planning, urban development decisions are made from local level community participation and in that case, citizens' perception in every aspect of urban life is important.

The quality of urban environment depends greatly on the quality of essential infrastructures and their appropriateness of the management. Utility services like sanitation, sewerage, drainage, drinking water supply, garbage disposal system, electricity, and gas and fuel supply for cooking are important physical infrastructures for maintaining healthy urban environmental quality [7],[8]. Environmental fibers are being continually strained due to population explosion. As the population grows, the demand for different types of urban services and facilities also increase. In Dhaka City, various authorities have made some efforts to increase social/urban neighborhood facilities. However, the tremendous population pressure has far exceeded these facilities, which are deteriorating the quality of such services. For this reason, the study of degradation of urban environmental quality is a great concern.

Geographical location of the study area

The study area is a part of Dhaka city and Savar area which is located in the central part of Bangladesh. Geographically, this area is in the southern part of Madhupur region. Based on flood control infrastructures, the study area is divided into two parts: Turag river East and Turag river west (Fig. 1). The major land transformation in the city is mostly pre urban/suburban and low laying flood plain areas, with wide range of land use types. The city land types of activities changes, which have led the city environment more susceptible to increasing population pressure.

2. Objectives of the study

The main objective of this paper is to assess and review the past and present situation of urban environment as perceived by the living in Dhaka City. The specific objectives are as follows:

- To determine the level of satisfaction of citizens' perception on the prevailing urban environment in Dhaka City;
- To investigate the spatial variations of the perceived urban environmental problems in the city.

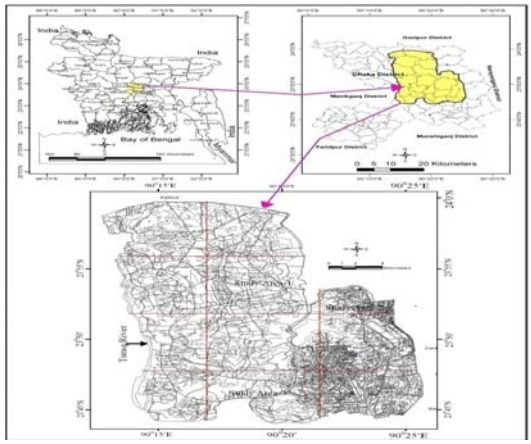

Fig. 1. Geographical Location of Study Area
(Source: Prepared by author based on Banglapedia [3].

3. Methodology

Investigation of spatial distribution of urban environmental problems in Dhaka City is based on the perceptual data as well as factual data. The factual data have been collected from various secondary sources whereas perceptual data were collected through a questionnaire survey. Major environmental problems have been identified from the perception of study population, which have further been assessed for the evaluation of environmental quality.

It is observed from the study area that land use change map were divided into 11th Gradient (for example Grid, A, B, C, D, E, F, G, H, I, J and K) respectively (Fig. 2). For this major land use change areas were selected through Location Quotient (LQ) formula [9] (*The term first used in European Union and later by Mack and Jacobson 1996*).

The formula for computing Location Quotient is: $LQ = \frac{e_i/e}{E_i/E}$

Where, ei = Local area in Grid-A; e =Total local area;
Ei =Reference area of the study area; E =Total reference area of the study area

The location quotient is most frequently used in economic geography and location analysis, but it has much wider applicability. The location quotient (LQ) is an index for comparing an area's share of a particular activity with the area's share of some basic or aggregate phenomenon. Following data were taken from a larger data set, which details the land use categories in the study area were divided into eleven parts (Table 1).

Table 1 Average location quotient value in the study area grid A to K

Grids	Land use categories								Total	Average
	BU	BL	AL	VG	WB	WL	TC	OT		
A	1.08	0.85	0.15	7.28	0.56	0.38	0.60	-	10.90	1.56
B	0.68	-	0.73	4.39	0.53	1.44	0.75	2.63	11.15	1.59
C	0.97	2.06	0.46	4.66	0.29	0.80	0.42	0.74	11.14	1.39
D	0.64	0.75	0.52	6.88	0.75	0.45	0.61	3.13	13.73	**1.71**
E	0.91	1.10	0.96	1.07	0.55	1.17	2.45	1.38	9.59	**1.99**
F	1.16	0.25	0.90	3.29	0.49	0.11	1.50	1.23	8.93	1.12
G	0.16	1.11	1.16	2.16	0.37	3.20	1.35	-	9.50	1.35
H	0.81	1.10	1.12	0.15	0.37	1.25	4.01	-	8.81	1.10
I	0.75	0.92	0.54	3.85	0.62	1.96	1.12	0.77	10.53	1.32
J	0.37	0.93	0.65	0.78	0.93	3.70	1.13	4.65	13.14	**1.64**
K	0.92	1.78	0.62	0.37	1.56	1.21	3.78	-	10.24	1.28

Note: BU = Built up, BL = Bare soil/landfill, AL = Agricultural land, VG = Vegetation, WB = Water bodies, WL = Wet/lowland, TC = Transport & communication, and OT = Others

Finally, Grid D, E and J were selected after analyzing the location quotient formula and observing the rapid change areas. Then the household numbers of these areas were found out with the consultation of BBS Community Series [2]. For this reason the whole study area was divided into eleven parts and selected only three survey area (Table 2).

Table 2 Sampled Study Areas

Names of the area	Ward number/Union Parishad (*Shown in Figure 2*)
Area- 01	Ashulia Union; A part of Yearpur and Birulia Union
Area-02	Uttara (a part of DCC ward-01) and Harirampur Union
Area- 03	Ward- 09, 10; and a part of ward- 08, 11, 12, 43, 46, and Aminbazar Union, and a part of Kaundia, Banagram, Bhakurta, and Tetuljhora Union.

Source: Field Survey, 2010

Determination of the level of satisfaction of population and perception is based on the questionnaire survey. A questionnaire framed with 8 neighborhood environmental variables and statement (Table 3) on 5 points scale (Highly Satisfaction, Satisfied, Acceptable, Dissatisfied, and Highly Dissatisfied).

Table 3 Major urban environmental variables

Major Environmental Variables	
1. Water Supply	5. Drainage Condition
2. Sanitation Facilities	6. Cleaning and Maintenance
3. Garbage disposal	7. Recreation Facilities
4. Sewerage System	8. Traffic Management

Source: Field Survey, 2010

For this study, the primary data has been collected by observation and field survey with questionnaire. For the questionnaire survey of three selected areas were Ashulia (study area-1), Uttara (study area-2) and Amin Bazar (study area-3) from the major land use changed areas (Fig. 2). From the three areas total

397 questionnaires have been administered. A random sampling technique has been adopted in the survey. To determine citizen's level of satisfaction, a Satisfaction Index [11] was selected. In this respect negative index of satisfaction was taken to select a degrading environmental variable.

Satisfaction Index, $Is = f_s - f_d/N$

Here, f_s= Number of Satisfied Respondents; f_d= Number of Dissatisfied Respondents

N = Total Number of Respondents

Table 4 Index for spatial variation of urban environmental degradation in Dhaka city

Index Value (Is)	Meaning
Is = +1	Highly Satisfied
Is = -1	Highly dissatisfied
-1 - -0.50	Highly Degraded Area (HAD)
-0.50 - -0.25	Moderately Degraded Area (MDA)
-0.25 - -0.001	Lower Degraded Area (LDA)
+ Value	Not Degraded Area (NDA)

The assessment of spatial variation of degraded urban environmental perception has done on the basis of satisfaction Index (Table 4). Each degraded variable from negative index of satisfaction was taken to assess the area variation and their grand total was taken for final presentation of area variation of the city.

4. Results and Discussion

Major Problems of Urban Environment

The quality of environment depends to a great deal on the quality of the essential infrastructural and utility services, like sanitation, sewerage system, drainage, supply of safe drinking water, garbage disposal system, electricity and gas or fuel for cooking. Urban environmental problems relate to the deterioration of the ambient environment and the inability of the public infrastructure and services to meet the demands imposed by rapidly growing population. Respondents were asked to identify the problems regarding environmental pollution and degradation. The result from the respondents appear as 67% of them report the problems of flash flood and drainage congestion, 68% water pollution, 79% air pollution, 63% water and sanitation, 73% garbage disposal system, 79% traffic congestion and 36% open space/recreation facilities. Table 5 shows the summarized opinions about the problems generated for land use change and environmental degradation.

Table 5 Identified major environmental problems in Dhaka City

Problems	No. of Respondents	Percentage
Flash flood and drainage congestion	267	67.25
Traffic congestion	312	78.59
Water pollution	268	67.51
Air pollution	314	79.09
Water and sanitation	251	63.21
Garbage disposal system	289	72.80
Open space/ Recreation facilities	142	35.77

Source: Field survey, 2010

Perceptions on Urban Environmental Conditions

In case of the degree of satisfaction, a wide range of variations has been found across the level of perceptions, such as 'highly satisfied'. On the other hand, a little variation has been identified in case of 'satisfied' and 'dissatisfied'. However, about 10% respondents were highly satisfied with the quality of cleaning and maintenance system. On the contrary, about 20% respondents were highly dissatisfied with the quality of sanitation facilities, sewerage system and drainage condition and recreation facilities of the city. More than 47% respondents were dissatisfied with the quality of water supply, sanitation facilities, garbage disposal, and drainage condition and traffic management system in neighborhood environment which is counted as the highest degree of negative satisfaction (Table 6). About 12% respondents were satisfied with the quality of sewerage system, cleaning and maintenance and recreation facilities. High level of dissatisfaction (65-70%) was determined for water supply and traffic management in the study area. Only for 15% respondents have accepted the qualities of water supply, sewerage system, cleaning

and maintenance and recreation facilities. Thus, it is obvious that from the eight urban environmental variables, people of Dhaka city are dissatisfied with half of the total variables.

Table 6 Perceptions (level of satisfaction) on urban environmental conditions

Variables	Highly Satisfied		Satisfied		Acceptable		Dissatisfied		Highly Dissatisfied		Not Respondent	
	F	P	F	P	F	P	F	P	F	P	F	P
Water Supply	9	2.27	44	11.08	61	15.37	266	67.0	10	2.52	7	1.76
Sanitation Facilities	8	2.02	32	8.06	52	13.10	175	44.08	92	23.17	38	9.57
Garbage disposal	2	0.50	34	8.56	45	11.34	189	47.61	64	16.12	63	15.87
Sewerage System	4	1.00	60	15.11	69	17.38	136	34.26	91	22.92	37	9.32
Drainage Condition	5	1.26	41	10.33	49	12.34	203	51.13	81	20.40	18	4.53
Cleaning & Mainten..	37	9.31	62	15.62	65	16.37	137	34.51	77	19.39	19	4.79
Recreation Facilities	11	2.77	72	18.14	92	23.17	125	31.49	84	21.16	13	3.27
Traffic Management	1	0.25	37	9.32	49	12.34	261	65.74	38	9.57	11	2.77

Source: Field Survey, 2010. Note: F= Frequency, P=Percentage (N=397 for the three sampled area)

Ranking urban environmental degradation

The Satisfaction Index has accessed degradation of urban environment. For the Satisfaction Index, eight variables have been considered, which found to be negative responses from the respondents (Table 7). Among these variables of urban environment, traffic management system (-0.564) has shown the highest negative value of satisfaction index. Citizens showed their strong reaction against mismanagement of the urban authority.

Table 7 Ranks of urban environmental degradation

Neighborhood /Social Environmental Variables	Number of Satisfied Respondents (fs)	Number of Dissatisfied Respondents (fd)	Satisfaction Index (Is)	Rank
Traffic management	37	261	-0.564	1
Supply of water	44	266	-0.559	2
Drainage condition	41	203	-0.408	3
Garbage disposal system	34	189	-0.390	4
Sanitation facilites	32	175	-0.360	5
Cleaning& maintenance	58	189	-0.329	6
Sewerage system	60	136	-0.191	7
Recreational facilities	62	137	-0.188	8

Source: Field Survey, 2010. Note: Rank indicates severity of the problem

In addition, in the case of traffic management, low-income residents are inadequately served. Supply of water (-0.559) takes the second position, while drainage condition (-0.408) is placed in the third position according to negative index of satisfaction. The residents feel problems of water supply hardly in the summer than winter season. Besides there is a huge gap between demand and supply of piped-water in the city. Drainage congestion (-0.408) is also one of the most important neighborhood problems. Most of the drainage channels are filled up by waste, used polythene bags and others garbage. For these reasons, water logging and drainage congestion are the common miserable conditions during the rainy season. The other variables, shown in the Table 7, are found to be negatively ranked, for which the residents are suffering a lot.

Spatial variations of urban environmental perception

The environmental variables of the three selected areas in Dhaka city have been shown in Table 8. Most of the citizens are not satisfied with quality of traffic management system in this city. Among the three areas, area-03 has the highest value of negative index and identified as a highly degraded area. Other two areas (area-01 and area-02) have shown moderately degraded environment (Table 8 and Fig. 2). The residential neighborhoods and urban poor areas are worst affected by the mismanagement of traffic management system. In all three areas, facilities of supply water have shown the negative index of satisfaction.

Table 8, shows that area-03 (-0.587) has shown the highest value relating to supply of water, and identified as a highly degraded area. In this respect, area-01 and area-02 have been found as the moderately lower degraded areas in the city.

Table 8 Spatial variations of Urban Environmental Degradation

Variables	Area-01 (Is)	Area-02 (Is)	Area-03 (Is)
Traffic Management	-0.533	-0.488	-0.590
Rank	**2**	**3**	**1**
Supply of Water	-0.511	-0.488	-0.587
Rank	2	3	1
Drainage Condition	-0.311	-0.302	-0.458
Rank	2	3	1
Garbage Disposal System	-0.422	-0.279	-0.397
Rank	1	3	2
Sanitation Facilities	-0.344	-0.348	-0.367
Rank	3	2	1
Cleaning & Maintenance	-0.311	-0.139	-0.367
Rank	2	3	1
Sewerage System	-0.166	-0.139	-0.208
Rank	2	3	1
Recreational Facilities	-0.166	-0.162	-0.200
Rank	2	3	1
Grand Total	-0.35	-0.29	-0.40
Rank	2	3	1

Source: Field Survey, 2010 Note: Rank indicates severity of the problem

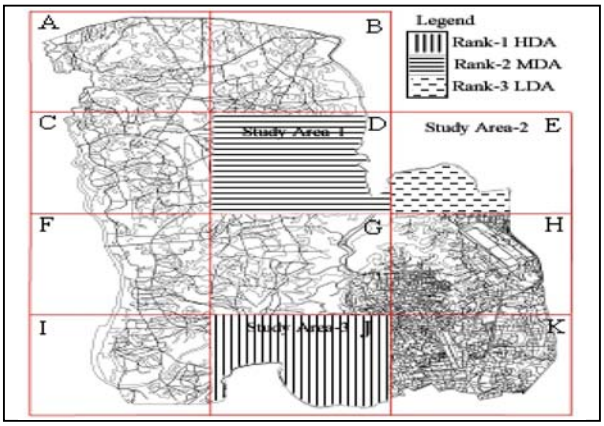

Fig. 2. Spatial variations of environmental perception in three study areas

(Source: Field Survey, 2010 Note: HDA-Highly Degraded Area, MDA-Moderately Degraded Area, LDA- Lower Degraded Area.)

This is found from the areal variations that all three areas have shown the negative index of satisfaction on drainage condition. Degraded drainage conditions are found only one area, area-03. Piedmont, low laying and congested areas is mainly affected by poor drainage congestion. Areal variations are also found in such feature, area-01 is situated on piedmont and low laying landform and area-02 is located on the congested newer part of the city (Table 8 Fig. 2). In case of sanitation facilities, cleaning & maintenance, sewerage system and recreational facilities, all these areas have shown the negative index and among them area-03 has found the highly degraded area. Other two areas (area-01 and area-02) have shown moderately degraded area. Maximum areas in Dhaka city, recreational facilities have not satisfied in the sustainable environment.

Most of the citizens are dissatisfied with quality of traffic management and garbage disposal management system in this city, which is reflected from the areal variation. For garbage disposal system all these areas have shown the negative index of satisfaction. The residential neighborhoods and urban poor areas are worst affected by the mismanagement of garbage disposal system.

In aggregate result, all these areas have shown the negative value of satisfaction index. So it is obvious that in all urban environmental conditions no area stands beyond the degradation boundary. But the magnitude of degradation may differ from one area to another area. Area-03 has shown the highest value (-0.40) and is identified as the highly degraded area. Except area-03 other two areas (area-01 and area-02) have been found as moderately and lower degraded areas (Fig. 2).

5. Conclusion

Within a short period, the survey of this study was conducted and resources were very limited. Income group did not take individual respondents and their duration of living in this city was not considered. Respondents of higher level of education were also very limited for getting accurate environmental perception of residential or neighborhood facilities. About 43 percent citizens mentioned that there is no environmental problem in this city. Among the perceptual environmental problems (from 45 percent citizens), 50 percent problems were neighborhood environmental related and 50 percent problems were physical environment related. Among the total neighborhood environment related problems, traffic jam and mismanagement of garbage disposal system placed the highest rank.

The aggregate result for the level of satisfaction, the satisfied citizens (12.03%) are slightly more than dissatisfied citizens (46.98%). On the other extreme point, the highly dissatisfied citizens (16.91%) are double than highly satisfied citizens (2.42%). In total 15.18 percent citizens have taken the urban environmental quality in Dhaka City at acceptance level.

Eight variables out of seventeen (about 50 percent) have been identified as degraded urban environmental variables. Most vulnerable variables are traffic management, water supply, drainage congestion and garbage disposal system.

In respect of spatial variation, all three areas have shown the degradation of urban neighborhood environment in Dhaka City. Area-3 is identified as the highly degraded area and other two areas (area-01 and area-02) have been found as moderate and lower degraded area respectively.

The effect of large population on the neighborhood environment is quite strong. The degradation of urban environment in this city is obvious from perceptual and factual data. In this case, the city authorities with government and non-government organizations should take proper development initiatives to save the degradation of urban environment. For these reasons, community people should extend their helping hand to such organizations for creating proper community action programs.

Dhaka can yet to be saved from environmental degradation provided suitable planning measures are taken. The physical and social environment of Dhaka city has already crossed well beyond its entrance limits and the city dwellers are susceptible to serious environmental concerns. The present study shows that the process of such degradation has already begun in Dhaka, the capital and the largest metropolitan city in Bangladesh. However, with the view to have a future sustainable city friendly for both environment and ecology there are still a lot of scopes to develop the city in a planned manner. That's why a systematic research is necessary.

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Paper ID: RT-16

Impacts of Climate Change on Water Supply and Sanitation: A Case Study in Char Area

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Abstract

Nowadays climate changes are an important issue in the world. Khulna, the third-largest city in Bangladesh, is located in the southwest of the country, where the consequences of climate changes are expected to be particularly severe because of its geographical location and low elevation (Four meter above the sea level). For 2050, according to IPCC the sea level rise for the low scenario is 20 cm and for the high scenario is 40 cm. For this reason the situation of water supply and sanitation condition would be highly vulnerable in near future due to climate change. The Natun Bazar Char area under Khulna district has been experiencing frequent water logging during rainy season. The sanitation facilities become unusable during floods and rainy season. The objectives of this study is to analyze the impact of climate change on water supply and sanitation (WSS) facilities in Natun Bazar Char areas in Khulna, where the status of health and hygiene is very poor and the awareness level at the dimming condition. This study revealed that 78% tube wells will be inundated and 58% latrines will be water logged and lost their usability by 2050.

Keywords: Climate Change, Water Supply, Sanitation, Sea Level Rise, Health and Hygiene

1. Introduction

Climate includes patterns of temperature precipitation, humidity, wind and seasons. “Climate change” affects more than just a change in the weather; it refers to seasonal changes over a long period of time. The global climate change is one of the most significant environmental issues of the present world [1]. The world has began to witness the consequences of climate change with the increased frequency of Tsunami, cyclones, and devastating floods which are seriously affecting its helpless populace and leaving them in limitless miseries. Rosenberg and Maheswary [2] mentioned that the effects of global climate change are evident now, as we are experiencing through irregular weather conditions, these effects are multidimensional and the effects are not the same across the globe, because of geographic locations and different levels of development. In recent years, climate change related on water supply and sanitation impacts have also taken precedence. According to IPCC [3], global warming would cause pollutes the water source thus increase of vector borne and water borne disease in the tropics [4]. Due to climate change, sea level, humidity, rainfall and temperature is changed. Bangladesh is a low-lying deltaic country in South Asia formed by the Ganges (Padma), the Brahmaputra (Jamuna) and the Meghna rivers and their respective tributaries. The country has been suffering from various types of major natural disasters like floods, cyclone, stormsurge, tidal bore, river bank erosion, salinity intrusion and drought etc. Currently climate change poses a new threat to life and livelihood of the people of Bangladesh. Climate change is recognized as a key sustainable development issue for Bangladesh [7]. These risks will be additional to the challenges the country already faces. Long-term changes in temperature and precipitation may impact on water supply and sanitation. Sea level rise may have severe implications on water supply and sanitation of coastal area through inundation and salinity. It has also various impacts on Bangladesh, a coastal country with a 710 km long coast on the Bay of Bengal. A sea level rise of 1m will inundate 17.5% of the country’s vast coastal area and flood plain zone. The possible increase in precipitation due to climate change coupled with sea level rise will make

the situation even worse to rivers. Temperature rise in the atmosphere causes sea level rise (SRL) and affects low lying coastal areas and deltas of the world. Global mean surface air temperature has increased by between about 0.3 and 0.6°C since the late 19th century. The additional data available since 1990 and subsequent reanalysis have not significantly changed this range of estimated increase. Data show that recent years have been among the warmest since 1860 [6]. This study has been carried out in one zones representing high vulnerability in Khulna district with an aim to explore and find the effect of climate change on water supply and sanitation in the study area. It is based on the available secondary resources such as IPCC reports, books, government policy documents, international reports and scientific journals. Emphasis was placed on assessing the impacts rather than measuring the rate of sea level rise, or the root causes of global warming.

2. The study area

Khulna is the third largest metropolitan city of Bangladesh (46 sq. km.). Once it was known as an industrial city with a large sea port at Mongla. Geographically, Khulna city is located on the natural level as the Rupsha and Bhairab rivers and characterized by Ganges tidal floodplains with low relief, criss-crossed by rivers and water channels, and surrounded by tidal marshes and swamps. Figure1 shows the map of Khulna. The average land surface elevation of Khulna is about 3.32 m from the Mean Sea Level (MSL) (Adhikari et al., 2006). The study area, Natun Bazar Chor, is a part of 22 no ward of Khulna City Corporation (KCC). It is situated on the bank of Rupsha River in the east side of KCC and merging the border line of KCC. It is one of the undeveloped areas under KCC which population is around 17 thousands in 2011 according to KCC report. Water supply and sanitation facilities of these people are very worst in condition.

