M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.4 (1-3)

Proceedings of the WasteSafe 2013 – 3rd International Conference on Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Industrial Waste Management and Its Social Efficacy in Bangladesh

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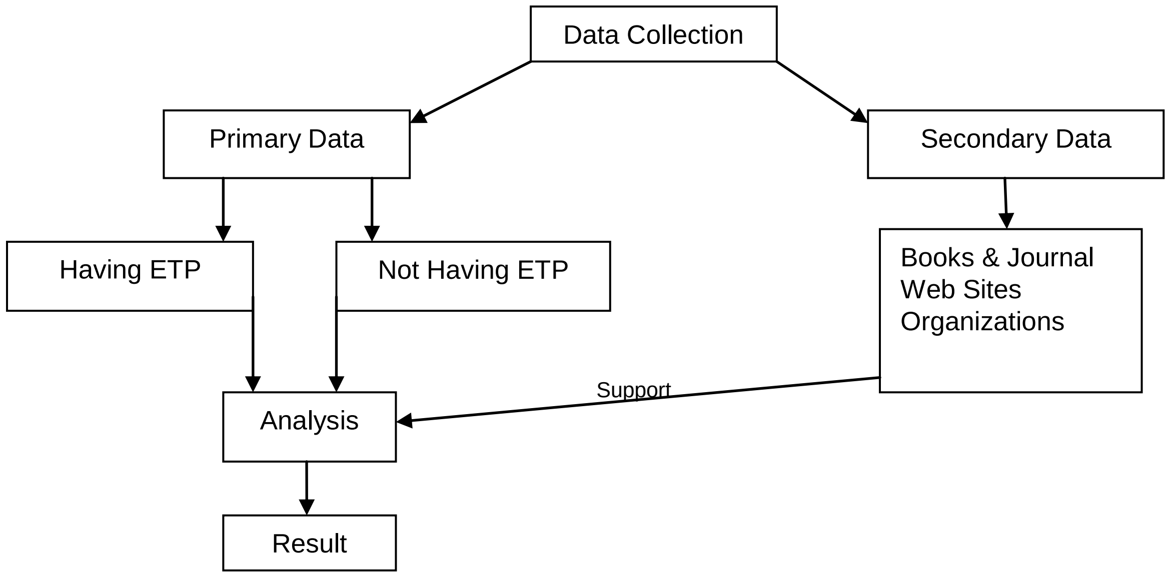
ABSTRACT

This paper focuses on the economic impact of waste management plant on the factories in Bangladesh. This paper tries to search some important questions, such as why a company should manage its effluents to the treatment, how it manages to do the task, whether the task is environmentally significant or not, how much the company is benefited, how much the society is benefited and globally what will be the outcome of it in return. In recent times, the world is so much concern on the Global Warming resulting from discharge of wastes from industries. Different sectors emit different types of wastes. We've considered four industrial sectors for this study. These sectors are tanneries, textiles, pharmaceuticals and fish processing industries. We have discussed the companies' cost- benefit, social cost & benefit, for having or not having waste management plant.

Objectives: To asses the impact of waste management procedure of four type of industrial sectors (tanneries, textiles, pharmaceuticals and fish processing industries) and its social efficacy in Bangladesh.

METHODS

Both primary and secondary data are collected for this study. We have used two types of questionnaires for collecting primary data.



We had prepared these different questionnaires for different sectors to get our desired information. We studied on four different sectors- Tanneries, Textiles, Pharmaceuticals and fish processing industries. First type of questionnaire was used for those industries that have ETP (Effluent Treatment

Plant). Second type of questionnaire was used for those industries that have no ETP. These two types of questions are shown below:

Having ETP	Not having ETP
1. Why you construct ETP in your industry? There had any force from government?	1. Why you don't construct ETP in your industry? Have you any plan to construct ETP in future?
2. How much the ETP construction cost was and from which source you have invest it?	2. Do you think there have any impact on production cost if you construct ETP in your industry?
3. What is the capacity of your ETP? What percentage of your industry waste is refined by this ETP?	3. Do you think there have any impact on labor's health if you construct ETP in your industry?
4. Is it cost effective? Have any economical return from this ETP?	4. Are the foreign buyers want to know about the waste management system of your industry?
5. Have there any impact on labor's health from this ETP?	5. Do you know about the government monitoring system on waste management? How you tackle this?
6. Have any impact on production cost because of this ETP?	
7. There had any government monitoring during the construction of ETP?	