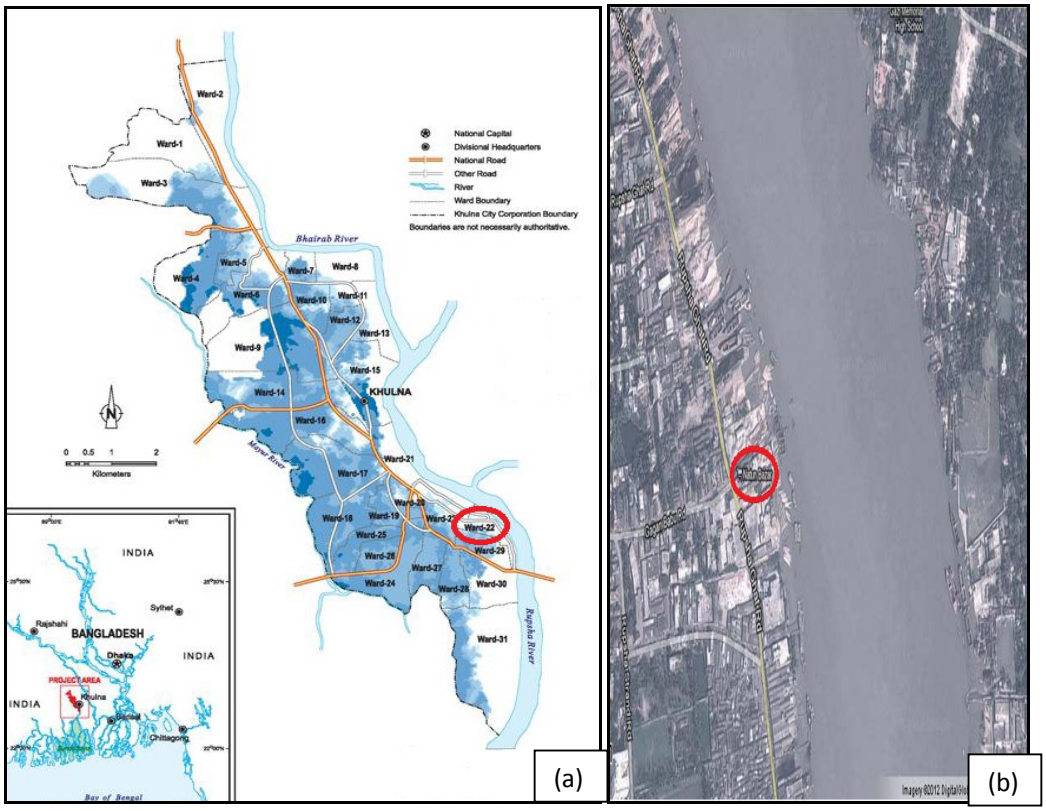

Fig. 1. (a) KCC map showing study area; **(b)** Satellite view of study area

3. Materials and methods

At first, preliminary field survey was conducted and tube wells (50 nos) and latrines (50 nos) are selected in such a way that it represents the entire study area. After finalizing the points final field

survey was done to collect the reduced level of the selected tube wells and latrines. In the mean time a detail questionnaire survey was conducted to investigate the present water supply and sanitation situation. To assess the impact of climate change on water supply and sanitation additional secondary data was also collected from Water Development Board, KCC and various journal and scientific research paper.

4. Result and Discussion

Present situation

It is observed from the questionnaire surveys that water supply situation in the study areas are not satisfactory (Fig.2.a, Fig.2.b). Moreover, the other services like sanitation, drainage and waste disposal are not adequate and needs improvement in most of the low cost areas and slums. However, the main source of drinking water is the tube well supply water. Around 65%, 25% and 10% water are used for drinking and other purposes from tube wells, rain water and river water, respectively (Fig.2.c). Most of the people use pit latrine (75%), but these latrines are not hygienic (Fig.2.d).

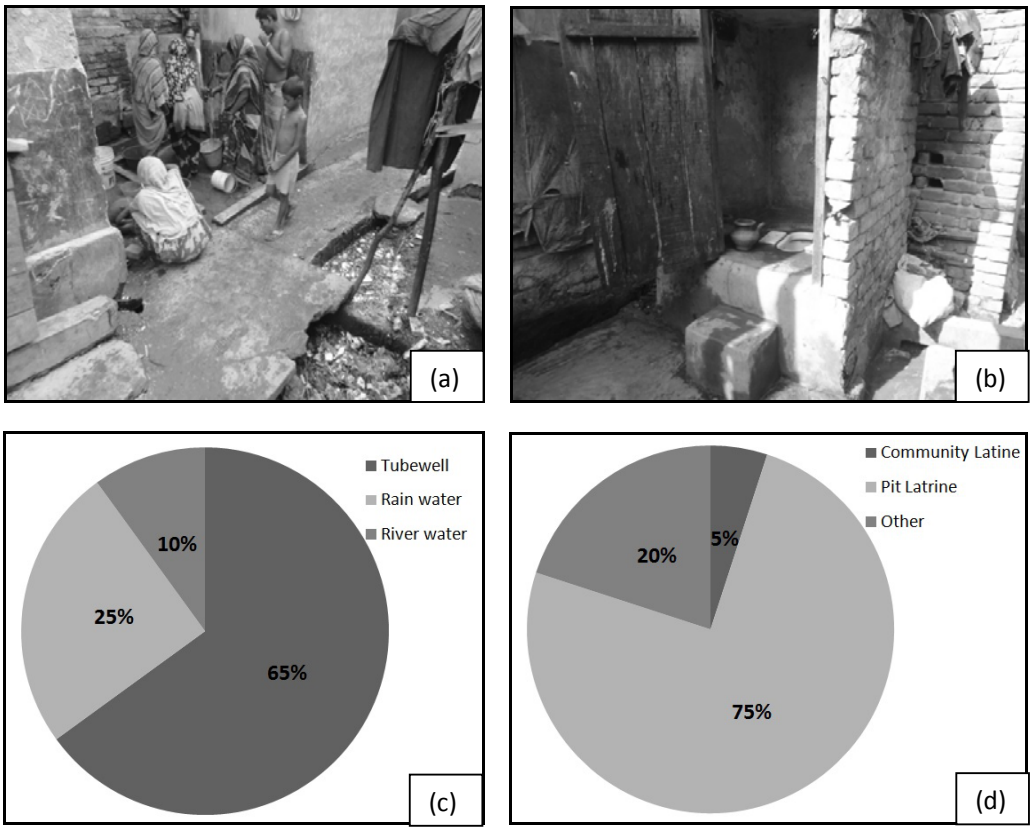

Fig. 2. (a). (b). Pictorial view of water supply and sanitation, **(c).** Source of water for drinking and other purposes, **(d).** Practice of sanitation.

Precipitation and temperature

The major climate change impacts which will affect the study area will be (i) increased salinity intrusion in surface and ground water due to sea level rise, which will make it difficult to secure sufficient fresh water, and (ii) more frequent and intense rainfall, which will aggravate water logging and flooding. Previous data for last 60 years (1948-2008) shows that maximum precipitation 233.25mm and minimum precipitation 71.83 mm occurred in year 1974 and 1971, respectively (Fig.3). Over the last 60 years the year 1969 was the hottest, when the average annual air temperature was recorded at 32.02 ºC. The coldest year was 1981, when the average annual air temperature was 28.89

ºC (Fig.4). The observation records of the past 60 years show the average annual air temperatures varying between 29.89°C to 32.02°C. However, this data shows that precipitation and temperature of this region is varying frequently, but due to green house effect temperature of the world increasing rapidly. Temperature effects the consumption of water. Hot season express higher water consumption than cold season. With the high increase rate of global temperature, sea level will rise at a faster rate of 2-6 times than the present rate. Hence, the sea level is rising; it affects the water supply and sanitation facilities of the study area as it is situated in coastal region. Considering predicted sea level, according to IPCC, reduced level (RL) of highest water level (HWL) of Rupsha River will be 3.6 m and 4.45 m in year 2020 and 2050, respectively. Tube wells and latrines, which base RL are below HWL will be flooded. Fig 5 and 6 show the RL of tube wells and latrines. Straight lines of the Fig 5 and 6 represent the HWL of Rupsha River. Fig 5 represents that 7 nos and 39 nos of tube wells will be inundated in year 2020 and 2050, respectively which is 14% and 78% of total tube well examined. Fig 6 represents that 5 nos and 29 nos of latrines will be water logged and lost their usability by 2020 and 2050, respectively which implies 10% and 58% of total latrine.

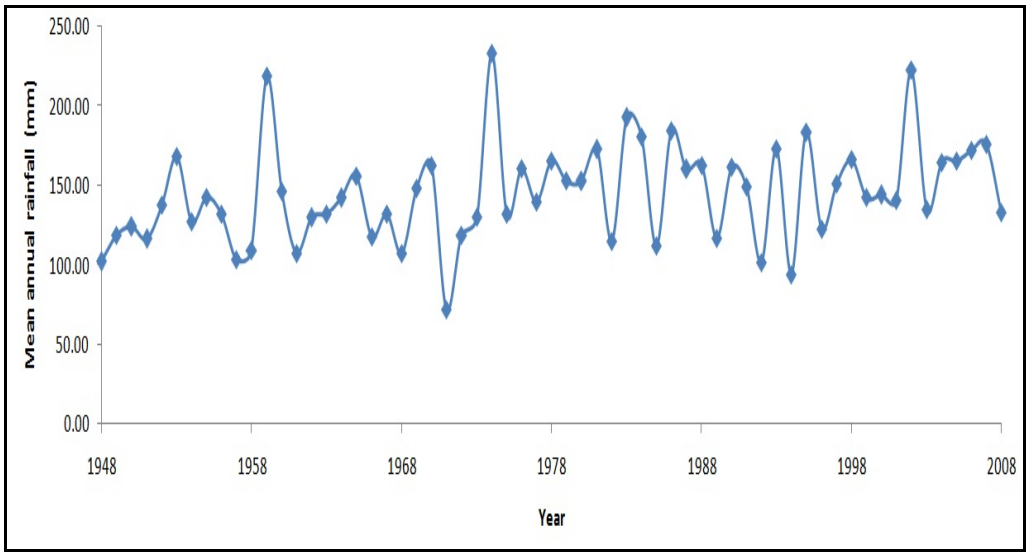

Fig. 3. Variation mean annual rainfall of previous year

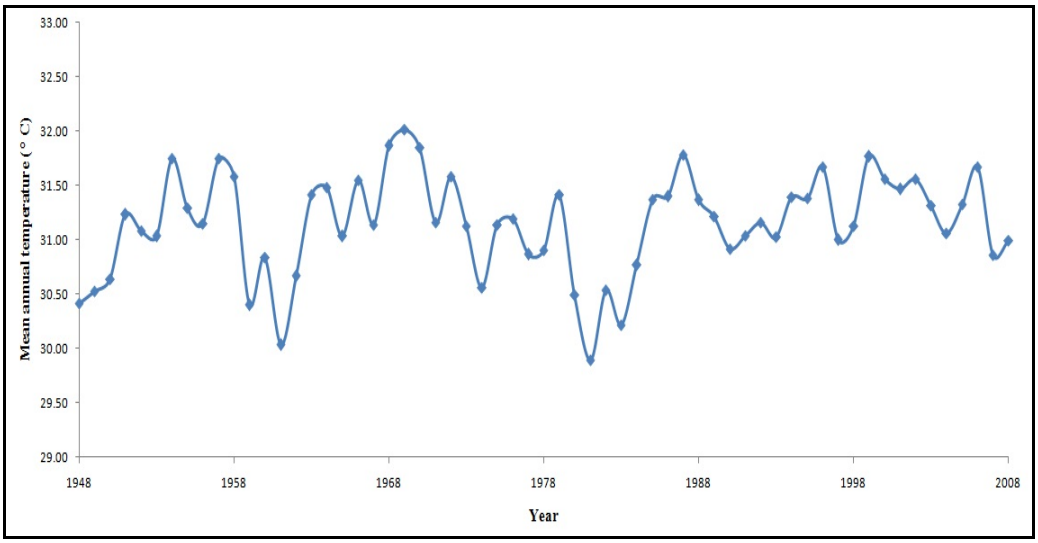

Fig. 4. Variation mean annual temperature of previous year

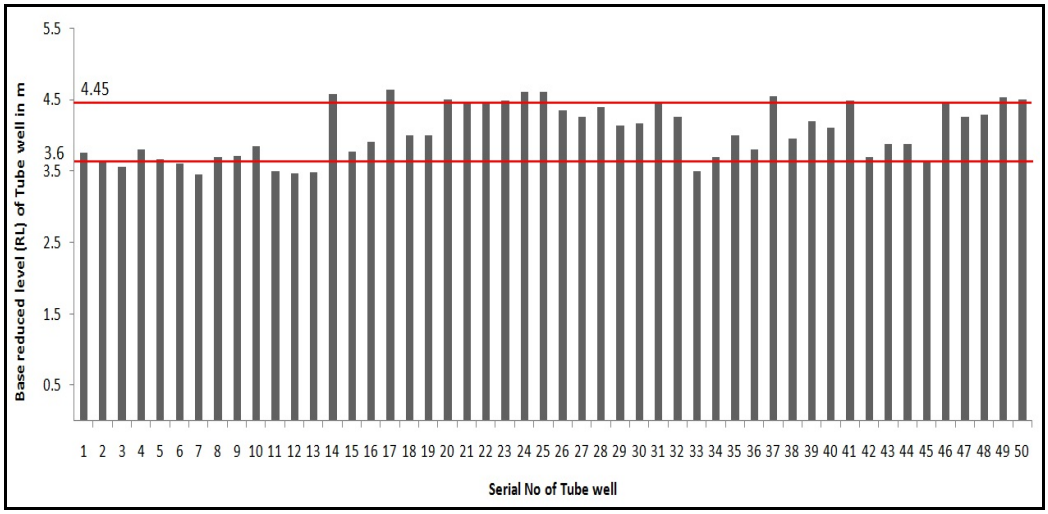

Fig. 5. Base reduced level (RL) of selected tube wells.

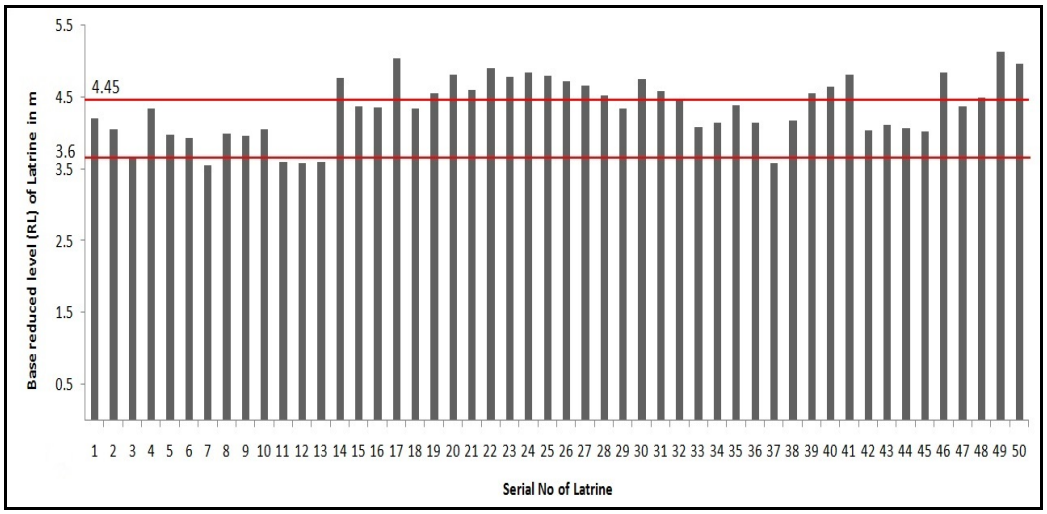

Fig. 6.: Base reduced level (RL) of selected latrines.

5. Conclusions

Water supply and sanitation facility in Natun Bazar Chor area is poor and it's become worsen day by day due to climate change. Due to sea water level rise, these facilities become flooded and spread water borne disease as well as health risk of peoples. It is not wise to think that the sea level will not rise, or to wait and see what will happen in the future. Instead, development and implementation of adaptation policies and appropriate mitigation strategies must be identified to respond to the issue of sea level rise. Base of the tube wells and latrines should make sufficient high. Research is needed to find practical solutions to the potential problems and to develop knowledge and capability in order to facilitate improved future water resources management plans. Adequate coastal protection must be developed including drainage facilities. Research is also required to ascertain how to save the country's coastal people threatened by the sea level rise. Technical and financial support from the international community is necessary to combat the impact of sea level rise in Bangladesh. Bangladesh alone is not able to face such a large scale problem.

Acknowledgement

The authors wish to express their acknowledgement to the Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Bangladesh and Water Development Board, Khulna, Bangladesh for extending all sorts of supports to use the laboratory facilities for this study and collecting secondary data respectively.

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Assessment of Supplied Water Quality of Khulna WASA of Bangladesh

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Abstract

In Khulna region of Bangladesh, scarcity of drinking water is remarkable. To fulfill the crisis of potable water, Khulna Water Supply and Sewerage Authority (KWASA) is supplying water to the Khulna city dwellers through its distribution network from the groundwater source (GW). However, the quality of supplied water is not satisfactory. In order to identify such water contamination problems, water samples from different locations of the distribution network were analyzed in this study. Important water quality parameters include pH, color, turbidity, iron, chloride, arsenic, hardness, BOD_5, total solid (TS), total suspended solid (TSS), total dissolved solid (TDS), total coli form (TC) and Escherichia coli (EC) were tested. Microbial water quality parameters, TC and EC were found that about 66.67% and 100% of total sample exceeds permissible limit, respectively. Except very few cases, other water quality parameters of almost all samples satisfy the allowable limits recommended by WHO and BDS guidelines.

Keywords: *KWASA, Water Quality, Distribution Network, WHO, BDS*

1. Introduction

Water is one of the fundamental components of the physical environment. The quality of drinking water is closely associated with human health, and providing safe drinking water is one of important public health priorities. A wide range of water problems faces nations and individuals around the world. The assessment published in 2000 by the World Health Organization (WHO), 1.1 billion people around the world lacked access to improved water supply. About 80% 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 [11]. The quality of drinking water in Khulna is also at high risk as well as Bangladesh. Bangladesh is largely dependent on GW source for drinking and other uses. Numerous water quality problems exist in GW systems in Bangladesh, especially in its southwestern coastal belt [5]. However, the southwest coastal belt of the country is facing enormous challenges in meeting the rising fresh water demand due to limited water supply from the available GW and SW sources as they are affected by the salinity and other water quality problems [8, 10]. Khulna is one of the densely populated urban areas with a population of about 1.5 million in Khulna City Corporation (KCC) area which has been suffering from inadequate supply of drinking water often associated with water quality problems too. KWASA, established in March, 2008, is the responsible body to supply water to this huge population. Water supply by Khulna WASA comes from deep tube wells without water treatment through its limited distribution network system of 268 km length to the city dwellers and is able to meet 47.5% of the total demand for water of the city. A variety of physical, chemical and biological transformations can happen once the water travels through a distribution system [13]. Water-borne diseases are caused by ingestion of contaminated water from pathogens contained in human or animal excreta. The available water treatment technologies for GW are costly. So, Khulna WASA is likely to not using this option. Since contaminated water can pose a potential source of health risk to Khulna city dwellers, the present investigation was undertaken with an objective to assess important water quality parameters of the KWASA's supply water. The study was undertaken as part of the under-graduate program of the Department of Civil Engineering of Khulna University of Engineering and Technology (KUET). Therefore, this study is an attempt to investigate some physical, chemical and bacteriological parameters of GW such as pH, Color, Turbidity, Iron, Chloride, Arsenic, Hardness, BOD_5, TS, TSS, TDS, TC and EC were tested in the central part of KCC area of Bangladesh.

2. The study area and Sample Collection

KCC, the study area, is an expanding center of southwestern Bangladesh, which is being directly influenced by tides. It currently covers an area of 46 sq. km and 1.5 million populations under the jurisdiction of KCC in 2012. The city along with its surrounding is bounded by the longitude 89°28'– 89°37' east and latitude 22°46'–22°58' north and its elevation is 1 to 2 m above mean sea level. The mean annual temperature from 2001 to 2007 was 26.7°C. Khulna receives a mean annual rainfall about 1620 mm. Out of 31 wards of KCC, 15 points were selected for the present study, which mainly covers the center part of the city. All sampling points are summarized in Table 1 and presented in Fig. 1. Meaningful and reliable sampling assures the validity of analytical findings. Therefore, utmost care was exercised to ensure that the analyses were representative of the actual composition of the water samples. The samples from different locations were collected in sterilized bottles and prior to filling the sample bottles were rinsed two to three times with the water to be collected. Collected samples were promptly carried to the Environmental Engineering laboratory of the Department of Civil Engineering of KUET and almost all the important water quality parameters were measured within four hours of collection. KWASA have interconnected water supply network. So, collection of water in several production tube wells and households were done.

Table 1. Sample no. and sampling location

Production Tube wells		Households	
Sample No.	Location	Sample No.	Location
1	Shekhpara Jame Mosque Pump	9	150 Baghmara Main Road
2	Bosupara Koboresthan Pump	10	10/1 Gagan Babu Road
3	Nirala Park Pump	11	Staff Quarter, Sadar Hospital
4	Mistripara Bazar Pump	12	Rokeya Villa, Banargati Bazar
5	Shipyard Pakarmatha Pump	13	29, Baro Boira Central Road.
6	Court Pump	14	180, Baghmara Main Road
7	Nur Nagar Fire Service Pump	15	North Khal Bank Road
8	Sher-e- Bangla Road Park Pump	-	-

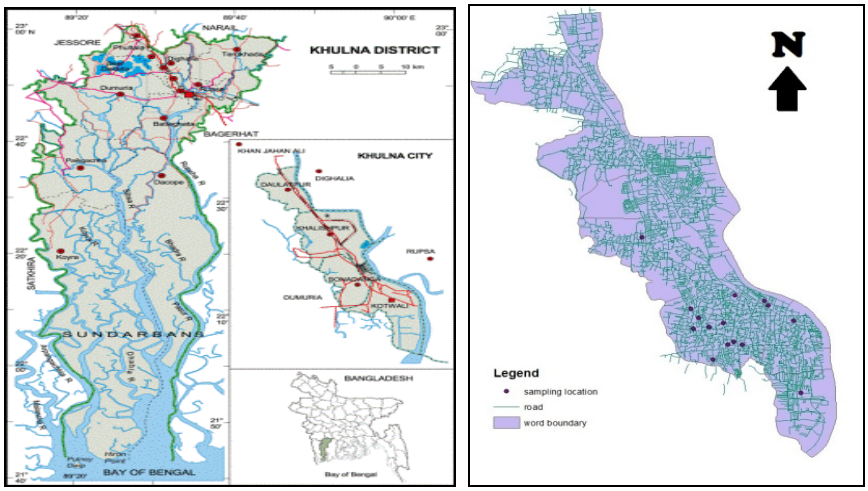

Fig. 1. Study area and Sampling point in KCC

3. Materials and methods

At first, field reconnaissance survey was conducted and the sampling locations are selected in such a way that it represents the entire area of distribution network of KWASA. It is performed by taking the water supply network map of KWASA. After finalizing the sampling points, samples were collected. Plastic bottles of one-liter capacity are used for this purpose. They are thoroughly cleaned by rinsing three to four times with sampling water. Before sampling from production tube well, sufficient amount of water is pumped out so that the sample represents the GW from which the well is fed [5]. Then the sampling bottles are filled up to the brim and are immediately sealed to avoid exposure to air [7]. The sampling containers are labeled including its station

name, source, coordinate, identification number, date and time for identification. Collection and preservation of the samples are carried out according to standard methods [1]. The samples are immediately transferred to the Laboratory for subsequent laboratory testing and analysis. The collected GW samples are analyzed for pH, Color, Turbidity, Iron, Chloride, Arsenic, Hardness, BOD_5, TS, TSS, TDS, TC and EC. All physical, chemical and bacteriological analyses are performed according to the standard methods for the examination of water and wastewater [1]. TDS and pH were determined by TDS meter and pH meter respectively. Iron and color were determined by Spectrophotometer and turbidity is measured by Hellige turbid meter. Chloride and hardness are determined by titration method. For chloride test, 0.0141N $AgNO_3$ with $K_2Cr_2O_7$ indicator is used and standard soap solution is used for hardness test. The water quality parameters are assessed by comparing the test results with both Bangladesh Drinking Water Standard (BDS) [3] and WHO guidelines for drinking water quality [12].

4. Result and Discussion

pH

The pH value is an important index of and controlled value of pH is desired in water supplies, sewage treatment and chemical process plants. The pH values of all samples of different sampling location were found in permissible range of 6.5-8.5 according to WHO (2006) and ECR (1997) recommended values with a varying range 6.76 to 7.78. The variations of pH in collected samples are presented in Fig. 2. (a).

Turbidity and color

Turbid water is not suitable as it causes quick clogging of filtered. The maximum turbidity 9.09 NTU was found in Staff Quarter, Sadar Hospital and minimum 0.46 NTU value was found in Sher-e-Bangla Road Park Pump. Among the production tube wells, 100% samples did not exceed the permissible value of 5 NTU. In case of house hold samples, 71.43% samples were below 5 NTU and the remaining 28.57% exceeded 5 NTU but remained within the range of 10NTU WHO standard (Fig. 2. b). One the other hand, colored water does not cause so many health problems but it is aesthetically unacceptable. Color in water is primarily due to the presence of colored organic substances, metals such as Fe, Mn or highly industrial wastes. Color values vary within the range of 25 Pt.Co to 166 Pt.Co exceeding the limit of WHO and ECR. (Table 4).

Chloride

High chloride content in inland water distribution system usually indicates sewage pollution. At concentrations above 250 mg/L, chloride rich water gives a salty test causes various diseases such as high blood pressure, although it depends on individual adaptability. The maximum and minimum chloride concentrations were found about 550 mg/L at Staff Quarter Sadar Hospital and 72 mg/L 180, Baghmara Main Road (Table 1,2). High chloride concentration are quite may be due to the saline water intrusion problem, which is quite frequent in KCC area. Although, among household and production tube wells, no sample exceeds 600 mg/L (Fig. 3. a).

Iron and arsenic

Iron defects lead to anemia, causing tiredness, headaches and loss of concentration. Minimum value of iron (0.01 mg/L) is found in house hold sample of Banargati Bazar and maximum value (0.31 mg/L) found in production tube well of Nirala Park. Among all samples, no samples exceeds ECR (1997) recommended value and 6.67% samples exceeds WHO (2006) permissible value (0.3 mg/L) for drinking water. Arsenic enters drinking water supplies from natural deposits in the earth or from agricultural and industrial practices. To protect consumers served by public water systems from the effects of long-term, it is limited to 0.05 mg/L. All the collected samples are totally free from arsenic.

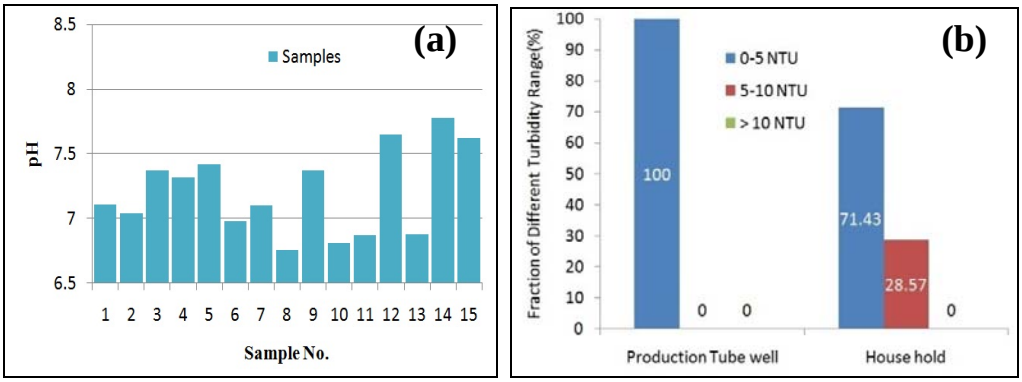

Fig. 2.a. Variation of pH of different samples, **b.** Turbidity of water samples in different ranges.

Table 2. Summary of measured water quality parameters in KWASA's supply.

Water Quality Parameters	pH	Turbidity	Color	Iron	Cl	Hardness	TS	TDS	TSS	BOD_5
Units	-	NTU	PtCo	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
BDS (1997)	6.5-8.5	10	15	0.3-1.0	150-600	200-500	-	1000	10	0.2
WHO (2006)	6.5-8.5	5	15	0.3	250	500	-	1000	-	-
Sample No. 1	7.11	1.98	40	0.20	233.3	574.1	820	650	170	0.37
2	7.04	0.70	44	0.12	166.7	370.4	530	480	50	1.11
3	7.37	1.73	38	0.31	233.3	259.3	430	390	40	2.19
4	7.32	0.77	27	0.11	166.7	407.4	480	210	270	1.0
5	7.42	1.89	63	0.06	83.33	222.2	420	370	50	0.95
6	6.98	1.57	56	0.06	233.3	407.4	650	510	140	1.11
7	7.10	1.17	90	0.25	200.0	314.8	600	410	190	2.83
8	6.76	0.46	25	0.16	170	486.2	450	390	60	0.78
9	7.37	1.80	84	0.10	83.33	185.2	550	480	70	0.86
10	6.81	5.69	71	0.16	516.7	592.7	1300	920	380	1.5
11	6.87	9.09	166	0.11	550	1222	1920	1870	50	2.97
12	7.65	1.12	69	0.01	155	310.2	490	400	90	2.83
13	6.88	1.32	72	0.13	160	292.8	430	350	80	1.30
14	7.78	0.98	83	0.10	72	277.8	460	410	50	1.24
15	7.62	1.01	78	0.18	180	493.9	470	420	50	1.69

Hardness

The maximum (1222.32 mg/L) hardness was found in sample of household sample at Staff Quarter, Sadar Hospital and minimum (185.2 mg/L) value was found at 150 Baghmara Main Road. Based on the hardness value water may be classified as in Fig. 3. b. Soft and moderately soft water was not found in samples. Hard and very hard water was found 42.86% and 57.14%, respectively in household water samples where 100% of production tube well water was very hard. Test result demonstrates that about 20% samples exceeds BDS permissible limit (500 mg/L). Soap consumption by hard waters represents an economic loss to the water use.

Total dissolved solid (TDS)

The TDS value has been increased to an amount of 1870 mg/L in Staff Quarter, Sadar Hospital and its minimum value of 210 mg/L in Mistripara Bazar Pump. As being of coastal area, seawater intrusion is the main factor for the increased amount of TDS in GW, which was supported by a high value of sodium and chloride. 16% samples exceed the permissible limits (1000 mg/L) of WHO (2006) and ECR (1997). Depending on the TDS values, water is grouped as excellent, good, fair, poor and unacceptable. Most of the samples lies in good (300-600 mg/L) and 14.29% samples of households are unacceptable and there is no sample of household in excellent (<300 mg/L) class (Fig. 4. a).

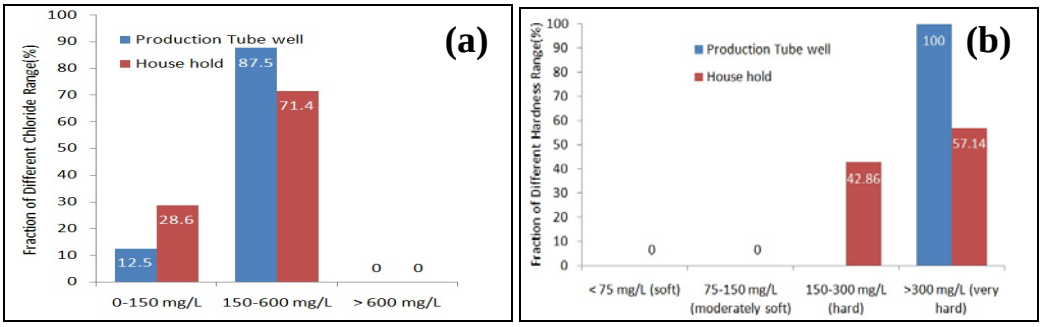

Fig. 3. a. Chloride of water samples in different ranges, **b.** Hardness of water samples in different ranges.

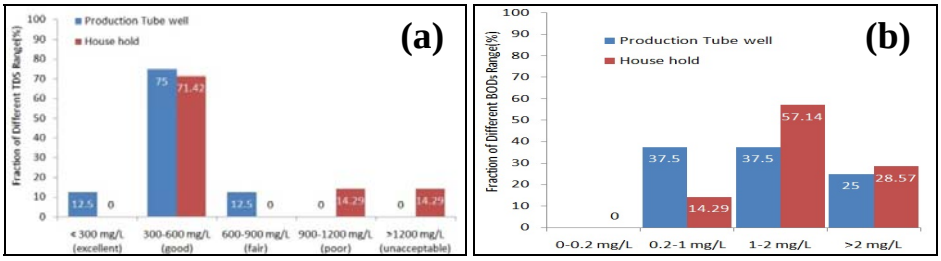

Fig. 4. a. TDS of water samples in different ranges, **b.** BOD_5 of water samples in different ranges.

BOD_5

All the collected water samples from different location of KCC had BOD_5 concentration greater than the permissible value of 0.20 mg/L of BDS. Fig. 4.b. shows the distribution of BOD_5 concentration in different ranges of household and production tube well samples. The maximum BOD_5 concentration was found 2.97 mg/L in Staff Quarter, Sadar Hospital and the minimum was 0.86 mg/L in Baghmara Main Road. Therefore, high BOD_5 concentration in the distribution system might be due to cross-contamination through leaking pipes, unauthorized connection, improper domestic storage facilities etc.

Total coli form (TC) and Escherichia coli (EC)

Test results for TC and EC are given in the following Table 3. Maximum TC was found in water sample collected from house hold (Staff quarter, Sadar Hospital). However, maximum EC was found in sample no 12 which is collected from house hold also at Banargati Bazar. Therefore, water supply in those areas may not be safe considering the microbiological water quality standard. The water passing through the distribution network in this area carries TC and EC which indicates that microbial contamination in the distribution system might happen due to cross contamination by leaking pipes, unauthorized connections, improper domestic storage etc.

Table 3. Coliform counts in water samples of KWASA in different production tube well & house hold

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TC(nos/100 mL)	130	125	115	200	290	10	70	42	190	185	335	180	80	160	76
EC(nos/100 mL)	0	0	0	70	10	0	0	17	100	5	5	120	7	100	46

Table 4: Comparison of water samples with its recommend standard quality

Parameters	Units	Max	Min	Water Quality Standard		% of samples exceeding water quality	
				WHO (2006)	BDS (1997)	WHO (2006)	BDS (1997)
pH	-	7.78	6.76	6.5-8.5	6.5-8.5	0	0
Turbidity	NTU	9.09	0.46	5	10	13.33	0
Color	Pt.Co	166	25	15	15	100	100
Chloride	mg/L	550	72	250	150-600	13.33	0
Iron	mg/L	0.31	0.01	0.3	0.3-1.0	6.57	0
Hardness	mg/L	1222.32	185.2	-	200-500	-	20
TDS	mg/L	1870	220	1000	1000	6.67	6.67
BOD_5	mg/L	2.97	0.86	-	0.2	-	100
TC	Nos/100mL	335	10	0	0	100	100
EC	Nos/100mL	120	0	0	0	66.67	66.67

Overall assessment of the KWASA supply water and recommendation

Test results of water samples collected from the outlet of production tube well and household revealed that the water entering the distribution system was not meet the desired chemical and microbial quality except pH, turbidity, chloride and iron. However, this quality drinking water can suffer more serious contamination in distribution system because of breaches in the integrity of the pipe work. Although the researchers are currently unsure about the exact effect of bio film produced within a distribution system [13]. Though the concentration

of water quality parameters in the outlet distribution networks (households) were higher than the level recorded at the outlet of production tube well and they were not still within the permissible range in some location. So, contamination occurs in the network. Therefore, it can be concluded from random tests of biological water quality that the people of Khulna city are at high risk due to contamination of drinking water.
One of the major tasks to ensure improved water quality is to find out possible point of sources of microbial contamination i.e., cross contamination by leaking pipes, unauthorized connection to the main at road sides, lack of maintenance of domestic storage and distribution system etc and to take necessary preventing measures. Current practice in many countries is to use disinfectant residuals to control the growth of microorganisms in distribution systems. In fact, proper system efficiency depends on quality monitoring which could be achieved by a program of frequent monitoring at service connection throughout the system. Besides, low cost treatment plants can be installed in the inlet of distribution network to provide standard quality water in the distribution network.

5. Conclusions

Khulna city dwellers are not only suffering from inadequate water supply but also are they posed to serious threat due to the scarcity of safe water. Water quality test results of random samples of KWASA's distribution system revealed that the water quality is not satisfactory in production tube well and deteriorated during its flow through the distribution system. KWASA's piped water supply systems are generally buried complex reticulations and they are difficult to operate and maintain. Nevertheless, they are as important as water resource and treatment facilities in ensuring the supply of safe drinking-water. The authority should conduct regular monitoring program to prevent possible contamination of water along its distribution. Public consciousness can also play an important role to help prevent such problems. The situation may exacerbate in near future if the authority does not pay attention and take immediate actions to restore water quality in the distribution system.

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Evaluation of Subsurface Geologic Formation in the Barind Tract, Rajshahi, Bangladesh

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Abstract

Hydrogeology is the area of geology that deals with the movement of groundwater in the soil and rocks of the Earth's crust. The study area, which is a north western part of Bangladesh, is one of the most diversified physiographic unit and the irrigation is almost entirely depends on groundwater. But over exploitation indicates falling groundwater heads in this area. So, to assess the sustainability of this yield it is necessary to examine carefully the nature of the aquifer system. In this connection about 1200 borehole data have been processed and analysed to study the geologic formations. In the investigated area three subsurface geologic formations are clearly identified. Maps of formation thickness and index have been prepared to identify the geometry of the aquifer system. Representative panel diagram, 3-D stratigraphic and cross-sectional views are also prepared for necessary assessment of the variation of individual subsurface stratum in different locations.

Keywords: *Subsurface, Groundwater, Aquifer, Stratigraphic.*

1. Introduction

Groundwater is considered as the largest available source of freshwater in Bangladesh. The optimum development and management of groundwater resource for mitigating human demands, needs a proper investigation of the water bearing formation of an area and its properties and characteristics [1]. Hydrological condition of the area depends on many parameters such as topography, geology, drainage system, rainfall, evaporation, soil characteristics, recharge, discharge and hydraulic properties of the aquifer [2]. The qualitative and quantitative availability of groundwater is generally influenced by varying geology, physiography and climatic conditions. The groundwater resource management is vital for human survival and is not feasible unless complete assessment of the system is made. Lithological logs are a source of valuable data for hydrogeologic studies.

1.1 Geography of the Study Area

The study area Barind Tract**,** consists of Nawabganj, Naogaon and Rajshahi districts. It lies between 24°07′ N to 25°13′ N latitude and 88°00′ E to 89°10′ E longitude (**F**ig. **1**). The alluvium is composed of mostly clay, silt and fine sand and are well oxidized and typically radish brown in color. The water condition is low due to firm and compact material [3]. There are three main seasons in the study area — Winter, Pre-monsoon and monsoon or rainy [4]. About 80% or more of the annual precipitation occurs during monsoon period. The average temperature ranges from 35°C to 25°C in the dry season and 9°C to 15°C in the winter season. The average population density of this area is about 804.47 km^2 [5].

2. Methodology and Description

Position and extent of different hydrological units is very important to understand the geometry of the aquifer. This information also important for the drillers to design the abstraction well [6]. Borehole lithological data is an important source of information for obtaining the subsurface distribution [7, 8, 9, 10, 11]. On the basis of borehole data, geological cross-sections, and panel diagram, the vertical continuity of different groundwater bearing formations are demarcated. The reliability of the information depends not only upon the accuracy of the data but also on the number of available data sources. About 1200 borehole data collected from Barind Multiple

Development Authority (BMDA) for the study area, have been processed, analyzed and interpreted for quantitative hydrogeological studies. The study area along with the data points is shown in **F**ig. **2**. The distribution of data points in the area investigated is clearly observed from the figure. An effective study area has been drawn considering the sufficient data points within the area studied. The geometry constituted by the continuous line is considered as analytical area and different maps of interpretation are to be presented in that form (**F**ig. **2**).

Fig. 1 Study area of Barind Tract

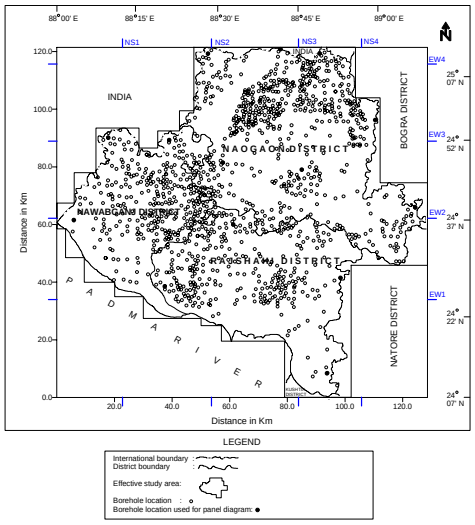


Fig. 2 Investigated area

2.1 Subsurface Layer Formation

A top clay layer, sand layer of different grain size and at the bottom (in maximum location) an impermeable clay zone is the common geologic formation in the area. Studying the grain size, the sand layer is clearly sub-divided into five parts, below the top clay which is fine in grains and others below that are consist of fine-medium, medium, medium-coarse and coarse in grain generally termed as "Composite Sand". The composite sand formation is overlying an impermeable clay zone which is very common in the area and usually known as "Black Plastic Clay" (BPC) due to high plasticity and black color. The maximum and minimum depths of borehole information are 24.3 m and 79.2 m respectively. According to the borehole information, the subsurface formations of the area are divided into three main layers:

Top Clay Layer: This clayey formation is very common in the area. The thickness of this layer is from 1.5 m to 51.8 m. **F**ig. **3** shows the variation of clay thickness of the study area. This clayey layer is overlying the only sandy formation recorded in the area studied.

***Sand Layer*:** In the investigated area the composite sand formation is the only usable groundwater source. The thickness of composite sandy layer of the study area has been estimated using the lithological information and presented in **F**ig. **4**. This figure gives a clear quantitative understanding of the presence of usable water saturated formation in different regions of the area studied. The thickness of composite sand varies between 3 m to 68.5 m. **F**ig. **4**, it is clearly observed that in the north-western corner and in some places of middle of south-western corner, the thickness is estimated low but in the rest of the areas the thickness of composite sand formation is recorded above 20 m. So, it could be said that the area occupied high thick bed of composite sand is more favorable for groundwater exploration and the thick bed could be used for small scale abstraction.

***Impermeable Zone*:** The impermeable zone in general, is underlying the composite sand formation. The physical shape of different layer interfaces have been presented in a generalized form with respect to a datum chosen at a depth of 60 m below mean sea level. The interbedded views along with the earth surface have been presented in a single view from two directions (**F**ig. **5**) for a comparative study. These figures give clear and detail idea about the variation of the thickness of different formations at any specific location of the investigated area.

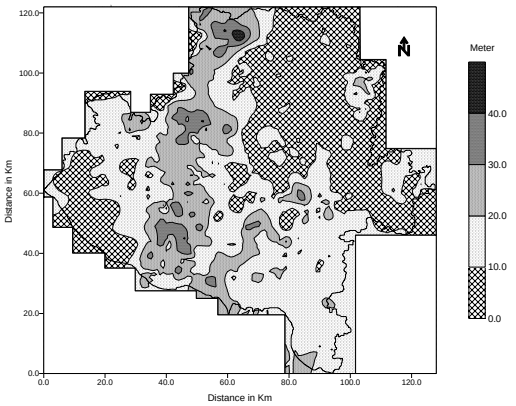


Fig. 3 Contour map of top clay (1st layer) thickness

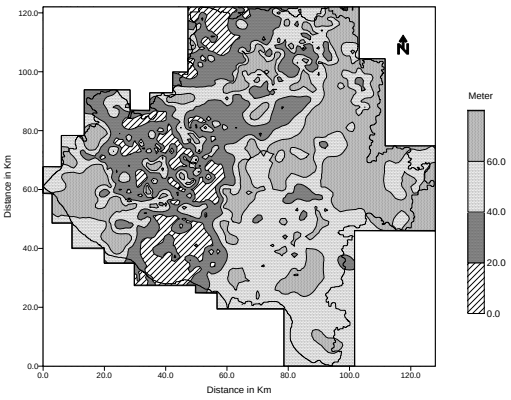


Fig. 4 Contour map of composite sand thickness

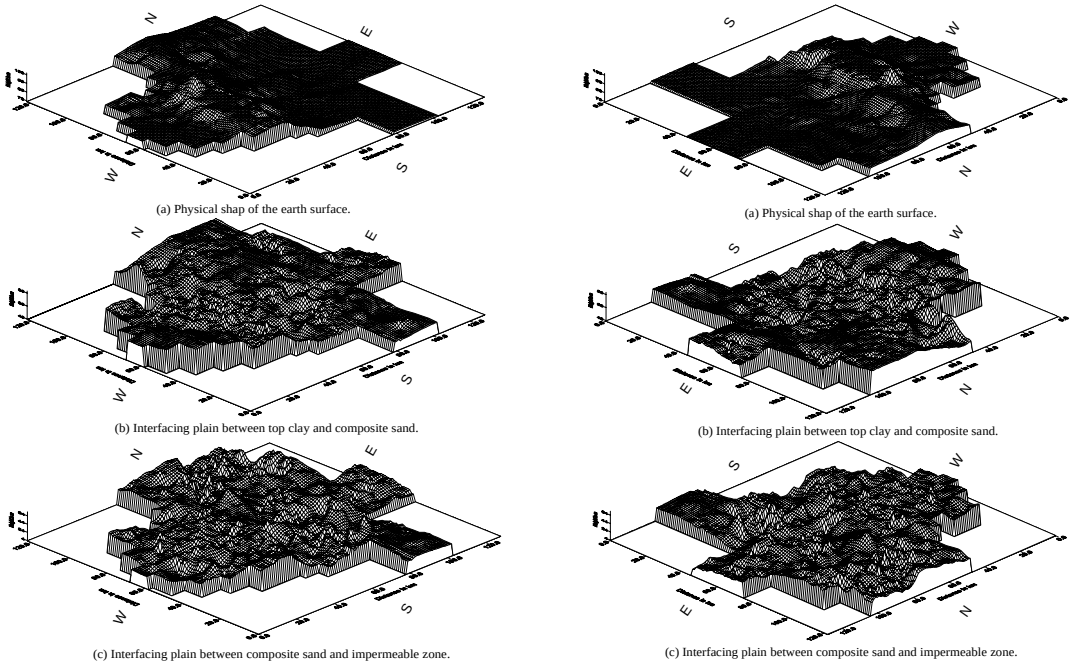


Fig. 5 Different surface views w.r.t. datum (Left: view from south-west and Right: view from north-east corner)

3. Panel Diagram

Construction of stratigraphic panel diagram is important to obtain the clear idea about the subsurface hydrological condition in different parts of the area. It also helpful to understand the geometry of the aquifer and the relation between the various beds and formation in geologic system. For this purpose, borehole data from 14 locations are selected to covering the whole study area to construct a panel diagram (**F**ig. **6**) it is evident that the subsurface formation of the area is divided into clay and sand. The sand formations is embedded between top clay and lower impermeable zone. The clay thickness is very high in north-western corner and south-western part of the area. In the north-eastern part the top clay thickness is low. The overall sand thickness of the study area is good. In the western part, the presence of fine-medium and medium sand is observed. In the north-western corner, medium sand is dominated. In the eastern part thick bed of medium-coarse and coarse sand is recorded.