This paper is prepared by incorporating and analyzing primary data and relevant secondary data according to the objective.

RESULT

Tannery Industries: Some Tanneries have ETP but they cut their labor wages for maintaining the high cost of ETP operation. For that reason these tanneries have lost some skilled labor which is not good for these tanneries. Establishment of an ETP is not mandatory to attract foreign market. That's why there has no major impact on production, but huge impact on environment. The foreign buyers only want the quality of the product and they even not interested to know any other external factor. The factories are dependent on local market to get low prices for their product. So they don't go to maintain the high cost of establishment of effluent treatment plant on their factory.
Textile Industries: It is very easy to run an ETP in case of textile industries. It takes a little cost of their total cost. It does not matter while the social benefit is in concern. In case of Bangladesh, need average Tk. 15 thousand per month as wage for it needs only three men to run this. ETP has an indirect relation to the production in textile industries. Having ETP is a matter of social awareness. The company which considers the social benefit may certainly be considered as reliable to the masses. So it can certain have the global demand for its product. The companies' main goal is to grasp the market. And to hold the foreign market, they have some mechanism, establishing ETP is one of them. By having ETP they can attract foreign buyers. That's why a company can demand high prices against their product and thus they can make more profit by having than not having ETP.
Pharmaceutical Industries: In Bangladesh, generally need 5 workers to maintain ETP of pharmaceutical industries and there average monthly salary is Tk. 5 thousand. It does not matter for such a large corporation. Moreover they are being reliable for having ETP which increase their products demand as well as production. That helps marketing strategy for the foreign market.
Fish processing industries: Some fish processing industries have ETP but they cut their labor wages for maintaining the high cost of ETP operation. Establishment of an ETP is very essential to attract foreign market. That's why there has a major impact on production. The foreign buyers always want hygienic product and for that reason they are interested on waste management. On the other hand some local factories are dependent on local market to get low prices for their product. So they don't go to maintain the high cost of establishment of effluent treatment plant on their factory.

ISBN: 978-984-33-7045-7, PI.4 (1-3)

CONCLUDING REMARKS

In context of Bangladesh, four industrial sectors (tanneries, textiles, pharmaceuticals and fish processing industries) need ETP because of social and environmental issues. Among these four industrial sectors, organic waste comes from tanneries and fish processing industries and inorganic waste come from tanneries, textiles, pharmaceuticals industries. Inorganic waste is more hazardous than organic waste. Most of the industries don't have capability to construct and maintain ETP. Most of the industrialists think that ETP would not cost effective for their business and production cost would be increase which is not market friendly. They want support from government to established ETP in their industry.

M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.19 (1-8)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

An Environmental Study on Surrounding Areas of Hazaribagh Tannery Industry

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ABSTRACT

The leather industry of Bangladesh is growing and environment of the Hazaribagh tannery area is gradually deteriorating. Tannery wastes are not treated properly before disposal and sometimes disposed off untreated. The results of questionnaire survey reveals that 68% of the people are not aware of the adverse effects of pollution, 39% of the industries are discharging their effluents directly into the natural stream, 49% identified water logging is the main problem of the locality. From the test results it is found that the BOD & COD level of the liquid wastes are found to be very high at discharging locations. Lead and Chromium level of both surface and ground water are higher than ECR-1997 standard. A sustainable approach should be taken to minimize the adverse effects of tanneries Relocation of tannery industry considering involvement of all the stakeholders should be a priority concern for improving the environment of Hazaribagh area.

INTRODUCTION

Nature has blessed human being with enormous resources, wealth and beauty. But in return in spite of being generous to nature, every activity of human is creating a stress on environment and thus disturbing the natural quality of the environment. Environmental pollution is now the major and most burning issue of the present era. Bangladesh, being a densely populated country in the world is suffering from serious environmental pollution due to unplanned development and industrialization. The situation of the capital city Dhaka is the worst in context of pollution level due to rapid industrial growth. Bangladesh has registered an impressive growth in the field of leather technology during the last three decades due to migration of leather tanning activity from developed to developing countries. Being an exporter of wet blue leather in the seventies, Bangladesh is now exporting crust & finished leathers and leather products. Bangladesh being a beef consuming agricultural country has a sizable livestock population and hence assured supply of hides and skins to sustain the leather industry in the country. The main raw materials are cowhides and goatskins. Only about 20% of the produced leathers are consumed locally and large surplus is exported. Currently leather industry is the fourth largest foreign currency earner for the country. The leather industry is situated in the midst of a densely populated Hazaribagh area of Dhaka city which is in the eastern bank of Buriganga river. With the growth of leather export the environment of the Hazaribagh area is gradually deteriorating. Tannery wastes and sewages are not treated properly through in-house effluent treatment plant before disposal and sometimes disposed off in a untreated manner. Toxic raw sewage is dangerous for public health. Harmful wastes of tanneries including Chromium, Lead, Mercury, Sulphur, Ammonium, salt and minerals, are severely polluting the capital city and the river Buriganga.

WASTES OF TANNERIES

The tannery industry of Bangladesh comprises 208 registered tannery units among which185 tanneries are located inside Dhaka alone mainly in Hazaribagh area. According to a report published by Department of Environment (DoE) the tanneries process 211 million square feet (75000 tons) of raw hides and skins. Volumes of wastewater and solid waste generation in 2006 stood at 1.30 million m^3/year and 26250 metric tons per year respectively. It is estimated that about forty three litres of wastewater generates through each square metre of hide processing and solid waste generation rate is 350 kg per ton. Wastewater generation from the tanneries is expected to increase from 1.3 million cubic metres of 2007 to 1.66 million cubic metres by 2012. The projected waste generation in 2012 is 33,502 metric tons per year (DoE, 2010). The processing of leather from raw hides produce both liquid and solid wastes. Major composition of solid waste from tanneries are fleshing and fat (45%), wet blue split/residue (20%), shaving residues (20%) and crust trimming/residues (18%). The solid wastes are predominantly from the initial and final stages of processing while the effluents are produced mostly during tanning and dying. The wastes from tanneries may be classified as continuous and intermittent flow wastes. Continuous flow wastes consist of wash water after various processes and comprises a large portion of the total waste. Spent liquors belonging to soaking, liming, bating, pickling, tanning and finishing operations are discharged intermittently. They are highly polluting and contain a variety of soluble organic and inorganic substances. The spent soak liquor contains soluble proteins of the hides, dirt and large amount of common salts when salted hides are processed. The spent liquor undergoes disintegration very rapidly as it offers a good amount of nutrients and favorable environment for bacterial growth. The growth of pathogenic anthrax bacteria occurs. The spent lime liquor contains dissolved and suspended lime, colloidal proteins, sulphides, emulsified fatty matters, and also carries a sludge composed of un-reacted lime, calcium sulphide and calcium carbonate. The spent bate liquor contains a high amount of organic and ammonia nitrogen due to the presence of soluble skin proteins, and ammonium salts used in deliming/bating. The spent pickling and chrome tanning waste comprises a small volume, having a low BOD, and contains traces of protein impurities, sodium chloride, mineral acids and chromium salts. In general, tanning industry wastes are of strong color, have high salt content, high pH, high BOD, high COD, dissolved lime, hydrogen sulfide, acids, chromium dyes, oils, organic matter and suspended solids. (Leather I., 2009) The waste water is discharged into open drains and ultimately finds its way onto land surfaces and into natural waters specially the river Buriganga in the vicinity. About 59% of solid waste comes from the hides and skins processed. Part of the solid waste is collected by the Dhaka City Corporation and taken to landfill sites but most of it accumulates in the swamp-sludge. Figure 1 shows the sources and types of pollutants in leather processing industries of Hazaribagh areas.