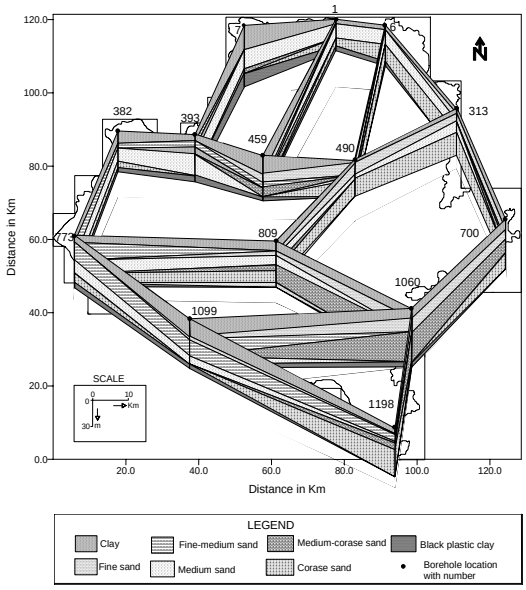


Fig. 6 Panel diagram of the study area

4. Stratigraphy

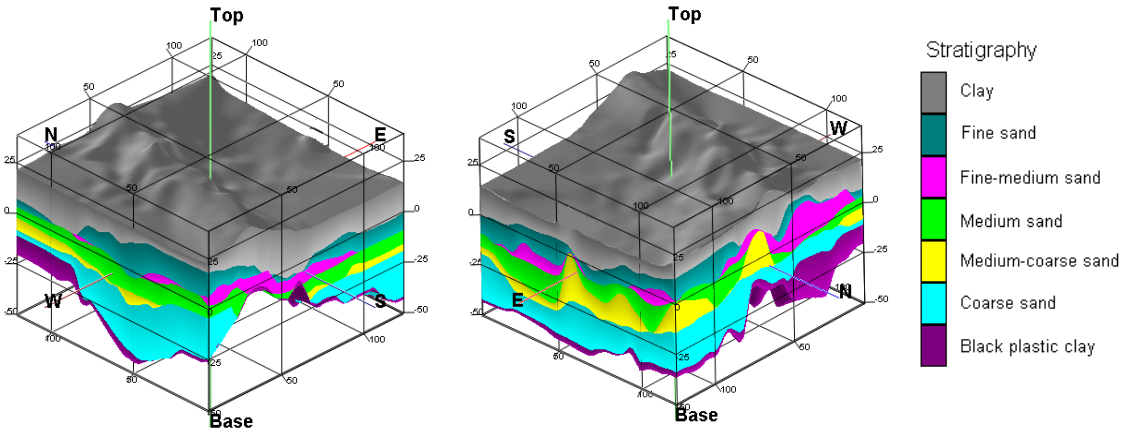
The stratigraphy is an essential tool in the search for water in areas of wide spread sedimentary rock. The position and thickness of water bearing horizons and the continuity of confining beds are of particular importance in the development of groundwater exploration zones. The three dimensional model of the individual layers of the study area have been prepared and shown in **F**ig. **7**. This model gives a clear understanding of geologic formations of the area studied.

4.1 Stratigraphic Cross-section

Subsurface hydrological cross-sections are normally the best way to ascertain the nature and location of aquifer. To observe the cross-sectional views in different parts of the effective investigated area eight representative vertical sectioning along the profiles of both north-south and east-west directions have been prepared. The orientations of the profiles e.g., NS1, EW1, etc are shown in **F**ig. **2**. The figures have been drown considering the thickness of different subsurface geologic formations. The sectional views clearly distinguished the earth surface elevation and the variation of different layer formations along the profiles. **F**ig. **8** represent the vertical divisions of subsurface formations along the profiles oriented in the north-south and east-west direction. The cross-sections furnish a clear picture of different stratigraphic units or layers underneath. The top clay layer is present everywhere. Fine and fine-medium sand are not available every places. But medium, medium-coarse and coarse sand are present in most of the places and there thickness are also satisfactory. From this figures it could be concluded that in most of the areas the subsurface geology is favorable for groundwater development provided the other conditions are agreed. So, these sectional views would definitely play an important role for selecting suitable well sites and its designing.

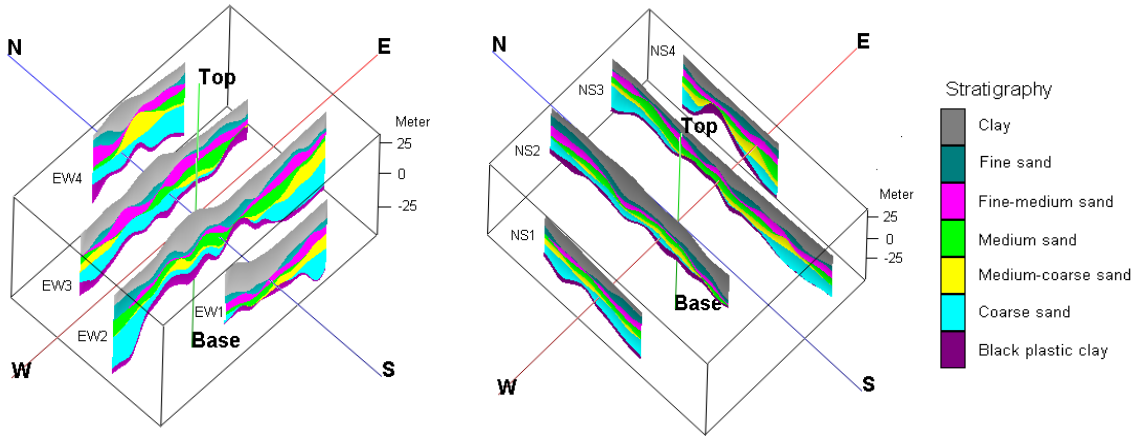
5. Formation Index

Potentiality of water saturated zone may be quantitatively represented by means of some index map. **F**ig. **9** represent the index map of sand-clay thickness. The thickness of the composite sand formations, in general is found 3 times than the clay formation in the study area. In the total area of the north-eastern side the thickness of sand is found more than 6 times of clay thickness. In the south-western corner, gradual increase of sand thickness is observed. It is clear from the index map that in general the subsurface formation is suitable for groundwater exploration.



(a) (b)

Fig. 7 3-D stratigraphic view of the investigated area (Distance in km, Height in m); a) view from south-west corner, b) view from north-east corner.



(a) (b)

Fig. 8 Stratigraphic view along different profiles of the 3-D model of Fig. 7

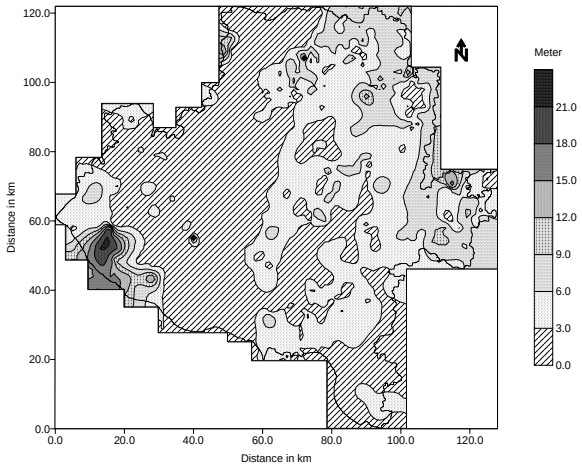


Fig. 9 Contour map of composite sand - clay thickness

6. Conclusion

The total subsurface discreteness of the study area is performed by detailed study of lithologs. Seven distinct hydrostratigraphic layers have been identified in accordance of its vertical distribution and lithological composition. They are top clay, fine sand, fine-medium sand, medium sand, medium-coarse sand, coarse sand and at the bottom impermeable BPC. Only top clay exists everywhere and the other being anomalously distributed.

To express in more convenient established terminology, aforementioned layers and units are defined into different distinct hydrogeological terminologies. On the basis of borehole information the groundwater bearing sequence of the area have been mainly divided into two hydrostratigraphic units: aquitard and aquifer consist of clay and sands of different grain size respectively. In most of the areas the thickness of the clay cover is below 20 m and only in a specific north-south stripe it is found above 20 m. The lithological data of this area have confirmed the presence of aquiferic materials of different granular, in this work this formations is termed as composite sand. This aquifer is just below the top clay. The thickness of this composite sand in the eastern side of the area is found greater than 40 m. Similar composition is observed in south-west corner. In the rest part of the area it is below 40 m. The interfacing planes of the top clay and impermeable BPC with the imbedded sands are also presented. To observed the vertical distribution of different geologic formations in different parts of the area a panel diagram has been prepared. 3D stratigraphic view of the investigated area in different angles have been constructed considering individual sand formation. Stratigraphic cross-section have also been shown along the north-south and east-west profiles. Formation index is an important parameter in groundwater development. In this relation, the composite sand-clay ratio i.e., the index map of the investigated area has been prepared.

The detail study of formation evaluation of the area investigated reveled that geologically it is suitable for groundwater exploration however for large-scale abstraction sites should be selected consciously.

Acknowledgement

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A Study on Heavy Minerals Reserve and Separation Processes from Raw Beach Sands along the Coastal Belt of Bangladesh

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Abstract

Bangladesh lies in the northeastern corner of the Indian subcontinent at the trend of the Bay of Bengal. A mineral is a naturally occurring homogeneous solid, inorganically formed with a definite chemical composition and ordered atomic arrangement. There are seventeen deposits areas (Cox's Bazar-Chittagong sea beaches, Nijhum Island & Kuakata) of *most prominent heavy mineral sands are discovered in the beaches along the coastal belt of Bangladesh till 1986. These minerals have been separated from beach sands using different gravity, magnetic and electrical separators in both laboratory and pilot plant. There are eight types of heavy minerals are found in these areas. Among them, major five economically extractable heavy minerals are Ilmenite, Rutile, Zircon, Garnet and Magnetite which have specific gravity: 3.5-5.18, hardness: 5-7.5, non-magnetic to strong magnetic, poor to good electrical conductivity and so on. In Bangladesh the total heavy minerals (major five) reserve is about 1.56 million tons which economic values large. These heavy minerals are more economical viable and can be used in different industries, nuclear power plants, meters and scientific apparatus, welding, rod coating and others. These minerals can be extracted and production by commercially to increase the national income.*

Keywords: *Bangladesh, Cox's Bazar, Heavy Minerals, Reserves and Economic Viable.*

1. Introduction

A non-renewable resource is a natural resource which cannot be produced, grown, generated, or used on a scale which can sustain its consumption rate, once used there is no more remaining. Minerals are one kind of non-renewable resource which can be extracted by open cast mining method [1]. A mineral is a naturally occurring homogeneous solid, inorganically formed with a definite chemical composition and ordered atomic arrangement [2]. A sufficient mineral deposits formed by mechanical concentration of mineral particles from weathered debris. The mineral concentrated is usually a heavy mineral. There are two types of placer minerals are present as beach placer and alluvial placer. Beach placers are formed when the mechanical or chemical breakdown of rock (An aggregate of minerals) masses is followed by a redistribution of the material along a continental shelf. The movement of the sea gradually sorts the sediments, directing the finer materials into deep water and coarser materials towards the shore. The valuable minerals are gradually resistant to weathering and hence become concentrated. Long time upward warping of the coastal areas, Castaic's variations in sea level and the migration of wind-blown sands dune has converted some of these sediments to land information and consequently many beach placers occurs a considerable distance inland from the present coast line. However, some vital factors are bearing on the formation of economic deposits of heavy minerals. These are area of source rocks exposed to erosion, duration and severity of the erosion cycle, mineral content of the exposed rocks, climate, topography and location [4]. This paper shows delineate of physical properties of heavy minerals, total reserves and separation processes from raw beach sands along the coastal belt of Bangladesh.

2. History of Investigation

The mineral resources were first found in Cox's Bazar in 1960 and later Bangladesh Atomic Energy Commission started diverse researches. Investigation of heavy (radioactive) minerals like monazite by the erstwhile Geological Survey of Pakistan around the Cox's Bazar sea beach area started in 1961 and a number of precious heavy minerals were identified the same year. Geologists of the Pakistan Atomic Energy Commission carried out reconnaissance work in 1967 and found that the beach sand contains economically important heavy minerals. After systematic surveys during 1967 to 1969, it was recognized that a potential zone of heavy minerals exists along the entire coastal belt, mainly from Cox's Bazar to Badarmokam, and in some areas of Maheshkhali, Kutubdia and Matarbari islands. Later, in 1975, a pilot plant was installed at Kalatali, Cox's Bazar with the cooperation of the Australian Government to sample, separate and assesses the commercial viability of the heavy mineral content in the placer deposits. In this plant, a flow sheet adopted by the Australian Mineral Development Laboratory was used to separate heavy minerals. By 1985 the nearly 550 km-long

coastline of Bangladesh was surveyed either partially or completely to map the beach sand heavy minerals. It was found that the reserves were concentrated mainly along the sea beaches of Chittagong and Cox's Bazar districts. On the basis of surveys carried out so far along the coast of Bangladesh a number of heavy mineral placers are delineated. Systemic exploration works have been carried out from 1968 to present and evaluation works completed in 1986. These works finally resulted in the discovery of 17 deposits of minerals sands in the beaches along the coastal belt of Bangladesh. Fifteen deposits are in the Cox's Bazar-Chittagong sea beaches and nearby offshore island [7] (Figure 1). The minerals are scattered in an area of 7,986 hectares of land in Cox's Bazar district, located in the eastern end of the 500 km sea beach [8].

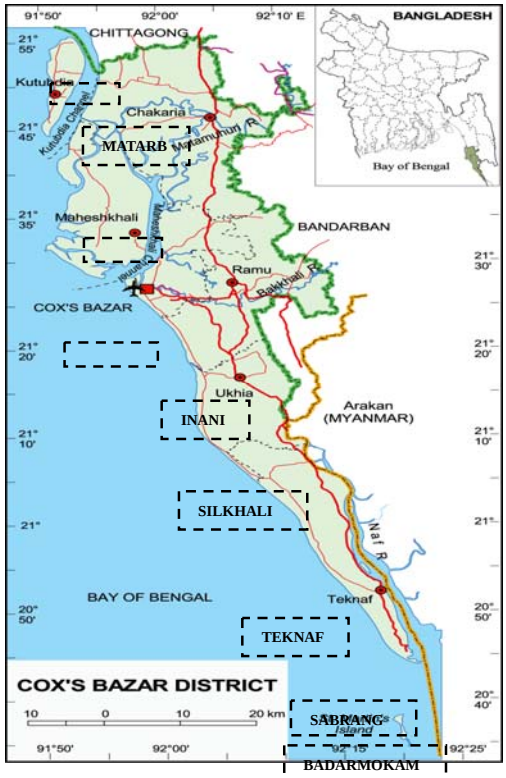

Fig. 1: Location map of heavy minerals deposits in Bangladesh (Source: Banglapedia, 2013)

3. Separation Process and Flow Charts

Heavy minerals are extracted from sea beach sands by open pit mining method using different types of equipments. Generally, mechanical and electrical equipments have been used in heavy minerals separation in Quality Control Laboratory. These are mainly tow major types as major equipments e.g. shaking table (Figure 2), Induced Roll Magnetic Separator, IRMS (Figure 3a & 3b), Electrostatic Plate Separator (ESPS) and High Tension Roll Separator (HTRS) and

Fig. 2: Shaking separator in wet process, Fig. 3a: IRMS Fig. 3b: Magnetic & None magnetic separation process.

minor equipments e.g. pressure filter, gas burner and permanent hand magnet. On the other hand, there are three types

separators are mainly used in laboratory and pilot plant. These are gravity separator (i.e. screw classifier, Wifley table, Vibro screen, air table, spiral, dewatering cone and hydro cyclone), magnetic separators (i.e. Low Intensity Magnetic Separator (LIMS), Wet High Intensity Magnetic Separator (WHIMS), IRMS and cross belt).

3.1 Working Flow Chart for Mineral Separation

In Bangladesh, generally two types of working flow chart have been developed from raw sand to desired heavy minerals at BSMEC. These are laboratory scale (small amount) mineral separation and large scale separation at pilot plant both dry and wet section. The raw sand has been collected from deposit of heavy mineral. Then heavy minerals have been separated successively by following as the below flow chart-1 [5&6].

In BSMEC pilot plant, raw sands collected from heavy mineral deposits are fed by Bobcat Loader into the Grizzly Feed Hopper (GFH) from where it reaches to the Trommel Screen Conveyer Belt. Water from bore pumps is mixed with the sand before the Trommel Screen to make slurry. Here the sands are screened out of oversize materials and thrash. It then enters into surge bin from where the slurry of sand and water is pumped through slurry pump and hoses to provide spiral concentration equipment for separation of heavy minerals components from light ones. In pilot plant separation process have been divided into sections, one is wet section and another is dry section. Both sections are shown in flow chart 2a and 2b [5,6&7].

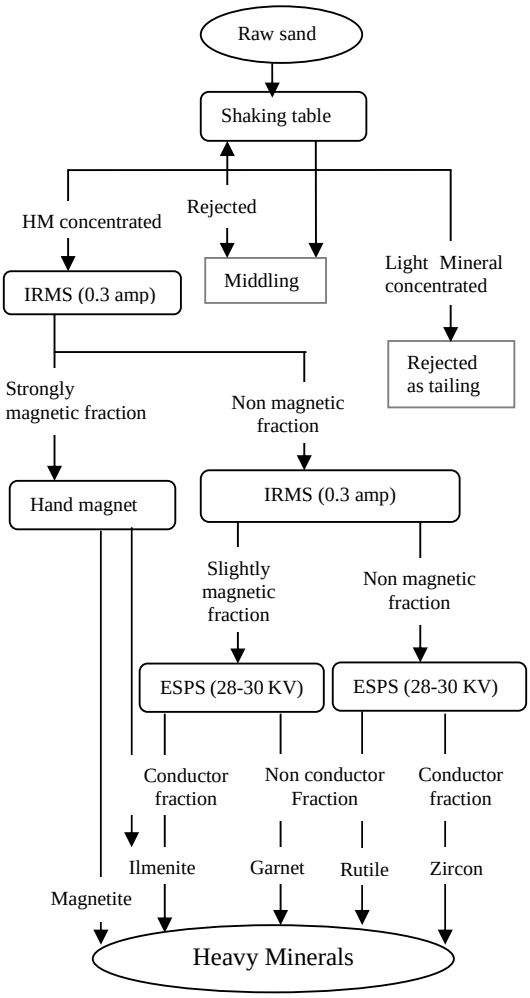

Fig. 4: Flow chart-1 for laboratory scale of heavy mineral separation

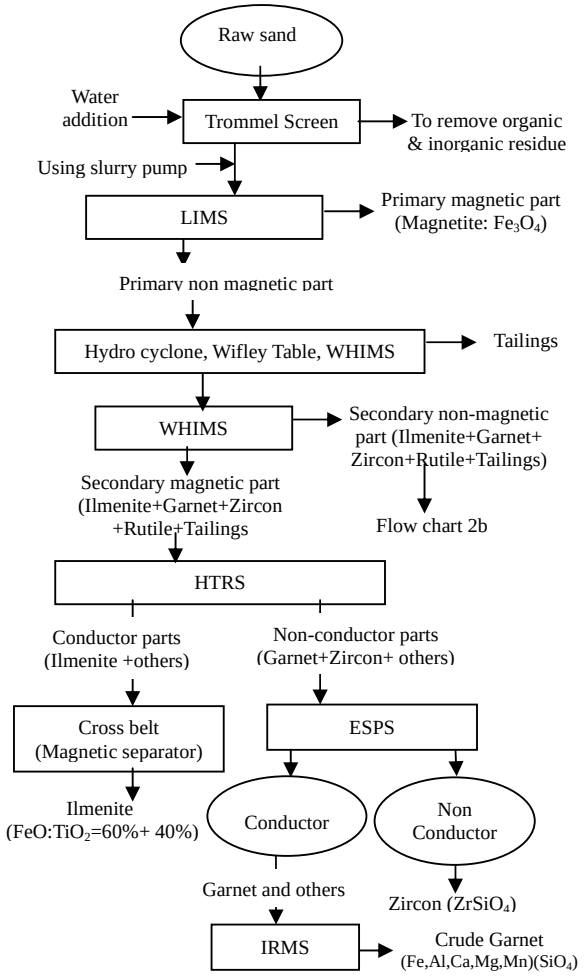

Fig. 5: Flow chart-2a for heavy minerals separation in pilot plant at BSMEC, Cox's Bazar.

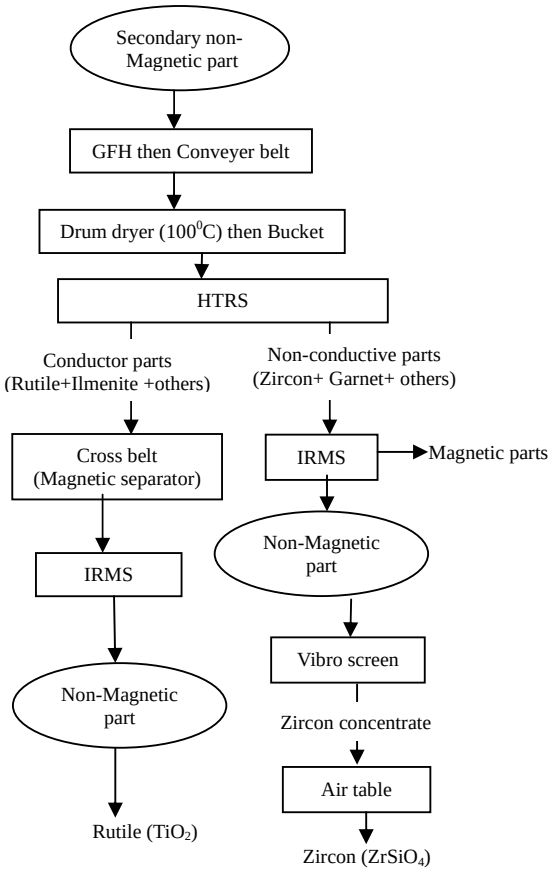

Fig. 6: Flow chart-2b for Rutile and Zircon minerals separation from secondary non magnetic part in pilot plant (dry section) at BSME, Cox's Bazar.

4. Physical Properties of Heavy Mineral of Studied Area

Those minerals which have specific gravity more than 2.88 are called heavy minerals. The physical properties of heavy minerals are specific gravity, hardness, crystal system, color, magnetic and electric property and radioactivity, etc. Specific gravity (Sp. gr.) is the ratio of the mass of unit volume of sand (soil) at a stated temperature to the mass of the equal volume of the air free distilled water at same temperature. Summarized physical properties [3, 5 & 6] of five heavy minerals (major) have been shown as tabulated form in Table 1. The major eight heavy minerals are present in the coastal belt of Bangladesh. Among minerals, Monazite and Zircon are well defined and slightly radioactive.

Table 1: Physical properties of Heavy Minerals

Properties	Magnetite	Ilmenite	Rutile	Zircon	Garnet
Sp. gr.	5.2	4.7	5	4.7	4.3
Hardness	6	5.5	6.5	7.5	7.5
Crystal system	Cubic	Hexagonal	Tetragonal	Tetragonal	Cubic
Color	Black	Black to grey	Pinkish red	Reddish brown	Less to pink
Magnetic property	Strong Magnetic	Moderate	Weak	Non	Non
Electrical property	Good conductor	Good	Non	Moderate	Non

5. Reserves and Discussions

All the seventeen deposits named as Badarmokam, Sabrang, Silkhali Teknaf, Inani, Cox's Bazar, Moheshkhali Foreshore Beach, Honak, Panirchara, Baraghoriapara, Fakirahata, Fakiraghona, Kutubgum, (Seven from Maheshkhali Island), Matarbari, Kutubdia and Nijhum islands, and Kuakata which consist of 20.496 million tons of raw sand which contains 4.355 million tons of heavy minerals (sp. gr. >2.88) [3&7]. Only eight types of economically important heavy minerals named as Zircon, Rutile, Ilmenite, Garnet, Magnetite, Leucoxene, Kyanite and Monazite occur in these deposits. The total stock of these eight types of heavy minerals in these seventeen deposits is 1.761 million tons where major five minerals (Zircon, Rutile, Ilmenite, Garnet & Magnetite) and other minor three (Monazite, Kayanite & Leucoxene) reserves are found as 1.557 and 0.204 million tons, respectively. On the other hand, light minerals reserve is 2.593 million tons which has specific gravity about less than 2.9. Total reserves of raw sands and heavy minerals have been listed [3&6] in Table 2. Graphically representation of minerals reserve versus heavy mineral bearing area has been shown in Figure 7 and 8.