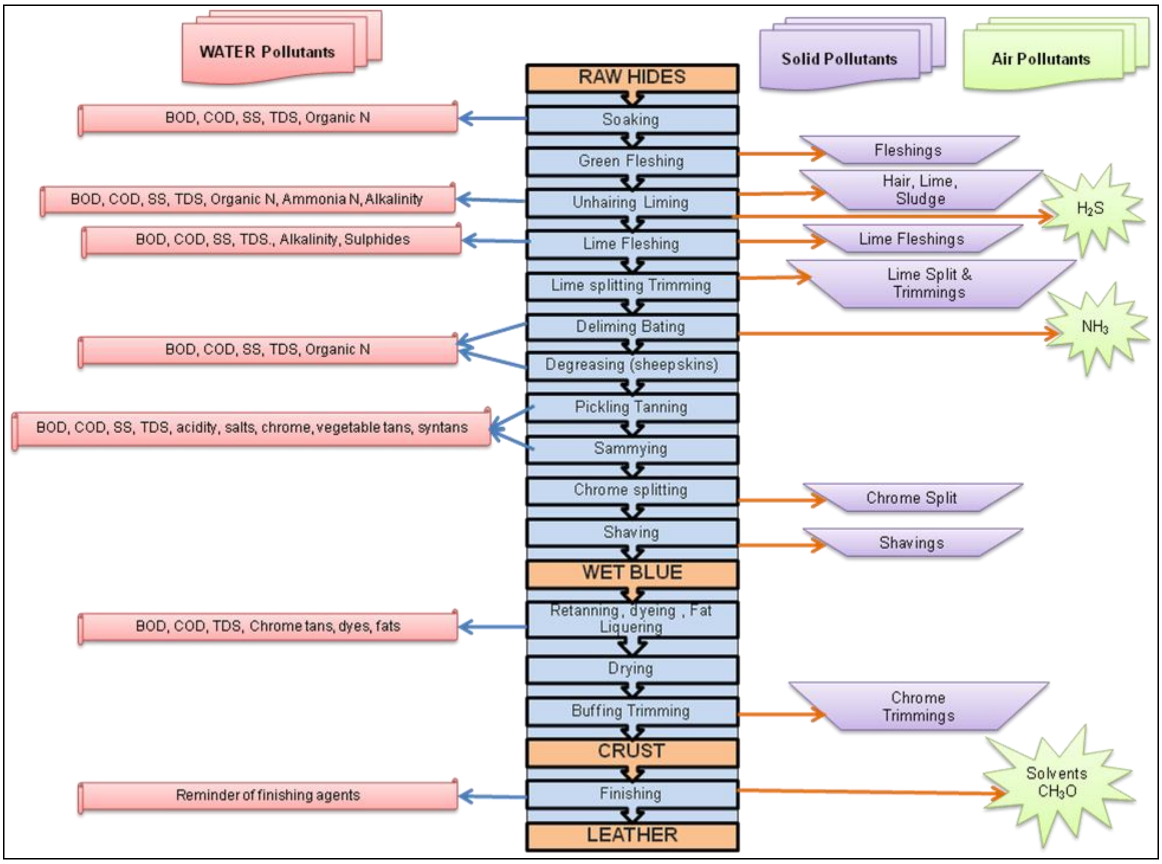

Figure 1 Sources and types of pollutants in leather processing industries of Hazaribagh

OBJECTIVES OF THE STUDY

The study has been conducted in the Department of Civil Engineering at Stamford University Bangladesh with the specific objective of assessing the present environmental condition of Hazaribagh area. The other objectives of the study are to determine the source of pollutants in the area, to determine the quality of liquid wastes disposed into the surface water stream, to determine the surface and ground water quality and finally to identify impacts of waste discharges from tannery as well as other industries & households on the surrounding environment.

METHODOLOGY

A primary report has been prepared based on the initial discussion with various stakeholders for outlining the scope of the work and the major information requirement for the study. Various relevant reports, project documents, existing literature have been reviewed and consulted. Interviews/discussions have been done with important stakeholders including owners of tanneries, laborers of the tannery industries, government officials and local community. Field surveys and door to door interviews have been conducted to explore the basic facilities available in the area & also to investigate the existing water supply, sanitation, and drainage facilities of the area. Tannery waste disposal and solid waste management systems have been analyzed. Required secondary data for this study were collected from various published and unpublished sources. The Hazaribagh area have been surveyed to realize the present situations & explore the pollution scenario of the area. For this study the some surface and ground water samples have been selected. The locations are selected in such a way that the samples represent the characteristics of the surface and ground water quality of the area. With a view to finding out the surface and ground water quality parameters water samples have been tested in the environmental laboratory of the university. Practical field observations have been made for collection of necessary photographs, data and information. This study has been tried to find out actual pollution level and to justify the urgent need for relocation of the tannery industry within shortest possible time.

SAMPLE COLLECTION IN THE STUDY AREA

The study was conducted at Hazaribagh tannery areas. Hazaribagh Thana (Dhaka district) with an area of 3.58 square kilometer is surrounded by Mohammadpur thana on the north, Kamrangirchar thana on the south, Dhanmondi and Lalbagh thanas on the east, Keraniganj upazila and Buriganga river on the west. It is situated on the south-west part of capital Dhaka. The study area is located between 23^{O} 43.85' to 23^{O} 44.05' N latitude and 90^{O} 21.85' to 90^{O} 22.15' E longitude (Hossain et. al.,