Table 2: Total heavy mineral resource in Bangladesh

Name of Deposited Place	Reserve of Raw Sands (tons)	Total Minerals Reserve (tons)	Reserve of Eight Heavy Minerals (tons)
Cox's Bazar	5119000	920000	286764
Maheshkhali Island	4114230	784210	418328
Kuakata	2872486	831668	172657
Shilkhali	2756828	489714	279506
Teknaf	1939580	442291	272235
Badarmokam	1765000	411000	134959
Inani	729286	175476	89249
Kutubdia Island	404646	120000	44412
Nijum Island	379337	96348	22463
Sabrang	347558	68582	33907
Matabari Island	69030	15215	7020
Total	20,496,981	4,354,504	1,761,000

According to analysis, about 22% heavy minerals are present within total raw sand in 17 deposits places. Highest and lowest heavy mineral reserves are 4.489% and 0.074% in Cox's Bazar and Matabari area, respectively. Others heavy minerals deposit areas are stand of 4.06-0.33%. Ilmenite reserve is highest than the other heavy minerals. Remaining all heavy minerals is found in the aforementioned deposits area except garnet mineral in the Matarbari and Badarmokam. Correspondingly, a fractional distribution of total minerals and 8 identified heavy minerals reserve is shown in Figure 9 and 10. Among total minerals reserve, light minerals and commercial major five heavy minerals are 59 and 36 percent, respectively. On the other hand, Ilmenite is 23% and other minerals ranges from 5 to 2 percent or less. But Ilmenite, Garnet, Zircon, Magnetite & Rutile reserve are 58, 13, 9, 5 & 4 percent but other three heavy minerals is 11% within eight heavy minerals reserve. Economical feasibility of the heavy mineral deposits depended on the utilization of heavy minerals. These heavy minerals are more economical viable and already used in sectors.

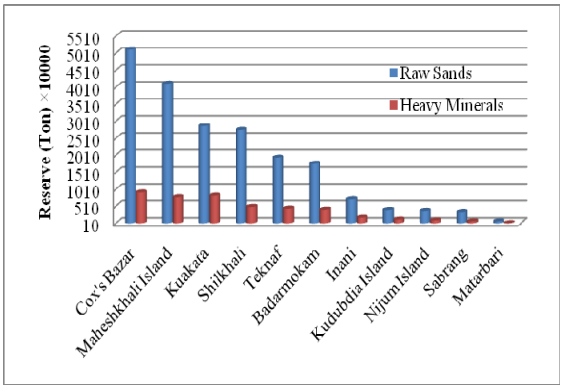

Fig. 7: Reserve vs. Heavy minerals deposited area

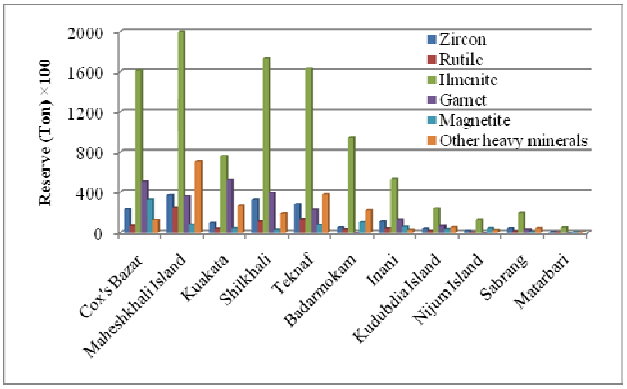

Fig. 8: Economical minerals reserve vs. deposited area

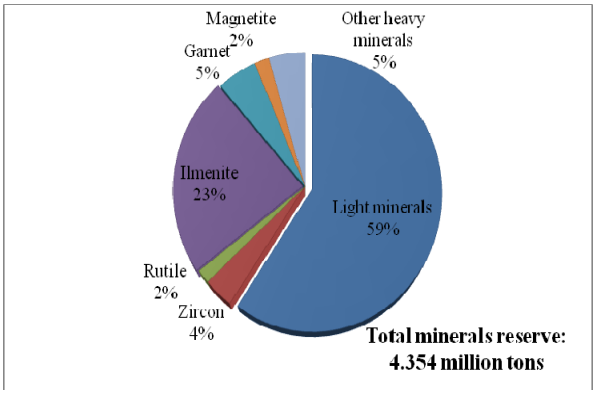

Fig. 9: Fractional distribution of total minerals reserve

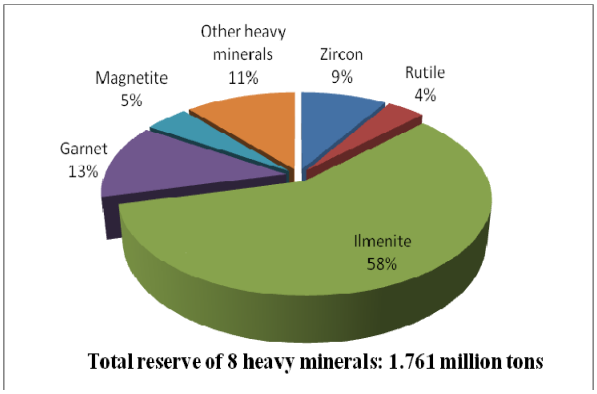

Fig. 10: Fractional distribution of eight heavy minerals

About 60% of all Zircon is used in foundry facing works, while 15% is consumed in the manufacture of zirconium metal, alloys and chemicals [6]. Rutile is used as raw material in the pigment industry, welding rod coating, leather dressing & finishing, and as a source of Ti metal. The industry consumes about 66% of the total Rutile production while 18% is used in welding rod coatings in this country. Ilmenite is a source of TiO_2 which is used chiefly as white pigment. It is extensively used in welding rod coatings and radiation shielding material. Titanium is used not only for building aircraft but also for brightening the color of paints and lifting coal from the mine [3]. One kilogram of titanium is now sold at 19,500 US dollars to 22,000 dollars in market. Mexico, India, North America and Australia are the main buyers of this mineral. It is possible to lift 1 million tons of Ilmenite from the coastal belt [8&9]. About 90% of the total Garnet production is used in the manufacture of emery cloth, paper, wheel and grinding stones. Magnetite used chiefly as a source of pig iron which is the primary material for the production of cast iron, wrought iron, malleable iron and the many varieties of ordinary and special steels. Monazite is a source of rare-earth metals and thorium. Leucoxene is being used as a substitute for Rutile with the increasing demand of TiO_2 material. Ilmenite, Leucoxene and Rutile are important because they contain some of the highest concentrations of titanium. Kyanite serves as a source of Aluminum. It is extensively used in the manufacture of refractory and foundry products. The utilization of heavy minerals is increasing day by causes for different uses in the world. The economic value has about 273.17 million USD based on world market price rate (USD/ton) of major five heavy mineral reserve as 1.56 million tons [3&7].

6. Conclusions

Heavy minerals have been found as beach sand heavy mineral placer deposits on the Cox's Bazar-Chittagong sea beaches, Nijhum Island & Kuakata along the coastal belt of Bangladesh. In these deposited areas, total heavy mineral reserve is 4.355 million tons. These heavy minerals are more economical viable and can be used in different industries, nuclear power plants, meters and scientific apparatus, welding rod coating, etc. These minerals can be extracted and large scale production by commercially to increase the national income. Yet the beach is allowed to lift the minerals, it will hurt the tourism and the biodiversity as well but it will open up a new vista of rapid economic development of this country. Proper exploitation of mineral resources will also generate employment opportunities in the field of research and other sectors. Government should take necessary steps to manage these resources and proper utilizations.

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Color Strength Modeling of Knitted Fabrics Using Fuzzy Logic Approach

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Abstract

Color strength modeling is an important issue for knitted fabrics in textile dyeing industry because of the high demand for quality products. Subsequently, Dyeing is a complex process which is affected by many factors such as dye concentration,temperature, time, p^H, electrolyte concentration etc.on its final quality. Several mathematical, statistical, empirical and intelligent models have been developed in the earlier research only to prognostic the fabrics qualities. It is noted that some of these models are trained using massive amount of experimental data, which are of course challenging and time consuming to accumulate from the textile industries. In this context, a fuzzy logic expert system (FLES) has been employed in modeling such a complex management of process mechanics. The main objective of this research is to model the color strength of cotton knitted fabric using fuzzy expert system as a function of dye concentration,temperature, and time.

Keywords: *Color strength; dyeing process; dye concentration; FLES.*

1. Introduction

Color strength modeling is one of the most fascinating topics in textile dyeing research for Textile Engineers. Specially, quality characteristic is considered as one of the biggest issue in the many parts of the world.Customers demand in today's Textile market is high quality products with minimum price and short time delivery. Subsequently dyeing is the most complex process for color application in Textile manufacturing and Dyeing process is affected by many inside and outside parameters such as dye concentration,temperature, time, P^H, concentration of electrolytes (salt), bath ratio (material liquor ratio), etc. [1]. But the traditional dyeing process consists on trial and error basis which is time consuming with lower efficiency and inferior quality. Moreover, Automatic control of dyeing process is also developing slowly due to complexity of dyeing process.For this reason, there is a need for more efficient and easier system that could be employed in modeling such a complex management of process mechanics .Hence, Fuzzy intelligent modeling and prediction of color strength have become one of the most viable alternatives toconventional predicting techniques.

In the past, a large number of predictive models have been developed to prognosticate the fabrics quality characteristics like color strength, fastness properties, levelness, pilling resistance, tensile strength etc. [2,3]. These models have been developed in the earlier research only to harvest restricted attainment in terms of prediction accuracy and general applicability [2]. It is noted that there are three distinguished modeling methods for predicting fabric quality characteristic such as mathematical models, statistical regression models and intelligent models. Mathematical models related to this study have been developed by various researchers [4, 5]. In fact, mathematical models are based on the fundamental theories of basicSciences. However, the prediction accuracy of mathematical models is not very encouraging due to the assumptions or simplifications used while building these models. On the other hand, statistical regressions models are developed by various researchers have been used in related research [6, 7]. But, the type of relationship (liner or non-linear) is essential for developing a statistical regression model. In addition, artificial neural network (ANN) models have been applied by several researchers related to this study (8-10).Whatsoever, artificial neural network models are trained using massive amount of noise free experimental data, which are of course challenging and time consuming to accumulate from the Textile Dyeing industries.

In contrast, some lacunas of ANN, Mathematical and statistical regression models can be overcome by fuzzy logic expert system, which can effectively translate the experience of a dyer into a set of expert system rules. In others words, Fuzzy logic are employed to solve problems in which descriptions of activities and observations

are imprecise, vague and uncertain. In addition, Fuzzy logic is focused on model of reasoning which are approximate rather than exact. For example, In Textile dyeing industries a dyer often applies the term such as high or low, strong or weak, for assessing the dyed fabrics qualities such as color strength, color fastness, color levelness etc.[2].

There are many publications on fuzzy logic application related to this research has been discussed hereunder.Jahmeerbacus et al. [11] successfully applied fuzzy control method for controlling pH in exhaust dyeing to achieve optimum color yield and levelness of dyeing. Huang et al. [12] developed fuzzy expert model for controlling dye bath concentration, pH and temperature in cotton fabric dyeing with direct dye to achieve expected color shade and even dyed product quality. Nasri and Berlic[13] used Evolutionary Fuzzy model for optimizing polyester dyeing process parameters with disperse dye to achieve desired color yield. Nasri et al. [14] proposed a hybrid modelling system Genetic-Fuzzy approach to model the color yield of polyester fibre in high temperature dyeing as a function of dye concentration, time and temperature.

In the present study, an attempt has been made to model a new fuzzy expert system in MATLAB/Simulink for the color strength of cotton blended knitted fabrics in exhaust dyeing with reactive dye as a function of dye concentration, time and temperature.

2. Materials and Methods

In this experiment, Single Jersey Cotton Lycra blended (95/5) knit bleached fabrics (190 GSM) were used for preparing dyed samples. Sodium carbonate (laboratory grade) was used as alkali origin from china and Glauber salt was used as electrolyte origin from china. Remazol Blue RR was used as dyes from Dystar Germany. Laboratory dyeing machine Ugolin and UV Visible spectrophotometer Data color 650 TM were used for the experiment**.**

All bleached cotton blended knit fabrics samples (Each 5gm) were dyed in a laboratory dyeing machine with alkali concentration 12 g/l, electrolyte concentration 45 g/l, material: liquor ratio 1:8 and according to a set of values for dye concentration (%), dyeing time (min) and dyeing temperature (0^0C) as shown in **Table 1**. However, dye concentration, dyeing time and dyeing temperature are the important factors affecting the color strength in cotton blended knit fabric dyeing. The relative importance of these factors can be seen in models representing the color strength as a function of them. These models may also have application in processing and cost minimization. After dyeing all the samples were washed. At the end, the sampleswere dried and measured reflectance value by the spectrophotometer Data color 650 TM brand in a visible region wavelength at 550 nm. Finally, the color strength (K/S) was calculated by Kubelka- Munk relation [15]as shown in Eq. (1).

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \tag{1}$$

where$K$ is the absorption coefficient, S is the dispersion coefficient and R is the reflectance of dyed fabric.
If the work is supported or funded by any organization, then it must be acknowledged in this section.

Table 1. Dyeing conditions

Process parameter	Value of parameters					
Dye concentration (% o.w.f)	0.5	1	2	2.5	4.5	7
Time (Min)	40	50	60	70		
Temperature (0^0C)	50	60	70			

3.Development of Fuzzy expert system

3.1. Structure of Fuzzy expert system

Fuzzy logic expert system is introduced in this study for the prediction of color strength in cotton blended fabrics dyeing. The general configuration of the fuzzy expert system, which is divided into four main parts as shown in Figure1 are: (1) Fuzzification- which takes the crisp numeric inputs (Dye%, time, and temp) and converts them into information of fuzzy form, (2) Knowledge base- which holds a set of linguistic term, if-then

rules that quantify the knowledge like human experts, (3) Decision making logic-which creates the control actions according to the information provided by the fuzzification module by applying knowledge about how best to control the plant, and (4) Defuzzification-which calculates the actual output, i.e. converts fuzzy output into a precise numerical value (crisp value) and then sends them to the physical system (plant).

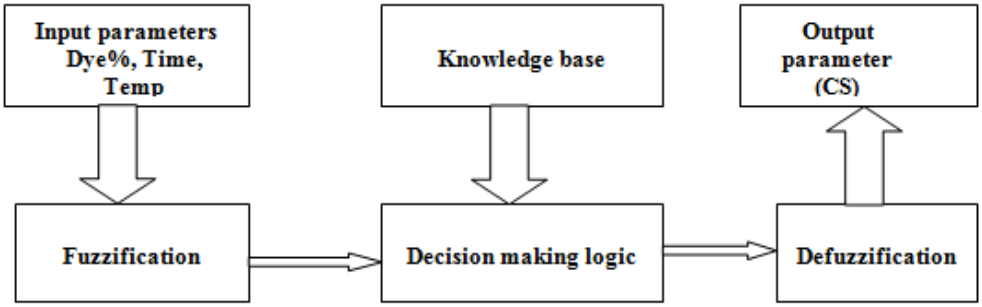

Fig. 1. Basic structure of fuzzy expert system

3.2. Implementation of Fuzzy expert system

In this work, three dyeing process parameters such as dye concentration (DC), dyeing time (DT), and process temperature (PT) have been used as input parameters and color strength (CS) of dyed fabrics has been used as output parameters.For fuzzification of these factors the linguistic variables low (L), medium (M), and high (H) are used for the inputs, and verylow (VL),low (L), medium (M), high (H) and very high (VH) are used for theoutputs. In this study, a Mamdani max-min inference approach and the center of gravity defuzzification method have been used (Fig. 2) because these operators assure a linear interpolation of the output between the rules [16]. The units of the input and output variables are: DC (%), DT (min), PT (0^0C) and CS (dimensionless). For the input and output parameters, a fuzzy associated memory is formed as regulation rules. Total of 27 rules have been formed.

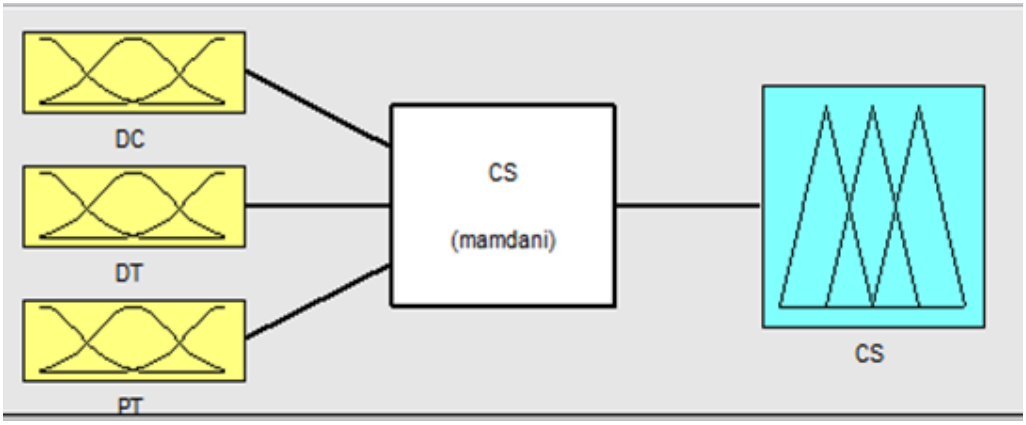

Fig. 2. Basic structure of fuzzy inference system

There is a degree of membership for each linguistic term that applies to that input variable. Fuzzifications of the used factors are made by aid follows functions.

(2)

(3)

$$PT(i_3) = \begin{Bmatrix} i_3; & 50 \le i_3 \le 70 \\ 0; & otherwise \end{Bmatrix} \quad (4)$$

$$CS(o_1) = \begin{Bmatrix} o_1; & 1 \le o_1 \le 22 \\ 0; & otherwise \end{Bmatrix} \quad (5)$$

In Eqns. (2)-(5), i_1 is the first input variable (*DC*), i_2 is the second input variable (*DT*),i_3 is thethird input variable (*PT*) and o_1 is the output variable (*CS*). Prototype triangular fuzzy sets for the fuzzy variables, namely,dye concentration (DC), dyeing time (DT), and process temperature (PT) and color strength (CS)are set up using MATLAB FUZZY Toolbox.

To illustrate the fuzzification process, linguistic expressions and membership function of dye concentration (DC) obtained from the developed rules and is presented analytically as follows:

$$\mu_L(DC) = \begin{Bmatrix} 1; & x \le 0.5 \\ \dfrac{2-x}{2-0.5} & 0.5 \le x \le 2 \\ 0; & x \ge 2 \end{Bmatrix} \quad (6)$$

$$\mu_M(DC) = \begin{Bmatrix} \dfrac{x-2}{3.5-2}; & 2 \le x \le 3.5 \\ \dfrac{5-x}{5-3.5}; & 3.5 \le x \le 5 \\ 0; & x \ge 5 \end{Bmatrix} \quad (7)$$

$$\mu_H(DC) = \begin{Bmatrix} 0; & x \le 5 \\ \dfrac{x-5}{7-5}; & 5 \le x \le 7 \\ 1; & x \ge 7 \end{Bmatrix} \quad (8)$$

Similarly,the linguistic expressions and membership functions of other parameters could be calculated. In defuzzificationstage, truth degrees (μ) of the rules are determined for the each rule by aid of the min and then by taking max between working rules. In this stage, the output membership values are multiplied by their corresponding singleton values and then are divided by the sum of membership values to compute CS^{crisp} as follows

$$CS^{crisp} = \frac{\sum_i b_i \mu_{(i)}}{\sum_i \mu_{(i)}} \quad (9)$$

whereb_i is the position of the singleton in the *i*th universe, and $\mu_{(i)}$ is equal to the firing strength of truth values of rule*i*.

4. Result and discussion

Fuzzy logic expert system has been developed based on dye concentration (DC), dyeing time (DT), and process temperature (PT). The final output (CS) of the fuzzy logic system is verified by using MATLAB Fuzzy Toolbox as shown in Figures 3and 4. The output result can be verified by changing the input variables values in the MATLAB® rule viewer as shown in Fig. 3. For example, if DC is 7%, DT is 40 min, and PT is 50^0C, then all twenty seven fuzzy rules are evaluated simultaneously to determine fuzzy output colour strength (CS). However, some of the rules are remain obsolete as 'fuzzy and' function has been used in the antecedent part of the fuzzy rules and they do not produce any output fuzzy set. Outputs of active fuzzy rules are then aggregated to get a final output fuzzy set, which is finally defuzzified using centroid method to produce the crisp output

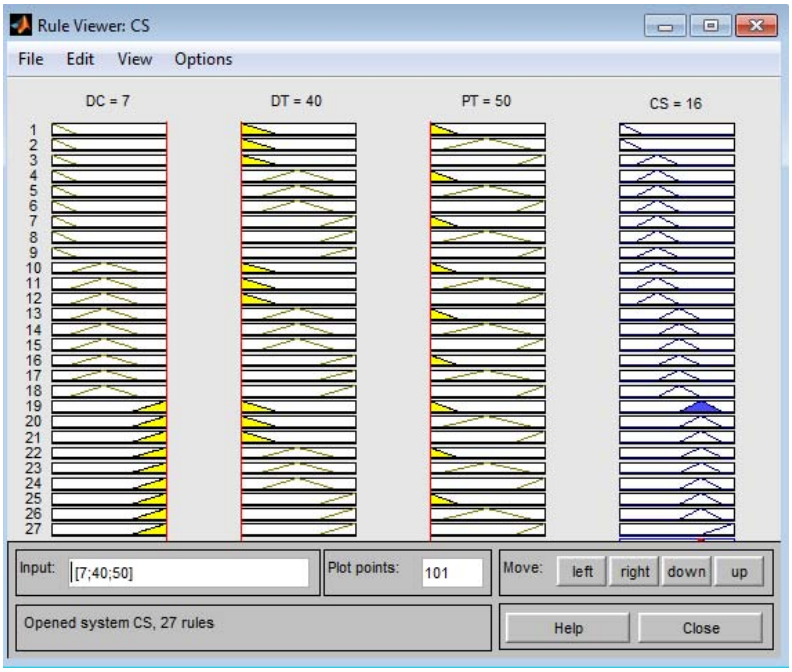

Fig. 3. Graphical representation of the fuzzy logic operation.

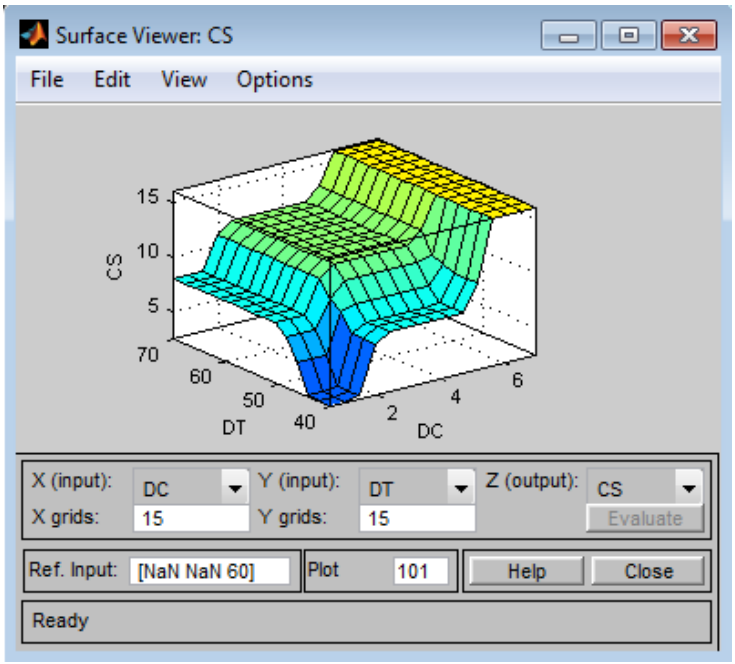

Fig. 4. Control surface of the fuzzy logic system.