Figure 2. Sample collection locations in map

2007). Most of the area covered by other tanneries, houses, schools. There are many permanent and non-permanent settlements adjacent to the industries. The tanneries discharge untreated or partially treated liquid wastes into adjacent drain which subsequently go to the river Buriganga. In order to characterize the wastewater from tannery industries, wastewater samples have been selected from five different locations. The locations have been selected on the basis of wastewater flow from source to downstream. 1st & 2nd surface water locations (SW1 and SW2) are very near to embankment and 3rd, 4th and 5th (SW3, SW4 and SW5) are about 1, 3 and 4 km downstream from the embankment as shown in Figure 2. The drinking water sampling points (DW1 to DW5) have been taken in the Hazaribagh tannery area in such a way that the results represents drinking water quality of the whole tannery area which are also shown in Figure 2. Photographs of some sample collection locations are also shown in Figure 3.

Figure 3 Two surface water and one drinking water collection points

RESULTS OF THE LABORATORY EXPERIMENTS

pH is measured electrometrically through pH meter. It is a measure of the acid or alkaline condition of water. From the experimental results of the collected samples, it is found that the pH of drinking water samples [Figure 4] are within the standards for drinking water in the gazette notification,1997 (ECR, 1997) of Environmental Conservation Act,1995. The pH of the surface water samples [Figure 8] are also within limit except the SW5 one. pH of SW3, SW4 and SW5 samples represent slightly acidic condition. This is probably due to algae growth in water surface that removes Carbon dioxide and makes the water acidic. In the tannery industries, for conservation of hides sodium chloride salt is used. Even the fresh hides are agitated in a saturated brine solution until the expected amount of moisture within the hide is replaced by the salt solution. So naturally there is a high amount of Chloride concentration in the tannery effluents. Chloride concentration has been measured through titration In our experimental results, Chloride concentrations in the drinking water [Figure 5] and surface water [Figure 9] samples are within the standard. It is noticeable the Chloride concentrations in SW1 and SW2 samples are three to five times higher that than the rest of the samples as SW1 and SW2 locations are very nearer to the tanneries. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) tests are measure of the relative oxygen-depletion effect of a waste contaminant. Both have been widely adopted as a measure of pollution effect. The 5-day BOD (BOD_5) measures the amount of oxygen consumed by biochemical oxidation of waste contaminants in a 5-day period. The total amount of oxygen consumed when the biochemical reaction is allowed to proceed to completion is called the Ultimate BOD. The Ultimate BOD is too time consuming, so the 5-day BOD has almost universally been adopted as a measure of relative pollution effect. COD is typically determined by digesting the sample in a strong oxidizing agent under acidic conditions. The BOD_5 and COD values of all drinking water samples of the study [Figure 6] are within the standard limit. But in the surface water samples [Figure 10], BOD_5 values are very much higher in SW1 and SW2 locations. BOD_5 values of SW1 and SW2 samples are 4.6 times and 2.6 times higher than the standard values where the COD values are only 1.45 times and 1.08 times higher than the standard values. Lead (Pb) toxicity causes reduction in the hemoglobin synthesis, disturbance in the functioning of kidney, joints, reproductive and cardiovascular systems and chronic damage to the central and peripheral nervous systems (Ogwuegbu & Muhanga 2005). According to Office of Environmental Health Hazard Assessment (OEHHA), Canada, Trivalent chromium (Cr^{+3}) is a nutrient but Hexavalent chromium (Cr^{+6}) is toxic and carcinogenic. In the study, Lead (Pb) concentration of all the surface and ground water samples [Figure 7], have been exceeded the standard limit of ECR 1997 whereas Chromium (Cr) concentration [Figure 11] is far above the limit for drinking water samples and within the standard limit for surface water samples.

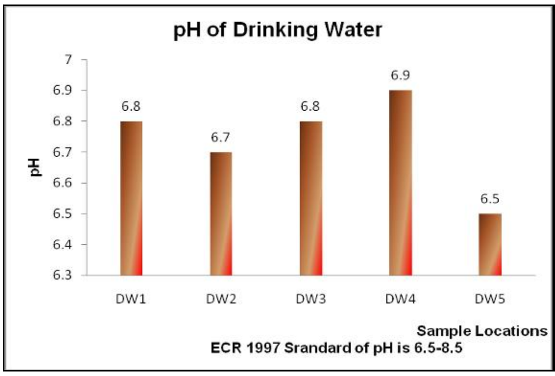

Figure 4 pH of drinking water samples

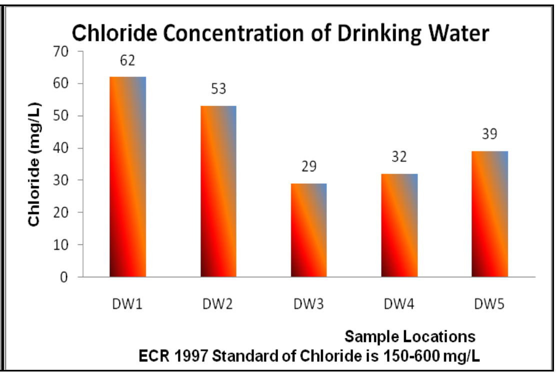

Figure 5 Chloride concentration of drinking water samples

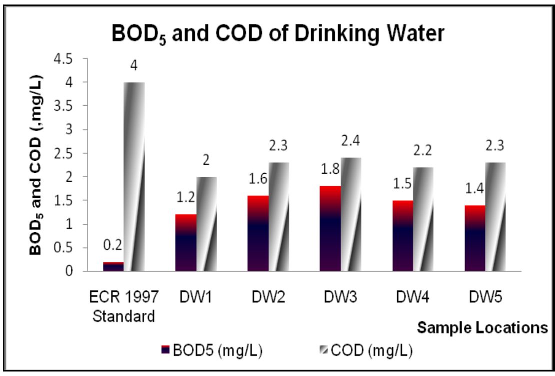

Figure 6 BOD_5 and COD of drinking water samples

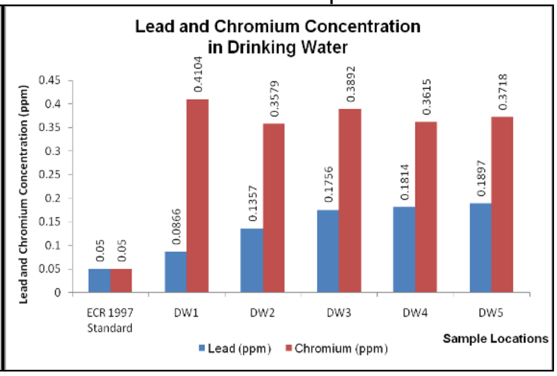

Figure 7 Lead and Chromium concentration of drinking water samples

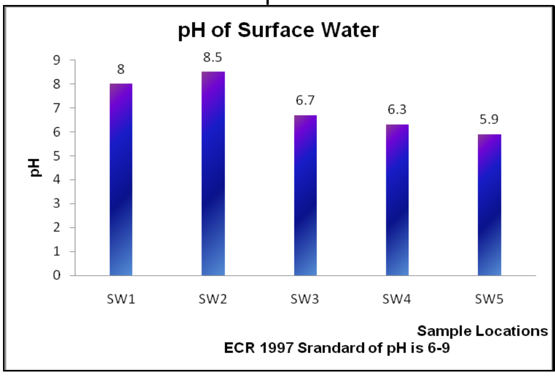

Figure 8 pH of surface water samples

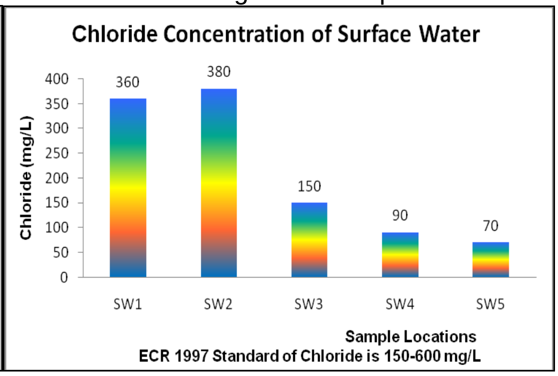

Figure 9 Chloride concentration of surface water samples

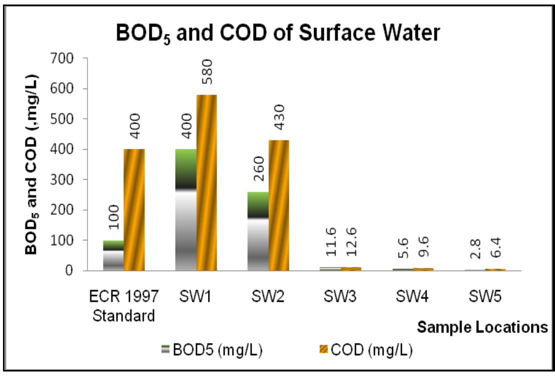

Figure 10 BOD_5 and COD of surface water samples

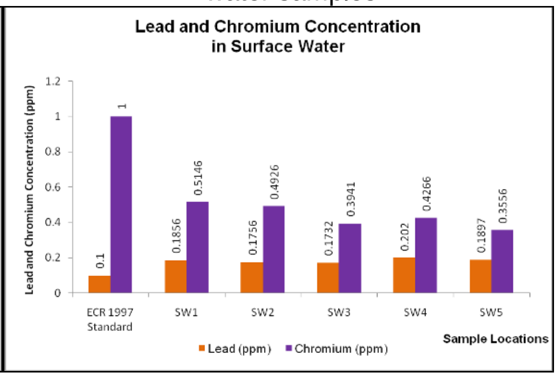

Figure 11 Lead and Chromium concentration of surface water samples

ENVIRONMENTAL CONDITIONS OF HAZARIBAGH AREA

Due to lack of awareness as well as the lack of poor implementation of rules and regulations, the practice of circulating tannery wastes and effluent into water bodies remains widespread. Flow of effluents from a tannery to a open drain is shown in Figure 12. Pollution is caused when suspended solids wash off open fields, construction and logging sites and eroded river banks when it rains. The substances, which degrade the quality of water is called water pollutant which causes water pollution. The solid wastes and tannery wastes are kept haphazardly near the open drains so they can easily mix with rain water and pass through natural water stream specially Buriganga river. Relentless water pollution of the water bodies, canals and drains occurs due to open disposal of tannery wastes. The environment of the slums near the Sadarghat-Gabtali embankment road is very alarming. People are living in a very unhygienic condition. Even Cattles are found to be kept with the garbage.

Figure 12 Flow of effluents from a tannery to a open drain

Figure 13 Polythenes are being sorted for recycling

Figure 14 A settlement near the bank of river is polluting the water directly

Apart from working in the tanneries, the poor people of the area are engaged in other businesses like bhangari shops, old plastic collection & supply, banned polythene business (Figure 13) etc. The level of sanitation knowledge and practice has been found to be extensively low among the low income slum dwellers specially the daily laborers of the tanneries. Most of the people in the area use tube well water and supplied water by Dhaka Water Supply and Sewerage Authority (DWASA) for drinking and other household works. Significant amount of open defecation is observed in the area. The settlements and unhygienic