(*CS*) of 16 as shown in Figure 3.Using MATLAB the fuzzy control surface is developed as shown in Figure 4. It may serve as visual depiction of how fuzzy logic expert system operates dynamically over time. This is the mesh plot of the example relationship between dye concentration (DC), and dyeing time (DT) on the input side and system outputcolor strength (CS) on the output side. This control surface displays the range of possible defuzzified values for all possible inputs of DC and DT. The plot is used to check the rules and the membership functions and to see if they are appropriate and whether modifications are necessary to improve the output. If

necessary, the rule base for the fuzzy sets is modified until the output curves are desired. In fact, the surface plot shown in Fig. 4depicts the impacts of dye concentration and dyeing time parameters on the colour strength. It shows that as the dye concentration and dyeing time increase positively, there is concomitant increase in colour strengthand vice versaas expected. The colour strengthreaches the apex when the dye concentration and dyeing time both reach their respective maximum level. Similarly, another input parameter process temperature can be included with any of the mentioned two input parameters to show their effect on the output colour strength. However, the surface represents in a compact way all the information in the fuzzy logic system. Hence, it can be noted that this representation is limited in that if there are more than three inputs it becomes difficult to visualize the surface. Furthermore, this figure simply represents the range of possible defuzzified values for all possible inputs.Therefore, it is important to keep the dye concentration in optimum level to get the maximum colour strength and hence sufficient time with process temperature to maintain the normal dyeing operation.

5. Conclusion

This paper employs fuzzy logic expert system to model the color strength of cotton blended knitted fabrics. Color strength has been modeled in terms of dye concentration, dyeing time and process temperature. The expert system was developed by translating the perception and experience of a dyer into a set of expert system rules. Development of fuzzy logic expert for color strength measurement of cotton blended knitted fabric can be done by using fuzzy logic toolbox in MATLAB. The developed model can be used in textile dyeing operation to predict the color strength as per requirement.

However, the developed fuzzy expert system is reasonably easy to develop and it could be modified easily if the dyeing process parameter is changed. Furtherresearches are ongoing to incorporate more input variables in the expert system in order to get more reasonably and good accuracy result. In addition, the developed model will be validated by investigating the experimental results which are in process.

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Paper ID: RT-22

Study of River Bank Sedimentation Using Permeable Structural Measures

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Abstract

River bank erosion is a more or less common issue in our rivers in Bangladesh. On the other hand, the river bank erosion protection by the conventional methods such as the revetment, spur or groin is very costly. We need to find any low cost & cost effective approach. So a laboratory experimental study has taken to address this issue. A series of permeable structural measures i.e. structures prepared by bamboo sticks & chatai are constructed in laboratory flume. With the use of these structures, river bank sedimentation is developed. The velocity distribution at the upstream & downstream of the constructed permeable structural measures has an effect for the river bank sedimentation. The velocities in between the structures are less whereas the velocities away from the structures are relatively higher. It is important to note here in this paper so that the river bank sedimentation has a indication for the river bank erosion protection.

Keywords: laboratory experiment; permeable structural measures; river bank sedimentation; river bank erosion protection

1. Introduction

River bank erosion and channel shifting are recurrent problems in Bangladesh that usually occur during the monsoon (more specifically, during rising stage and recession stage) when huge sediment load is generated by means of bank erosion and bed changes. Conventionally, spurs, groins, revetments or combination of them are used in order to manage sediment load thus generated and mitigate river erosion and related problems. Spurs, groins or revetment-like structures are too expensive to adapt along the longer reaches of the large-scale alluvial rivers in Bangladesh. Therefore, it is important to develop alternative low cost approaches that can be adaptive within local socio-economic and environmental condition.

In Bangladesh, over the years, channel width is increasing and depth is decreasing because of unfavorable geographic location and discharge control by the countries in the upstream reaches that lead to unexpected erosion-siltation processes along the major rivers. It is very difficult and even impossible to maintain in-stream flow requirement that is very important for the maintenance of river ecology and aquatic habitat necessary for the healthy life cycle of plants and animals. Rivers are loosing their navigability and waterways are severely obstructed during the dry season. On the other hand, conveyance capacity of rivers is reducing and is insufficient for safe and expeditious passage of floodwater and sediment discharge during the monsoon. As a result, country had experienced severe flood disasters during the past such as in 1988 and 1998. However, the situation seems to get more severe gradually as compared with the past events.

Floodplains and riverbanks are developed from recent deposits consisting mostly silt and fine sand that are highly susceptible to erosion. As a result, the river channels often shifts within wide range of river belt. To prevent the river erosion groins, spurs, revetments, porcupines, sand bags, boulders etc are applied. Some of these methods (groins, revetments) are very expensive considering the large river dimensions and corresponding limited financial strength of Bangladesh. On the other hand, porcupines, sand bags, boulders are being used from experience of local people against river bank erosion and none of these methods have been proved to be effective for the protection of river erosion in long-term basis.

Bandals are one of the local structures developed in the Indian sub-continent that obstruct flow near the water surface and allow it to pass near the riverbed. These are made of naturally available materials such as bamboo, wood etc. and regarded as inexpensive method over conventional structures and mostly applied for the improvement of navigational channels during the low flow season. But application of Bandalling for riverbank protection is not yet practiced in Bangladesh. In recent past some field tests along the Jamuna was executed for the bank protection using Bandalling (FAP 21/22, 2001). At the laboratory scale, the preliminary idea on the possibility of use of Bandalling for sediment management (erosion and siltation) was discussed (Rahman et al., 2003, 2004).The main objective of the laboratory experimental study in order to investigate the sediment deposition and the flow field around bandals that are conducted under different scenarios.

2. Methodology

To achieve the objectives of the study, an experimental set are taken in re-circulated straight flume that is 22 m long, 2.2 m wide and 1.05 m deep. The flume setup was in live-bed condition. The effect of a series of bandals structures are examined in terms of the arrangement of spacing & with certain angle of the flow direction in the flume river channel. The laboratory experimental set-up with the circulated water supply system is shown in Fig.1 & Fig. 1a.

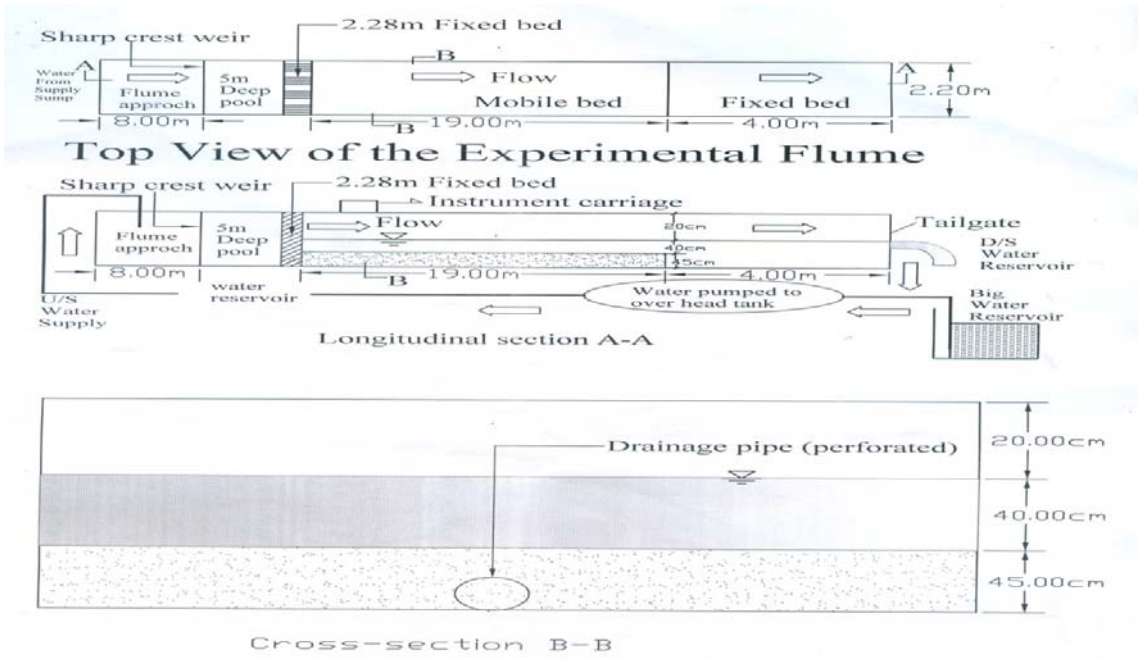

Fig.1 Laboratory experimental set-up with the circulated water supply system

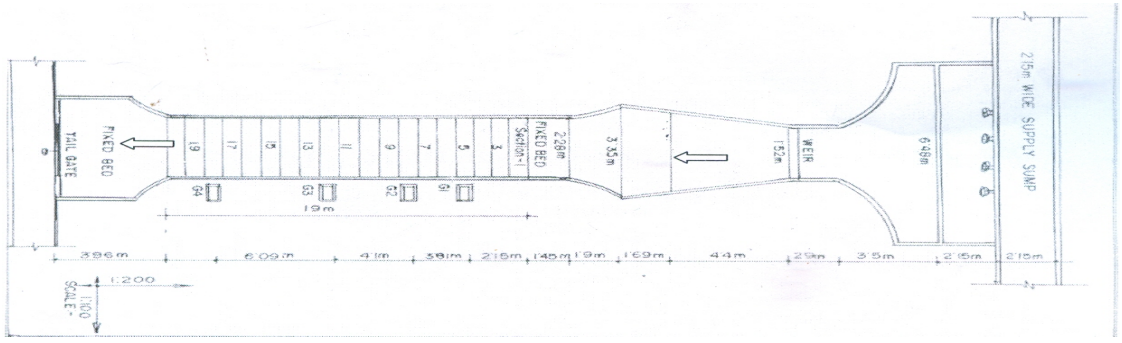

Fig. 1a The experimental test rig using for velocity measurement as wel as the bed level data collection

The laboratory channel/ flume width is 2.2 m which 30% i.e. 66 cm is blocked at the right bank by the bamboo bandalling structures. The test scenarios with the different channel parameters are seen in table-1.

Table -1: Matrix showing different experiment scenarios of the laboratory flume/channel

Channel/ Flume Contraction (C) in percentage	Angle with flow Direction in degrees (θ)	Length of the Bandal in centimeter (L)	Spacing between the bandals in centimeter (S)	Opening below the bamboo chatai in the percentage of water depth (36 cm) of the channel/flume in centimeter (O)	No. of bandals (Test name)
30	30	132	1.5*132=185	40	4 (T2.1.1)
			2.5*132=330	40	3(T2.3.1)

3. Result & discussion

As the channel is blocked by 30% at the right bank of the channel, the sedimentation is occurred near the right bank which is shown in Fig.2 whereas the channel bed is deepen away from the right bank. In the Fig. 2, the x-axis shows the channel length from upstream to downstream in metre along the main flow of the channel whereas the y-axis shows the channel bed level measured from a Temporary Bench Mark (TBM) from the different grid points at 25 cm intervals from the right bank. The plot line shows the initial bed level as well as the river bank sedimentation due to effect of the bamboo bandalling structures along the channel length of the laboratory flume .

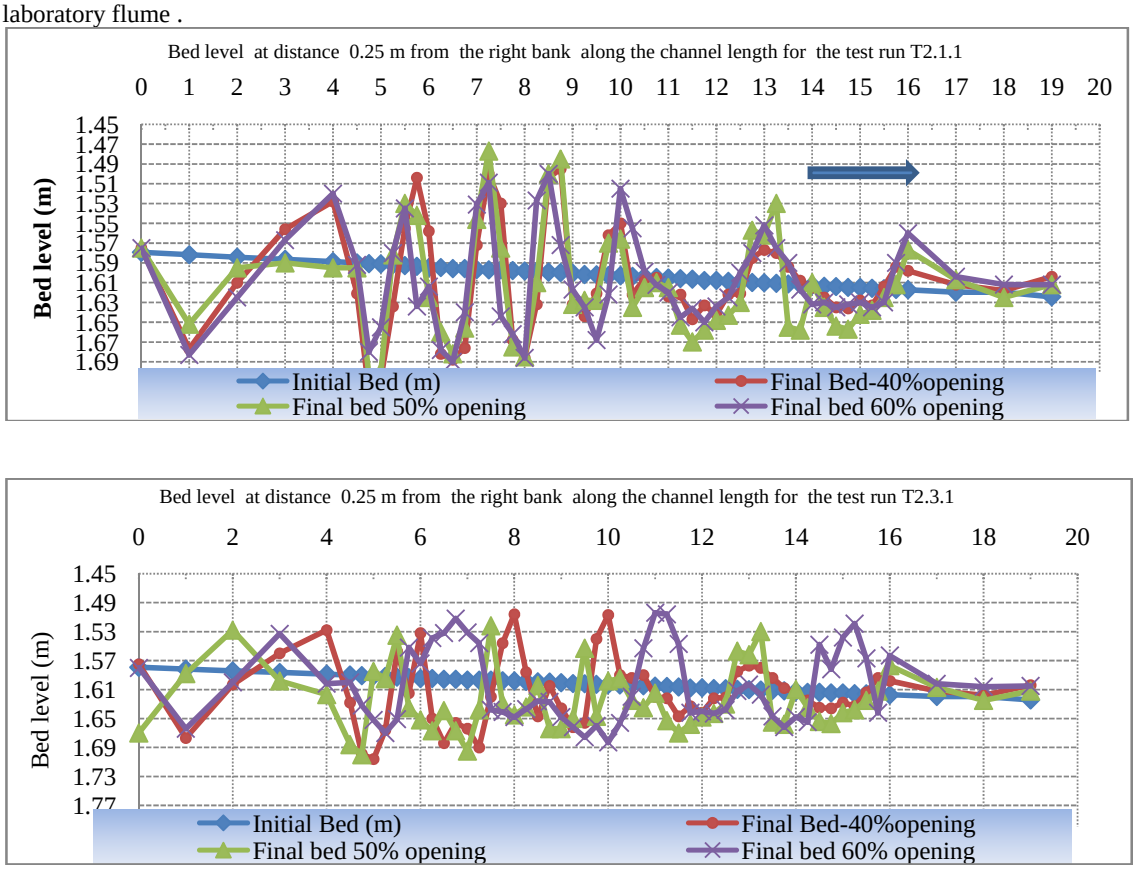

Fig.2 River bank sedimentation of the bamboo bandalling structures constructed in the laboratory flume .

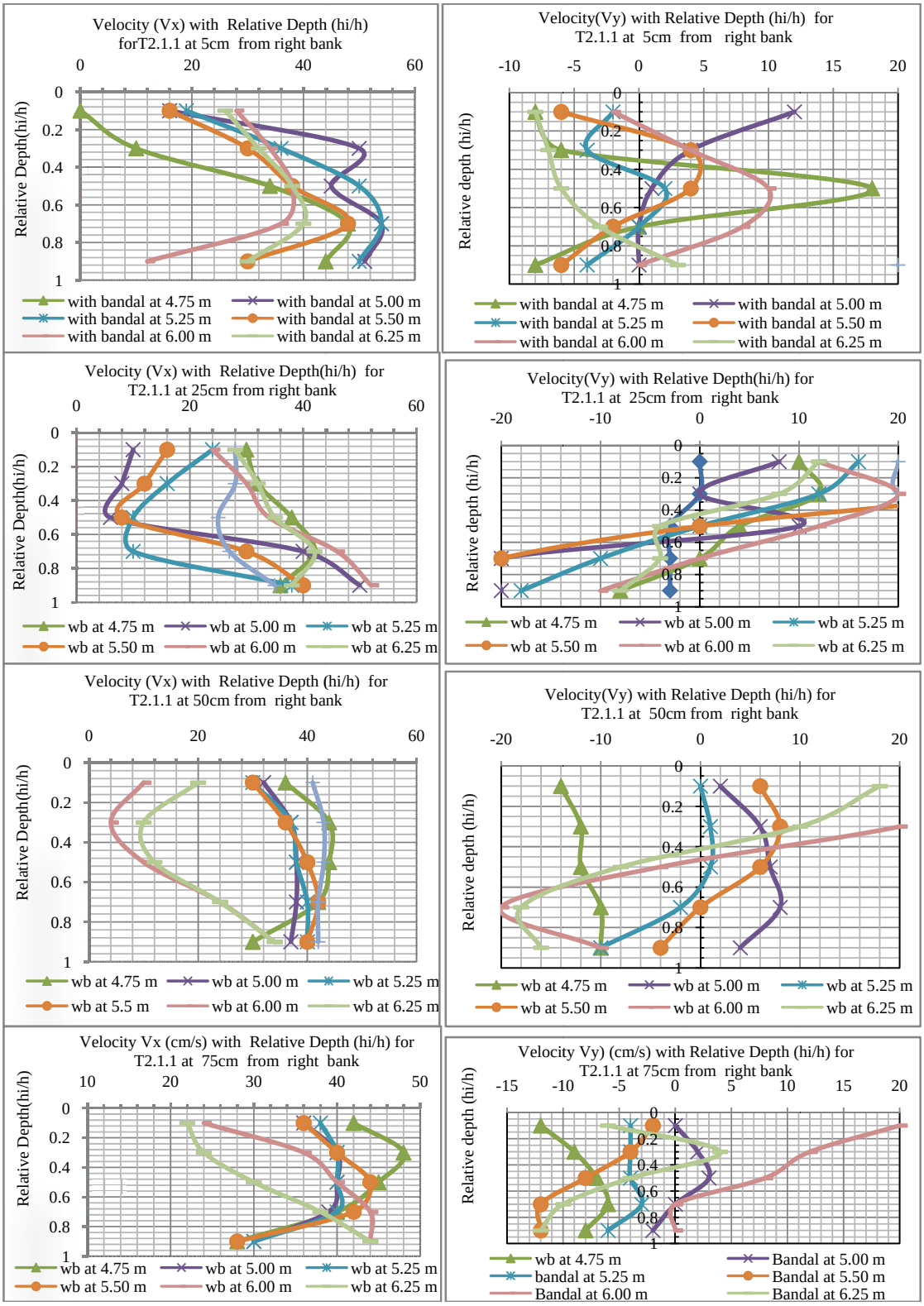

Fig.3 : Velocity distribution at different grid points at depth 0.1h,0.3h,0.5h,0.7h & 0.9h where h=36 cm

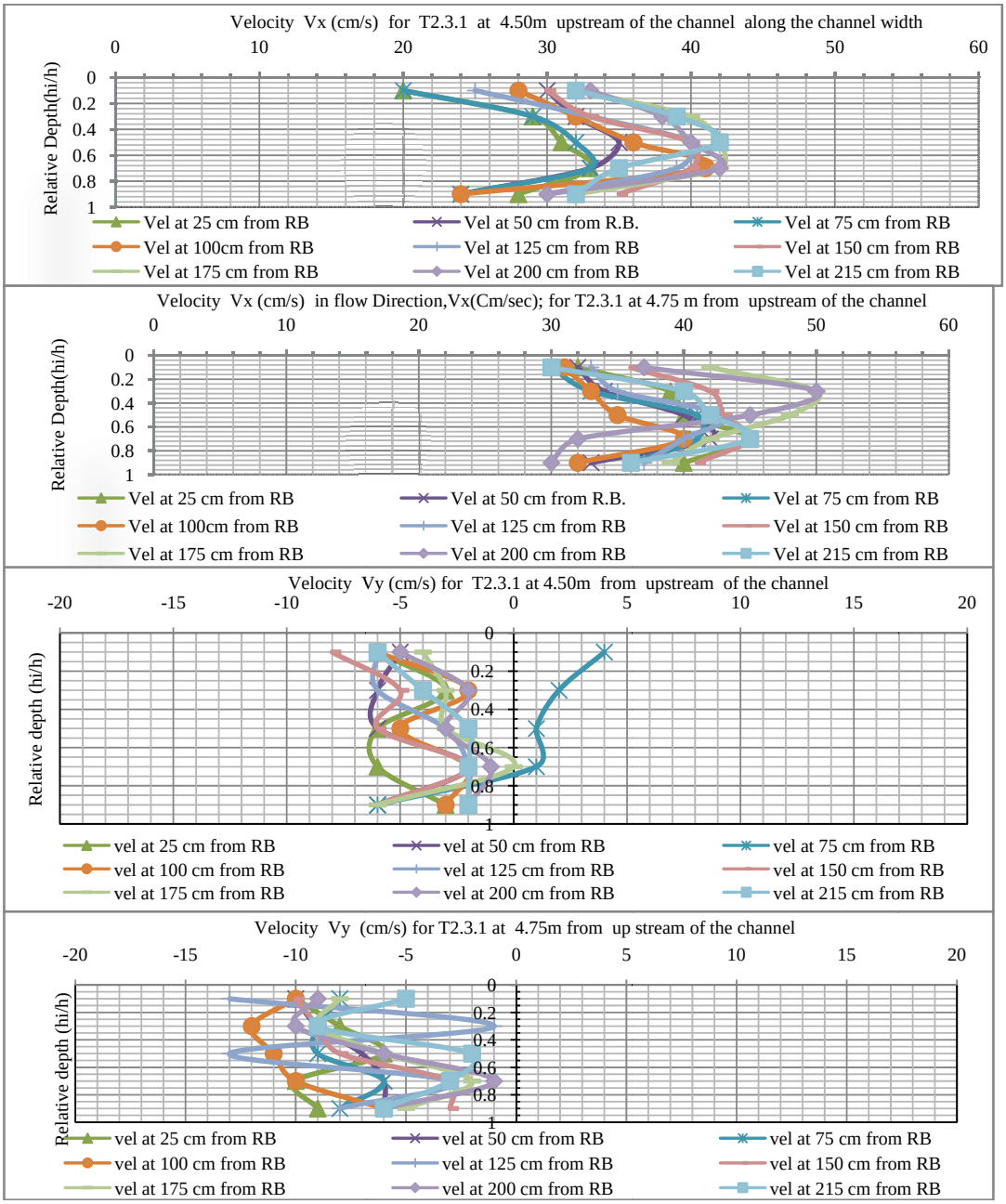

Fig.4 : Velocity distribution from right bank (RB) at depth 0.1h,0.3h,0.5h,0.7h &0.9h where h=36 cm

There are four bamboo bandalling structures are constructed near the right bank of the laboratory flume for test run T2.1.1 as in Fig.3 and that of 3 bandals are constructed as in Fig. 4 for the test run T2.3.1. Tthe velocities are measured at 25cm grids except the 1st one is measured at 5cm from the right bank. The grid points velocities are measured in each points at depths 0.1h, 0.3h, 0.5h, 0.7h & 0.9h from the water surface where h is the depth of water at initial bed condition which is 36.00 cm. As in Fig.3, distribution of velocities at distance 5cm from right bank at points 4.50m,4.75 m, 5.0 m, 5.25 m, 5.5 m, 6.0 m & 6.25m are measured and graphically presented for test run T2.2.1. If the velocities are taken at point (4.75m, 5cm), it is seen that at 0.1h water depth velocity is much less and that velocity increases in deeper water at points 0.3h, 0.5h & 0.7h. It appears to be realistic, because the points 0.1h, 0.3h are behind (downstream) bamboo chatai. Bamboo chatai blocked water current down to 18 cm (0.5h, 50% blockage in this test arrangement). As a result, the velocities are much less. But at 0.7h depth velocity is maximum at this grid location. It is obvious since this point is below the bamboo chatai. So the point is in the opening (water could flow freely below the chatai). Now the lowest point (at 0.9h

depth) shows again relatively less velocity than that at 0.7h. Again it is realistic since it is near the bed & influenced by bed friction or other parameters.