simple pit latrines are also observed near the river bank (Figure 14). Poor solid waste management system and inadequate sewerage and drainage system have been observed in the areas. The tanneries burn the toxic wastes from the crudely processed hides and skins of cattle to sell cheap fish meals. Tannery waste, along with dried fish dust and bone, is used to feed young broiler and layer chickens. Poultry feed made from waste material without proper sterilization contain bacteria and other toxic elements. According to Bangladesh Council of Scientific and Industrial Research (BCSIR) laboratory test results, presence of Chromium as high as 23 micro-grams have been detected in eggs of broiler chickens, while a child between four and 8 years of age can absorb only 15 micro-gram of chromium a day. If this poultry feed industry is not banned, the chromium might damage kidney and might cause damage to bones, brain, liver, lungs and central nervous systems. The deteriorated scenario causes severe environmental degradation affecting the environment of entire Hazaribagh and surrounding areas.

FINDINGS OF QUESTIONNAIRE SURVEY

Questionnaires related to environmental conditions of the Hazaribagh Tannery area, the pollution level of the tanneries and improvement measures have been filled up by direct interview with the workers of the tanneries and local people. Survey is mainly focused on areas like present condition of the area, the main problems of the area, water quality, sanitation condition and government initiatives for improving the environment of the locality. From the questionnaire survey it is found that 68% of the people are not aware of the adverse effects of pollution due to tannery wastes whereas 17% have limited idea of pollution and 8% have sufficient ideas about devastating short and long term effects of pollution which is shown in Figure 15. In the study area it is found that 39% of the industries are discharging their effluents directly into the natural stream, 34% of the industries are discharging their partially treated effluents directly into the natural stream which is shown in Figure 16. 49% identified water logging is the main problem of the locality, 33% people identified bad odor and unhygienic condition, 12% people identified improper sanitation facilities which is shown in Figure 17. Bangladesh government has taken a decision of relocation of tanneries. But 45% people are not satisfied of the decision of the government of relocation of the tannery industries outside Dhaka as they are afraid of losing their jobs. This information is shown in Figure 18.