Similarly if compared velocities at grid (4.5m, 5cm) with that at other grid points such as (5.0m,5cm),(5.25m,5cm),(5.5m,5cm),(6m,5cm), (6.25m,5cm) that shows higher velocities (but nature of vertical distribution is similar). It is realistic/ natural since the grids lies downstream and further away from the structure (Chatai), the chatai has less influence on this grid point. If velocities at grid points away further from 5cm such as 25cm, 50cm and 75cm is considered as in both 3 & Fig.4, it is seen that the velocities further away from 25 cm & 50cm and in more distance from the right bank are higher in magnitude. This is obvious, since they are away from the structure and the structure has less influence on them.

The velocity Vx distribution profiles as in Fig. 3 & Fig.4 represent the result as in Fig.2 in which there is sedimentation behind the bamboo bandals near the right bank of the flume. From Fig, 2, it is clear that the river channel bank is deposited where as Main River central channel is deepening to improve the navigational channel development. Although there is an idea from the Fig. 2 so that the river channel is deepen away from the right bank & at the same time the sedimentation near the river bank. Again from the Fig.3 & Fig.4, it is clear that the channel flow velocity is less behind the bandal as well as the velocity away from the influence of bamboo bandals i.e. from right bank is more or grater.

In case of velocities Vy perpendicular to the main flow velocities Vx is considered as in Fig. 3 & Fig.4, all the Vy velocity components moves towards the right bank & in these case the velocities are working as a sediment carrying agent. For the case of the velocity Vy perpendicular to the main flow velocity is always scattered and direction of these velocities are negative in magnitude that indicate the velocities are in towards the right bank that carry additional sediment near the right bank so that the river bank sedimentation occurred near the channel right bank.

5. Conclusion

In conclusion, we can say that bandals are capable for flow diversion towards the main channel leading to deep navigational channel formation. On the other hand, flow velocities are reduced near the bank lines that ensure sediment deposition. . If the bandal structure functions optimistically, the river can get sufficient time for its adjustment and new main channel and bankline development.

6. Recommendation

Pilot projects are recommended in the field are very important to execute before applying such method for the formation/ restoration of navigational channels in alluvial river. The output of the present research for the stabilization of river course can solve the problems of Bangladesh that is more or less inherent due to its complex geographical location at the lower riparian of the catchments

Acknowledgement

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Paper ID: RT-23

Zincalume Profiled Steel Sheet for Self-supporting Roofing Element

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Abstract

Profile steel shell structures are used popularly due to aesthetic and economical use of materials. The aim of this research work is to develop a self-supporting roofing element using profiled steel sheet such as Zincalume, with potential for application in affordable quality housing. An experimental study on the structural strength and behaviour of a selected roofing element is conducted to validate the numerical investigation. This kind of roofing system has significant advantages of removing the internal trussing and support. An attempt has been made to find out efficient, economic and aesthetically pleasing shape of shell elements to provide self-supporting roofing system on the basis of present results. It is showed that parabolic roofing element having crown height 1/6 of chord length is more efficient than others. It can be concluded that the proposed roofing system has a great potential to be exploited for housing construction.

Keywords: *Profile steel sheet, Zincalume, Self-supporting Roofing Element, Thin shell, FEM analysis.*

1. Introduction

Shelter, the second basic need of man, has been a preoccupation for many governments all over the world trying to house their growing population. The roof protects the building and its occupants from the effects of weather, but it are also is an architectural feature that gives the building a desired appearance. Roof accounts to a substantial part (about 25%) of the total cost of a building whether it is residential or industrial [1]. Therefore, it demands high technical and design specifications for both of the individual products elements and for the roof as a whole in order to achieve a satisfactory design life. Recent trends, research and developments are directed towards developing a lightweight, economical and structurally strong material that can be precast or prefabricated and easily erected. Conventionally, profile steel sheet such as zincalume and galvanized iron sheet is using in roof as a covering. The use of the corrugated metal thin shells in roofs, leads to considerable saving in materials, labour and cost. Analytically critical loads of self-supporting cylindrical roofs can be found out by energy theorem [2]. The possibility of using these sheets in folded plate roofs was investigated [3]. A study has been performed on structural strength and practical applications of cylindrical shell roofs made of corrugated metal sheets [4]. The exact differential equations used to explain the behavior of orthotropic shells. More recently, a study was carried out to develop a procedure for the design of steel roof subjected to non-uniform loads such as drifted snow using purlins frame [5]. Self-supporting concept was not considered in their study. Rib steel deck ware used as a covering materials, without any attention paid to their structural capability. Geometric and materials nonlinearity also was ignored. Extensive study on support settlement of cylindrical shell roofs was carried out [6-8]. Experimentally an investigation on structural strength and behaviour of ferrocement semicircular roofing elements were conducted [9]. Theoretical studies relating to ferrocement have been reported in the literature observed and found out an optimum shape within selected five shapes [10-11].

The main objective of this study is to develop a self-supporting roofing system, with potential and efficiency for application in affordable quality housing. Structural behavior of Inverted V shape, Cylindrical, Parabolic, Doubly curve, Single pitch and Flat plane shell roofing system are investigated numerically to provide as a self–supporting roofing system. This research was an attempt to investigate the contribution of corrugated sheet in reducing the buckling and displacement and enhances its load carrying capacity. An experimental program was undertaken in the course of present study. The experimental results showed good agreement with those obtained theoretically. The deflection and stress behavior of different types of roofing

elements are compared each other. The efficient and economic shape of self-supporting roofing elements has been found out after a through investigation on the basis of present results.

2. Roofing Material Zincalume

Normally corrugated metal sheet such as Zincalume is used in roofs as a covering only, while depending on different types of intermediate support. A self-supporting roofing system is when a roof runs its continuous length from on end to other end support by eliminating internal supports such as purlins, rafter, fastener and truss. This method provides a particularly neat and attractive solution to roofing whilst eliminating the ridge capping, thereby avoiding any possibility of leakage along this fitting. This roof can save material, construction and erection cost.

The shape and size of precast/prefabricated roofing element is chosen to satisfy the general requirements of strength and stiffness, lightness and economy, ease of handle and erection, proper seating and leak proof joint. There are different types of materials for construction of roof frame and roof covering. Common types of materials are metal sheet, ferrocement, plastic, and concrete and clay tile for roof covering. Timber and metal are normally used for the trusses. For this investigation the corrugation metal sheet Zincalume was chosen in an effort to develop the self-supporting roofing system. The main features of using of Zincalume sheet as a roofing material as according to Bluescope-Lysaght [12] are as follows;

(a) Speedy installation; no shuttering required, Less installation errors
(b) 30-40% cost saving over RCC roofing
(c) Lower dead load on the walls, Light weight and easy handling
(d) High strength to weight ratio
(e) Easy to for into complex shapes, new shape more efficiently allowing to be used.
(f) Elegant profile and uniform sizes, large span possible with intermediate supports
(g) Abundantly available, and inexpensive, corrosion-resistant
(h) Fire registrant, Material consistency high
(i) Unaffected by termites and longevity
(j) Does not required paint
(k) No materials wastage, recyclining system is applicable
(l) Economical considering mean service life

Zincalume sheet can be considered as the best and most durable roofing elements for affordable quality housing in the world. Zincalume consists of high strength steel substrate protected with corrosion inhibitive treatments and coatings designed to provide the broad spectrum of performance that is essential for long life and minimum maintenance. All steel sheets used in the manufacture of the roofing sheets shall have a protective metallic alloy coating of zinc (43.5%) aluminium (55%) and silicon (1.5%), applied by the hot dip process and having a coating thickness of 0.05mm as stipulated in AS1397-1993 for coating class AZ 150. Chromic acid sealed, zinc phosphate pretreatment is applied after alkaline cleaning for coating. Galvanized steel is treated on both sides with phosphate conversion coating followed by application of an impervious epoxy primer incorporating a corrosion inhibiting compound. Modified polyester coating of 20 micrometers is used for finish coat to ensure maximum durability. Composition layer of zincalume is shown in Figure 1.

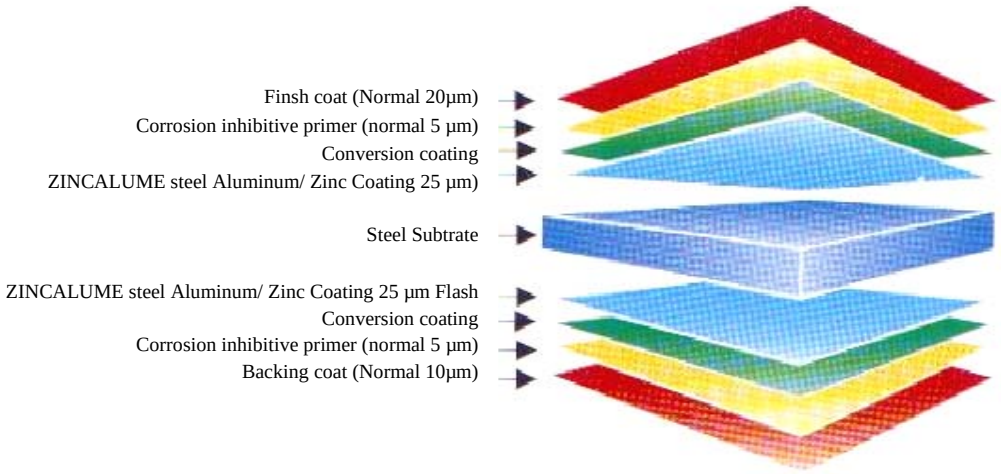


Fig. 1. Different composition layer of Zincalume sheet of Bluescope-Lysaght [12]

Zincalume, which is used in the investigation, are locally available in Malaysian, Singapore and Australian market. It is obtained strength as steel grade ASTM A446 E, minimum yield strength 550 Mpa, Modulus of elasticity E = 210 Gpa, poisons ratio ν = 0.30: mass = 4.7 Kg/m2 (for thickness of 0.47 mm sheet). Zincalume obtained two basic strength grades G 550 and G 300, which is shown in Figure 2. High tensile steel G550 was used in this study to develop self-supporting roofing elements.

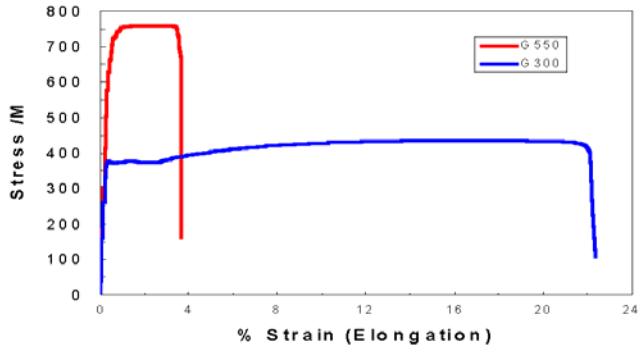


Fig. 2. Stress-strain diagram for Zincalume steel of Bluescope-Lysaght [12]

3. Field Application of Profiled Steel Sheet for Roofing

The purpose of a structure is to transfer external forces to the supports through structural elements. The trend of modern architecture is now changing from traditional flat surface towards curved shapes that encloses a volume of space. Shells are structures that can be idealized mathematically as curved surface for building roofs. Shells are being used on an increasing scale for roof. Shell element is suitable for roofing because of its efficiency as load carrying member with a high degree of reserved strength and structural integrity, high strength to weight ratio, very small thickness ratio to other dimension, very high stiffness and containment of space. A shell which is formed by translating a curved line along a straight longitudinal axis and which span longitudinally between supporting diaphragms is termed as cylindrical shell. The cylindrical shell is the simplest form of shell, which can be employed in roofing engineering due to its singly curved surface. Figure 3, 4 and 5 illustrates the different applications of profile parabolic shell roof.

Fig. 3. Profile Parabolic Shell Roofing Element Bluedcope-Lysaght [12]

Fig. 4. Profile doubly Curve Shell Roofing Element of Bluescope- Lysaght [12]

Fig. 5. Self-supporting roofing element at Universiti Pulra Malaysia

4. Finite Element Models

The shell roofing element were models and analysed employing the finite element software LUSAS [13]. The shell-roofing element was analysed as a 3-D problem. It was discretised by means of 8-noded semi-loof elements having three translational displacements in the global axes at the corner and mid side nodes and one rotations with respect to axes in the plane of middle surface as shown in Fig.6. At first an arc was drown by three Cartesian points and then translate required width and corrugation for profile sheet. Width of different types of roofing elements was considered as 0.76m and 8.0m for analysis. Thickness of flat sheet and profile sheet were assigned as 1.2mm and 0.47mm respectively. A nonlinear analysis was carried out assuming Zincalume to be elastic-plastic material. The model was subjected to global distributed load along the vertical direction. Different types of roofing element such as Inverted V shape, cylindrical, parabolic, doubly curve, single pitch and flat plane have been subjected to incremental global distributed load. The boundary conditions for the roofing element were assumed as fixed, pin and simple supported to make a comparative study of effect of boundary condition. Different mesh sizes and different numbers of element were tried so that accurate results could be obtained.

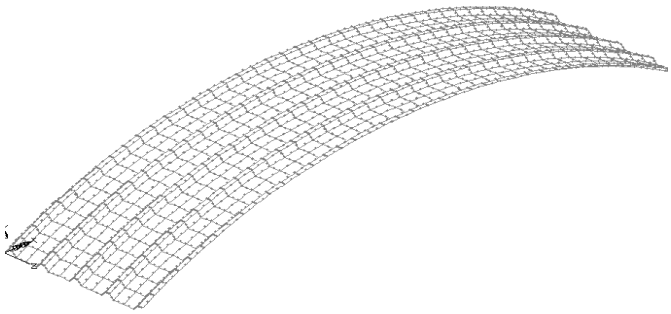


Fig. 6. Finite element model of profile of parabolic shell roof

5. Experimental Investigation

In order to verify the validity of the finite element analysis of different type of roofing elements, critical and limited model test is conducted. The dimension of the model was span 3.0m, width 0.76 m and crown height 0.125m, 0.25m, 0.5m, 1.0m and 1.5m respectively. All specimens were tested to ensure curve edge free and straight edge hinged. U type metal channel were used to provide hinge support at straight of cylindrical and parabolic shell roofing element to maintain self- supporting condition. All the specimens were tested in the vertical position. Sand bag loading was used to provide uniformly distributed load. Each bag was contained 5 kg load. The load was applied manually by gradually increased until yield failure of the model. 4 deformation gauge, 2 LVDT and 10 electronic strain gauge are used to measure deflection and stain. Deformation gauge and LVDT were set at the center of bottom surface for the specimen with required stand. Strain gauges also were used the mid position of top surface of the specimen. Figure 7 and 8 are shown sand bag loading and failure mode respectively.

Fig. 7. Sand bag loading on cylindrical shell roofing

Fig. 8. Experimental deflected shape

6. Results and Discussions

In shell elements, it is observed that corrugated sheet is structurally 10 times stiffer than flat sheet, which is shown in Table 1. Profile sheet is stronger because of its rib and section modulus. According to the non-linear finite analysis, parabolic shell roofing element is more efficient than other type of roofing element due to its less deflections and stresses. Parabolic and cylindrical roofing elements obtain arch action so load carrying was higher. Non-linear analysis and those obtained experimentally that is shown in Figure 9. The load –deflection, stress strain and deform shape profiles for investigated roofing element showed that parabolic roofing element having crown height 1/6 of chord width is more efficient than others as self supporting condition [14]. It is observed that a parabolic shape roofing element with optimum crown height is structurally and economically able to use as a self-supported supporting roofing system for 8 m span lengths using 1.2 mm thick corrugated Zincalume. Nine types of roofing elements are studies in the present work. The presence of corrugation in the metal roofing element resulted in a significant improvement on the roof's structural performance compared to flat sheet element. Experimental load-deflection profile of different crown height parabolic roof using 0.47mm thick corrugated Zincalume sheet, 3 m span, 0.76m width and pin support along the straight edge are shown in Fig. 9. Good agreement was found between the results from non-linear analysis and those obtained experimentally as shown in Fig. 10.

Table 1. Displacement of parabolic roofing elements with different span length

Type of Roofing System	Thickness of Materials (mm)	Applied load KN/ M^2	Span 3 m	Span 4 m	Span 5 m	Span 6 m	Span 7 m
			Deflection (mm)	Deflection (mm)	Deflection (mm)	Deflection (mm)	Deflection (mm)
Parabolic shell roof	0. 65 (Flat sheet)	0.528	44.5	171	384	688	1210
	0.47 (Profile sheet)	0.528	4.99	9.58	21.54	42.50	228.0

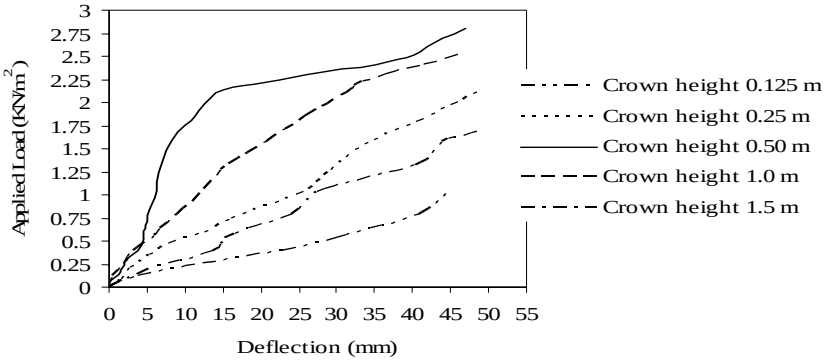
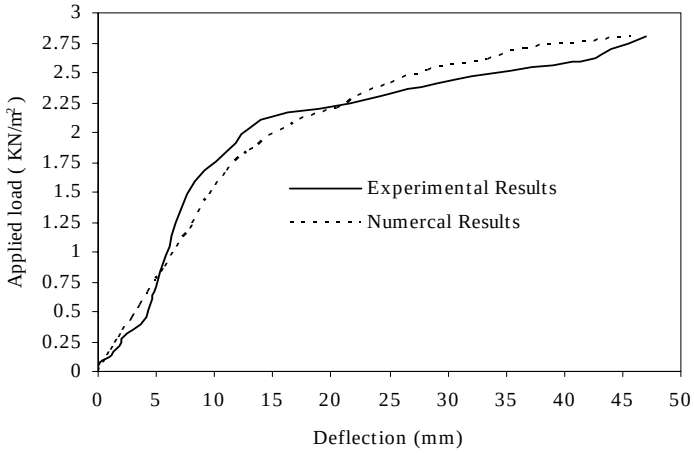


Fig. 9. Experimental load deflection profile of different crown height parabolic shell roofing element



Crown Height 0.5 m (1/6 of cord width), Span 3 m, zincalume corrugated metal sheet, pin support along the straight edge, Circumferential edge free, thickness 0.47 mm

Fig. 10. Comparison between Experimental and Numerical deflection for parabolic roofing element

7. Conclusions

Conventionally, metal sheet such as Zincalume and GIS is using in roof covering through truss as a covering. It has been implemented a novel and new approach to provide self- supporting roofing system. The behavior of nine different types of roofing element is studied to find out an economical, efficient, architecturally pleasing shape in self -supporting condition. Nonlinear effect has been adopted in the finite element analysis. From the parametric study, it is found that the central deflection and stresses are least in parabolic shape of roofing element with crown height about 1/6 of chord length. On the basis of the present analysis, it is found that the parabolic shape profiled Zincalume steel shell element is the most economical, efficient, architecturally pleasing shape in self- supporting condition.

8. Acknowledgement

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Strip Tillage Seeding Technique: A Better Option for Utilizing Residual Soil Moisture under Rainfed Moisture Stress Environments of North-West Bangladesh

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Abstract

Strip tillage seeding system technique is a conservation agriculture based resource conserving technology, which employs tilling the soil in strip just in front of furrow opener and place seed, and fertilizer in line at right depth in a single operation just after aman rice harvest to utilize the residual soil moisture for crop establishment. especially in rainfed moisture stress areas. The rotating strip blades can operate through moderate anchored previous crop residues without plugging and dragging with furrow openers. The seeder creates 4-6 cm wide planting strip and produce good tilth for better seed and soil contact which facilities better plant germination. A multi-location experiment was conducted to evaluate the performance of strip tillage for wheat, lentil and mungbean during 2008-2011 in Rajshahi district, Bangladesh. The higher soil moisture (16.4 %) was maintained at 35 days after seeding under strip tillage than full tillage treatments (13.4 %). The effective field capacity was 27 % higher with strip tillage than minimum tillage (Power Tiller Operated Seeder). The total time requirement for field preparation and planting was highest in conventional tillage (17.5 hr/ha), intermediate in minimum tillage (6.7 hr/ha) and lowest in strip tillage (5.26 hr/ha). The fuel consumption during seeding operation was 57 % and 38 % lower than conventional and minimum tillage, respectively. The strip tillage achieved higher grain yield (wheat 4.96t/ha, lentil 1.4t/ha, mungbean 1.5 t/ha) in all three crops with a net saving in cost of sowing BDT 3050/- ha^{-1} than conventional tillage. In this study, we found that the break-even point of strip tillage seeder was 4.0 ha in a year for service providers.

Key words: *Strip tillage, minimum tillage, conservation agriculture, break-even point*

Introduction

Agricultural machinery plays an important role to reduce drudgery of farm works, turnaround time and production cost. The current methods of land preparation and sowing operations are very exhaustive, expensive and time-consuming for crop production. Right amount of seeds and fertilizers and right placement are necessary for good germination and crop establishment thereby better crop yields [1]. Strip till planting system in which tilling the planting strips and accomplished seed and fertilizer placement simultaneously in a single operation, thereby reducing the number of field operations which is environment friendly because of low fuel consumption and less soil disturbance. In this system land is remain untilled between the two seeding lines. No till facilitates improvement of soil quality, reducing the surface soil erosion and keep residue over the soil surface which reduces soil moisture losses [2, 3].

Farmers of Bangladesh are becoming more dependent on mechanical power. Now a days two wheel tractor operated power tillers are available all over the country. There are about 700,000 two wheel tractors (2WT) in operation [4]. Survey showed that the use of 2WT in wheat planting is gradually increasing for example, 11%, 17% and 55% in 1991, 1992, and 1994, respectively [5, 6]. The turn-around time between T. Aman (Monsoon) rice harvest and wheat seeding is very narrow only 15-20 days. After harvesting of T. Aman, farmers do not have enough time for land preparation with current conventional tillage practices that results in delayed wheat planting and high risk of soil moisture losses. Delay in planting is one of the main constraints in wheat production. Generally after harvesting T. aman, 10-22 days are required for field preparation under conventional tillage, which includes 4-5 ploughings followed by 3-4 times laddering. Power tiller operated seeder (PTOS) performs tillage operation, seeding in line and seed covering simultaneously. During last few years, performance of strip tillage seeder was demonstrated at different locations of North-West Bangladesh. In the strip tillage system crop residue remains on the soil surface, which helps to

preserve soil moisture and also have smothering effect that partly reduces weed infestation, especially in rainfed moisture stress environments.

The objectives of the study were,

(i) To establish crop under strip tillage seeding system utilization of residual soil moisture;
(ii) To demonstrate and evaluate strip tillage performances for different crops under rainfed moisture stress areas, and
(iii) To compare the cost of planting between strip tillage seeder and the conventional methods.

Materials and Methods

Power tiller operated seeder (PTOS) has 48 numbers of rotating blades for pulverizing soil at shallow depth with very high speed rotating blades. The seeding part is attached with power tiller replacing the rotavator part of the power tiller. In strip till system, rotating blades were reduced to 24 numbers. Only 4 blades in face to face configuration remain in the gang at front position of seed furrow opener for tilling in 4-6 cm strip and creating tilt soil just in front of furrow openers and between the two furrow openers the soil remained untilled. The "J" type blades of the seeder rotates at the speed of 450 rpm. Simultaneously, the seed and fertilizer placement was done in a single operation. (Fig.1). The experiments were conducted in Chargat, Durgapur, and Puthia area of Rajshahi district during 2008-2011. Wheat, and lentil were planted after the harvest of T. aman rice and mungbean was planted immediately after wheat harvest using residual soil moisture. Rice was harvested at 20 cm height to keep around 30% anchored residue.. Recommended fertilizer was used and placed during seeding operation. Each block was separated into three parts for the three methods of tillage: (i) Strip tillage (ii) minimum tillage by PTOS, that means full shallow tillage in one pass and (iii) conventional tillage broadcasted method. During the study the following observations/ data were collected (i) Seeding depth/placement (cm), (ii) Implement travel speed (km/hr), (iii) Effective field capacity (ha/hr), (iv) Field efficiency (%), (v) Fuel consumption (l/hr), (vi) No. of plant/m^2, (viii) Soil moisture (%), (ix) Yield(t/ha) (x) Tillage cost BDT.

Fig.1. Strip till seed drill

Results and Discussion

Three years results clearly showed that the retention of soil moisture was longer under strip tillage system as compared to conventional and minimum tillage (Fig 2). The maximum soil moisture content (16.4 %) at 0-15 cm soil depth was observed at 35 days after seeding under strip tillage techniques followed by (14.2 %) with minimum tillage (PTOS) and conventional tillage methods (13.24). The higher soil moisture content under strip tillage could be due to less soil disturbance, and residue management that might have reduced surface evaporation than that of minimum and conventional tillage.

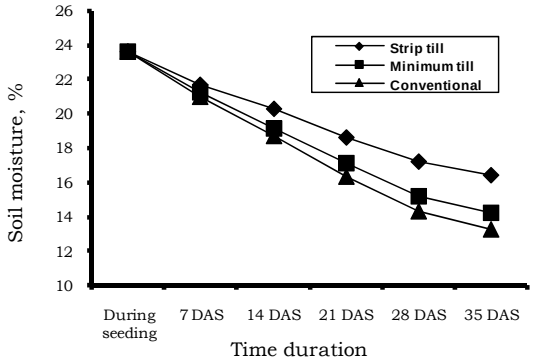

Fig. 2: Soil moisture variation after seeding

Performance of strip tillage, minimum tillage by power tiller operated seeder (PTOS) and conventional tillage is shown in the Table 1. The effective field capacity of the seeder in strip tillage method was higher (0.19 ha/hr) than minimum tillage (0.15 ha/hr). In strip tillage method, seeder moved (19%) faster than minimum tillage seeder (PTOS). The higher effective field capacity and speed under strip tillage system might be because of work load variation due to less tillage area with half number of blades, their configuration and alignment that resulted in less slippage losses and more surface area coverage. The fuel consumption measurement was also made under different tillage systems during planting and field preparation. In strip tillage seeding, 57% and 38 % lower fuel consumption were recorded than conventional tillage and minimum tillage seeding, respectively. The lower fuel consumption under strip tillage (5.8 l/ha) was due to, partial soil tillage, and less power requirement by reducing the number of tilling blades.

Table 1: Comparative performance of different tillage methods

Sl. No.	Parameter	Strip tillage	Minimum tillage	Conventional
1	Travel speed (km/hr)	2.5	2.1	-
2	Effective working width, cm	120	120	-
3	Effective field capacity (ha/hr)	0.19	0.15	-
4	Drive wheel slippage (%)	6	8	-
5	Fuel consumption (lit./ha)	5.8	9.3	13.6
6	Total time requirement (hr/ha)	5.26	6.7	17.5

Results clearly showed that seeding operation by strip tillage method were completed in 5.26 hrs for one hectare land compare to 6.7 hr and 17.5 hr of minimum tillage and conventional broadcasted method, respectively. The seeding operation through strip tillage saved 69% time compare to conventional tillage and broadcasted method.

Fig.3: Strip till wheat field

In strip tillage and minimum tillage (PTOS), seeding depth was maintained at 3-4 cm and it could be adjusted as per crop type and soil moisture level but in conventional tillage broadcast system, there is no mechanism available to maintain the seeding depth and it can be varied from 0-8cm depending on tillage depth and type of tillage implements used for mixing the seed. In new seeding techniques, strip tillage and minimum tillage seed rates was 120 kg/ha compared to 155 kg/ha under conventional tillage broadcasted system. In conventional broadcasted method 20 % higher seed rate were used than recommended rate to mitigate improper seed germination risk because of improper seed placement. The placement of seed and fertilizer at right depth and amount resulted better crop establishment in different crops under strip tillage and minimum tillage compared to conventional system (Table 2). The higher plant population of wheat (286/m^2), and lentil (195/m^2)under strip tillage than conventional system (wheat=255 /m^2, and lentil=180/m^2) might be due to better soil to seed contact, less soil moisture depletion after seeding and better seed and fertilizer placement at right depth. There was no difference for mungbean was quite surprising (Table 2).

Table 2. Comparative performance of strip tillage, minimum tillage and conventional tillage method in 2011

Parameter	Strip tillage			Minimum tillage			Conventional method		
	Wheat	Lentil	Mung	Wheat	Lentil	Mung	Wheat	Lentil	Mung
Seed rate (kg/ha)	120	25	20	120	25	20	155	35	30
Seeding depth (cm)	4-5	3-4	4-5	3-4	3-4	3-4	0-8	0-6	0-6
Width of strip (cm)	4-6	4-6	4-6	-	-	-	-	-	-
Plant population/m^2	286	195	30	275	205	28	255	180	23-35

In general, higher yields were observed under strip tillage than minimum and conventional tillage system (Table 3). Strip tillage seeding system produced significantly higher grain yields for all three crops i.e. wheat (4.96 t/ha), lentil (1.40 t/ha) and mungbean (1.50 t/ha) than conventional tillage seeding system i.e. wheat (3.56 t/ha), lentil (1.20 t/ha), and mungbean (1.00 t/ha), respectively. There was no difference between minimum tillage and conventional tillage

methods in wheat yield, however, this was not the case for lentil and mungbean, where minimum tillage found to be better than conventional tillage statistically. The higher crop yields under strip tillage and minimum tillage could be due to better crop establishment, uniform crop stand, and higher fertilizer efficiency through band placement of fertilizer than conventional tillage system. The more additive crop yield gain under strip tillage might be cumulative effect of partial surface residue retention and better soil moisture content than minimum tillage.

Table 3: Yield performance of strip tillage over minimum tillage and conventional method

Method	Crop yield (t/ha)		
	Wheat	Lentil	Mungbean
Strip tillage	4.96	1.4	1.5
Minimum tillage	4.80	1.2	1.0
Conventional	3.50	0.8	0.75
SE	0.5	0.3	0.6
(CV%)	12	14	11

The cost of planting in different seeding methods was shown in Table 4. Among the three planting methods the cost of strip tillage system was minimum (Tk.1850./ha) and the highest was in conventional method (Tk.4900). In both modern techniques (strip and minimum) 62 % planting cost were saved over conventional tillage (broadcasted seeding system). The major saving under strip tillage was achieved due to drastic reduction in tillage operations, less labor, seed and fuel cost.

Table 4: Cost of planting in different tillage methods

Sl. No.	Planting methods	Cost of planting (Tk./ha)
1	Strip tillage	1850.0
2	Minimum tillage	1873.0
3	Conventional method	4900.0
SE		247
CV (%)		13

1 US$=Tk.80.0

Beak-even point of crops for strip tillage drill is shown in Fig. 4. Break-even point is calculated on the basis of fixed cost and variable cost of strip seed drill considering purchase price, interest on investment, machine life, etc. [7]. Cost per hectare decreased with the increase of land area used annually. Breakeven point of strip tillage was found 4.0 ha which indicated that it is the point where no loss or no profit occurs. The owner of the strip seed drill must plan for profit, therefore they are suggested to cover much more than 4.0 ha land per seeder on annual basis.

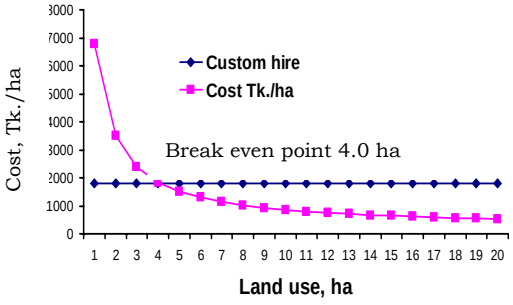

Fig.4: Break-even use of strip till drill

Conclusion

This study evaluated a set of conservation agriculture based resource conserving tillage techniques to address how to use residual soil moisture in rain-fed areas, higher cost of production and low productivity due to late planting in northwestern Bangladesh. Based on the multi-locations trial results, the following opinions and conclusions were made.

i) Strip till can be replaced to existing conventional system for higher crop productivity with reduced cost of production. This is equally important with respect to soil health.

ii) Residual soil moisture can be utilized through strip tillage technique by advancing the seeding of wheat and lentil after T. Aman harvest.

iii) It can be reduced the fuel consumption up to 57 % (good for environment) and reduce turnaround time for field preparation.

iv) This technology could be promoted to other parts of Bangladesh where bio-physical and socio-economic environments are similar.

v) The further research to be needed to quantify the total net returns, effect on soil health on long run.

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An Assessment of Subsidence due to the Extraction of 1203 Slice with its Associated Factors in the Barapukuria Coal Mine, Bangladesh

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Abstract

This research, primarily the development of subsidence caused by the extraction of 1203 slice has been evaluated under the profile functions and influence functions methods and the results show that the calculated subsidence profile is almost trough like subsidence where the maximum amount of subsidence is about 0.89 m. In the latter cases, the different preceding research, scientific papers have been consulted and analyzed for recognizing the various influencing factors of subsidence which replicate that the geology and stratigraphic configuration, structural setting of the coal basin, hydrogeological characteristics, less competent nature of overlying rock body, dip and depth of coal bed, applied mining method with angle of draw (γ) and so on are the major factors in propagating the subsidence incident in the area. Moreover, the intensive field investigation recognized almost similar pattern of subsidence and its associated conscientious factors in the mine.

Keywords: *Barapukuria Coal Mine, Slice 1203, Profile Function Method, Influence Function Method, Subsidence.*

1. Introduction

The Barapukuria coal mine is located at 50km east of the district capital Dinajpur, the northwest part of Bangladesh (Fig. 1). Geological Survey of Bangladesh (GSB) discovered presence of extensive coal reserve at relatively shallow depth in April 1985 in Barapukuria [1]. With six layers the total reserve of coal is identified at average depth of 118-509m, among of them 6^{th} seam is most significant as it contain about 90% of the total reserve [2]. For coal extraction multi-slice Longwall mining method has been implemented for 34 years mine lifetime, with 1 million tons per annum production target when the mine has been extracting this bituminous coal since 2005. Recovery percentage of this mine is very low, about 10% of total reserve will be extracted. The principal reason for this low recovery ratio are the difficult underground geological structures and conditions for mining [3]. The 2,500 acres underground mine includes 650 acres of agricultural land on the surface. The International Accountability Project reports that mining operations at Barapukuria have destroyed roughly 300 acres of land, impacting about 2,500 people in seven villages, as land subsidence of over one meter in depth has destroyed crops and lands and damaged homes [4]. For instance large-scale land subsidence has occurred at Kalupara village, south-southeast of the Barapukuria mine, due to extraction of a 3m high section of mining panel 1101[5].

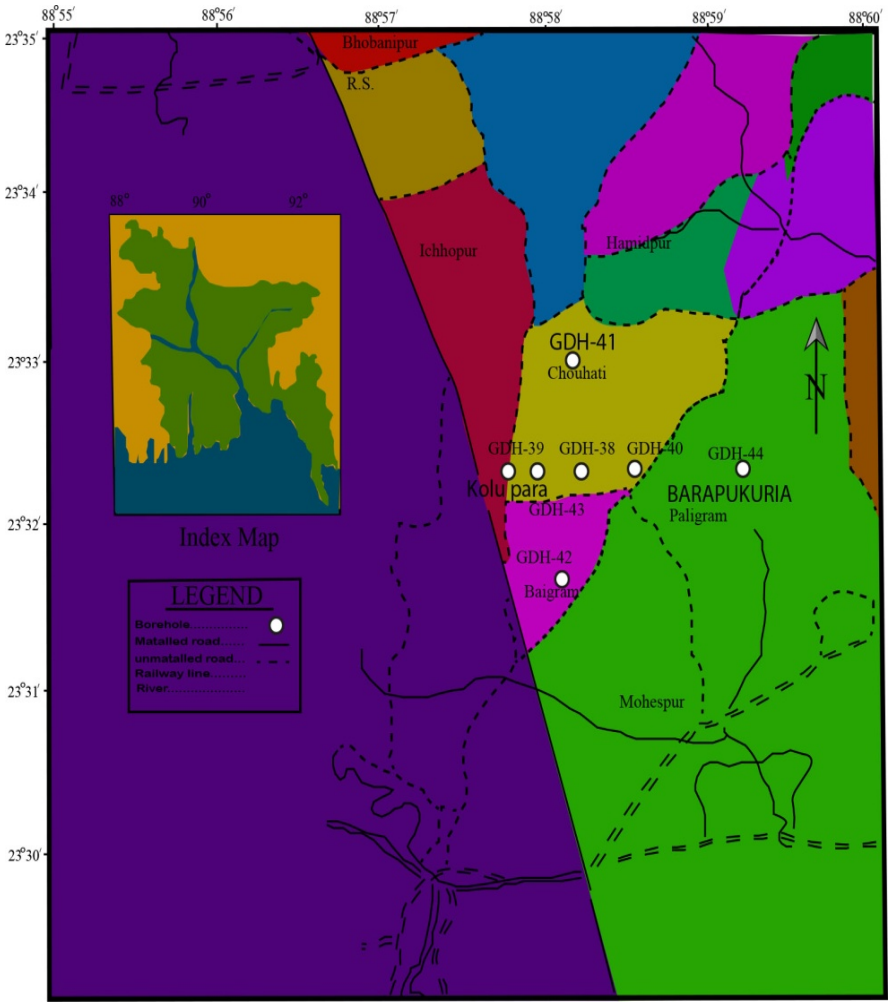

Fig. 1. Location map, total mining area and present working area

Coal mining industry itself is a very complicated technology, of which frequently faces problem in the mine. One of such problem in the mine is subsidence around the mining area and which is the common incident of such mine all over the world. Currently, the industry producing the coal from the mine by underground long wall pillar less mining method and some coal faces have already been finished as a result the mine out area is subsiding and will be subsided with time being. From my direct field observation, some of the area has been subsided about 2-3 feet or more and some of the house, plain land as well as cultivated land have fractured. From the common sense, these scenarios will be continued for long time and which would not good for local inhabitant as well as the mining industry. Therefore we have to take some preventive measures to reduce such incident around the area for sound and healthy production. In this case, to ensure the safe and healthy production, it is very much indispensable to figure out the pattern of subsidence over there. Therefore, the objectives of the research are to clarify the possible patterns of subsidence and its possible factors by direct field and laboratory analysis and, finally propose the necessary recommendations for preventing the subsidence for safely production of coal from the mine.

2. Methods of Study

In predicting the development of subsidence, two major assumptions are commonly made such as firstly the subsidence is proportional to the mined seam thickness; and secondly implies that subsidence at a point on the surface is a function of its coordinates with respect to the mined area, and that the maximum value of subsidence is observed above the geometrical center of the excavation. Whittaker and Reddish [6] consider five main groups of subsidence prediction methods, namely empirically derived relationships, profile functions, influence functions, analytical models, and physical models. Karmis et al. [7] consider three main groups of subsidence prediction methods such as theoretical models, numerical methods and empirical or semi empirical methods.

However the present research considered the profile functions and influence functions method for assessing the development of subsidence in the area. In the case of profile functions method, please see the Howladar [8] research paper where the detail processes of calculation of maximum subsidence, horizontal displacement and strain has been shown. On the other hand, the Influence Functions Method also applied for assessing and comparing its results with the profile function method. In this method, the subsidence at any point on the surface is obtained from the sum of the influence of each extracted element using the principle of superposition.

The direct field investigation has also been performed to clear the factors of mine subsidence around the mining area. During the field investigation the Geo-structural, Geo-hydrogeological**,** applied coal mining method, mine design and present situation has been investigated. The different research work, technical papers and analyses records were also consulted for the present this research.

3. Result and Discussions

The magnitude of the maximum subsidence is found to be increasing with the depth of the working and decreases gradually with larger depths [9]. However the development of subsidence has been predicted by many researchers such as Kratzsch [10]; Whittaker and Reddish [6]; Bahuguna et al. [9]; Chang et al. [11]; Quamruzzaman et al. [12]; Howladar [8] and others with different methods. In the present research, the Profile Functions Method and Influence Function Method have been appealed to envisage the development of subsidence incidences in the area. In order to perform these methods, the overall geometric parameters of 1203 long wall face have been considered. The parameters such as the thickness of coal seam is 3 meters, the mining depth or depth of overburden is 320 meters, the length of the long wall panel is 950 meters and the width of the long wall panel is 114 meters which are the common parameters for both of these methods. The computed horizontal stress, horizontal strain, distance from the center of the panel, inflection points are also the regular parameters and they are varied in a small amount. The predicted maximum subsidence with these methods is 0.89 meters shown in Fig. 2 and Table 2. Tthe type of subsidence is almost trough subsidence. From the field, it has been observed that more than one square kilometer have been subsided with a depth at the midpoint of the subsidence is about 1 meter which looks like a trough shape structure in the area. According to the principal of subsidence, the present research anticipated that this developed structure must be the trough subsidence which is also matched with pattern of subsidence predicted by Quamruzzaman et al. [12] and Howladar [8] in the case of 1101 slice with NCB and profile function method.

From the direct field investigation and laboratory analysis, it should be noted here that a number of geologic and mining parameters could affect the magnitude and extent of subsidence in and around the Baropukuria coal mine Dinajpur. These include the thickness of extracted materials; overlying mining areas; depth of mining; dip of mining zone; competence and nature of mined and surrounding strata; near surface geology; geologic discontinuities; fractures and lineaments; in-situ stresses; degree of extraction; surface topography; ground water (Including water elevation and fluctuation); mine area; method of mining; rate of advance; backfilling; time and structural characteristics.

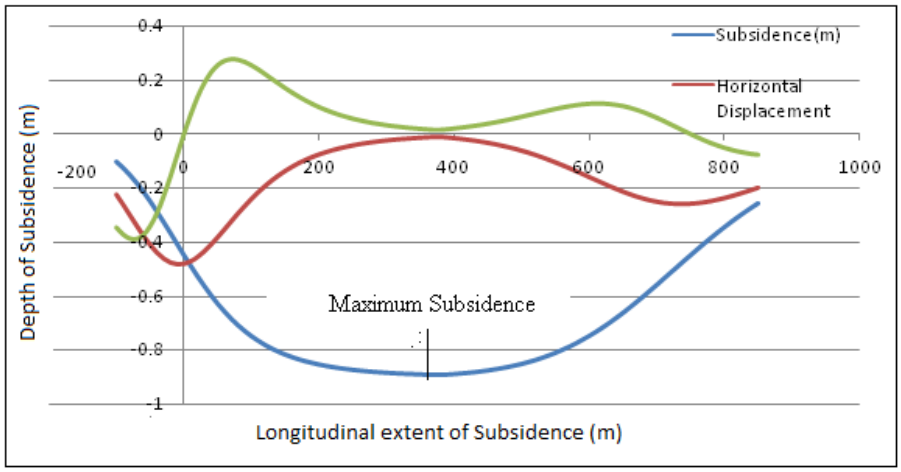

Fig. 2. Calculated maximum subsidence, horizontal displacement and horizontal strain profile from Profile Functions Method of 1203 Coal Seam, Barapukuria Coal Mine, Dinajpur.

Tables 2: Calculated Subsidence, Horizontal Displacement and Horizontal Strain values from Profile Functions Method (a) and Influence function method (b) of 1203 Coal Seam, respectively.

(a)

Distance(m)	Subsidence(m)	Horizontal Displacement	Horizontal Strain
-100	-0.10578	-0.22583	-0.34825
-70	-0.1841	-0.34093	-0.39082
-40	-0.28916	-0.44031	-0.29423
-10	-0.40952	-0.48317	-0.07842
20	-0.52765	-0.45661	0.137343
50	-0.62919	-0.38304	0.257155
80	-0.70817	-0.29571	0.276962
110	-0.76569	-0.21698	0.240866
140	-0.80604	-0.15502	0.188302
170	-0.83386	-0.10962	0.139403
200	-0.85296	-0.07751	0.100563
230	-0.86612	-0.05514	0.07185
260	-0.87527	-0.03959	0.051325
290	-0.88169	-0.02875	0.036853
320	-0.88627	-0.02113	0.026679
350	-0.88957	-0.01572	0.019504
380	-0.89125	-0.01299	0.015921
410	-0.88601	-0.02017	0.023842
440	-0.87817	-0.03046	0.034544
470	-0.86678	-0.04472	0.048251
500	-0.85068	-0.06372	0.064629
530	-0.82862	-0.08789	0.082407
560	-0.79939	-0.11698	0.099072
590	-0.76205	-0.14973	0.110907
640	-0.68121	-0.20518	0.108849
670	-0.62285	-0.23297	0.090582
700	-0.55944	-0.25218	0.060882
730	-0.49369	-0.26048	0.02463
760	-0.42851	-0.25749	-0.01175
790	-0.36652	-0.24466	-0.04259
820	-0.30968	-0.22465	-0.06456
830	-0.29209	-0.21691	-0.06973
840	-0.27525	-0.20882	-0.07386
850	-0.25914	-0.20049	-0.07699

b.

Distance(m)	Subsidence(m)	Horizontal Displacement	Horizontal Strain
-100	-0.10578	0.152569	0.552161
-70	-0.1841	0.357377	0.838437
-40	-0.28916	0.576353	0.71759
-10	-0.40952	0.686859	0.199077
20	-0.52765	0.640367	-0.3465
50	-0.62919	0.489159	-0.61909
80	-0.70817	0.317896	-0.60358
110	-0.76569	0.181264	-0.44458
140	-0.80604	0.093006	-0.27328
170	-0.83386	0.043846	-0.14751
200	-0.85296	0.019322	-0.07223
230	-0.86612	0.008073	-0.03284
260	-0.87527	0.003237	-0.0141
290	-0.88169	0.001257	-0.0058
320	-0.88627	0.000477	-0.00231
350	-0.88957	0.000178	-0.0009
380	-0.89125	9.18E-05	-0.00047
410	-0.88601	0.000477	-0.00215
440	-0.87817	0.001937	-0.00759
470	-0.86678	0.006328	-0.02141
500	-0.85068	0.017044	-0.04923
530	-0.82862	0.038657	-0.09405
560	-0.79939	0.075246	-0.15148
590	-0.76205	0.127811	-0.20778
620	-0.71625	0.19227	-0.24375
650	-0.66246	0.259534	-0.24312
680	-0.60215	0.318028	-0.20047
710	-0.53764	0.357447	-0.12387
740	-0.47176	0.371906	-0.03102
770	-0.40738	0.361156	0.058046
800	-0.34693	0.329751	0.12774
830	-0.29209	0.284942	0.170382
840	-0.27525	0.268378	0.178415
850	-0.25914	0.251451	0.183566

4. Concluding Remarks

Barapukuria Coal basin in Dinajpur district, Bangladesh enters into the coal mining era for the first time. As the country having no coal mining experience in the past, Barapukuria Coal Mining Company is expected to bring about a number of others mining related activities in the country. Barapukuria coalmine is now currently under production mode and facing the very great problem on subsidence around the mining industry. Considering this point of view, the present research deals with understanding the subsidence, and its possible factors by direct field investigations and laboratory analysis. The investigation shows that the trough subsidence developed around this mining field which is caused by many factors such as applied mining method, multi-sliced ultra thick coal seams, less competency of overburden strata, depth & dip of the coal seam, existed geologic discontinuities such as faults, Joints, fissures and other inconsistencies in the overlying and surrounding strata.

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