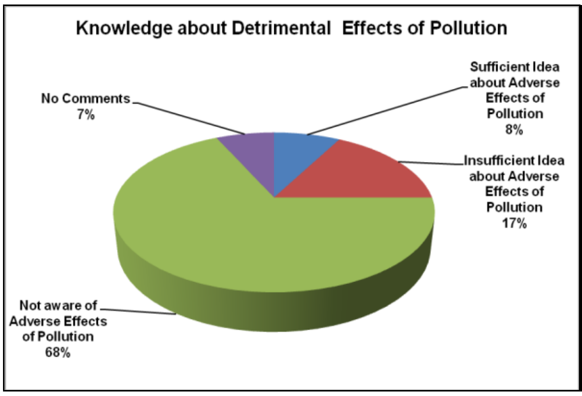

Figure 15 Knowledge about Pollution Effects

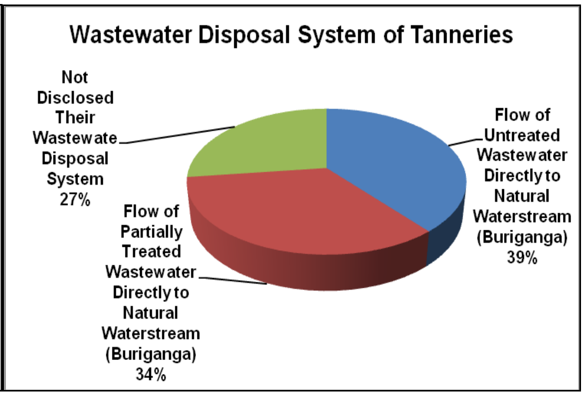

Figure 16 Wastewater Disposal System of Tanneries

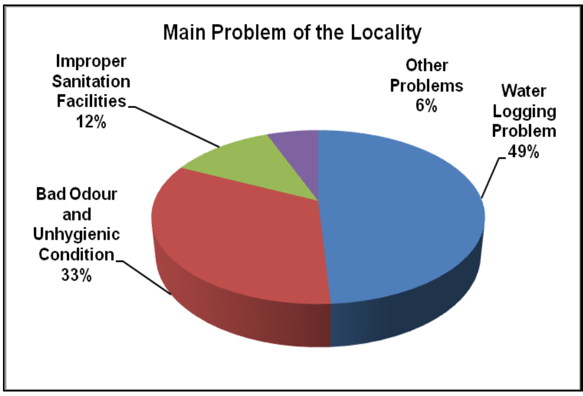

Figure 17 Identified Main Problem of Hazaribagh Tannery areas

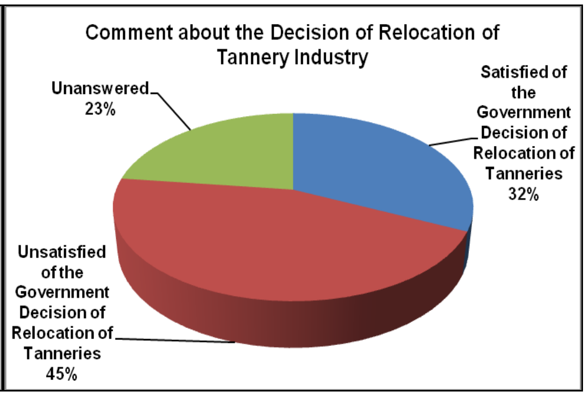

Figure 18 Comment about the Decision of Relocation of Tannery Industry

CONCLUSIONS AND RECOMMENDATIONS

Tannery wastes, their treatment and disposal i.e. the management of tannery wastes is the most vital environmental dispute facing leather industry of Bangladesh. Environmental degradation in tannery area requires major spotlight for immediate attention. The local people and the workers in the leather industry are vulnerable group of adverse effects of tannery pollution because the surface water they use is contaminated with all sorts of chemicals. The tanneries use a large amount of water for processing leather and depend on groundwater sources for their daily requirements (Heijnen et. al., 2003). The discharged untreated or partially treated effluents from the processing units of tanneries contain dissolved salts which percolate into the surrounding soil resulting ground water contamination. The overall environmental condition of the area is deteriorating rapidly due to indiscriminate discharge of industrial wastes, particularly the liquid wastes into the water environment. From the experimental test results it is found that the BOD & COD level of the liquid wastes are found to be very high at discharging locations, pH of ground water varied from 6.5 to 6.9 and that of surface water varies from 5.9 to 8.5, Lead and Chromium level of both surface and ground water are higher than the standard. Environmental pollution problems of the tanneries must be addressed at the source. The tannery workers have limited safety knowledge and limited facilities. Short-term training on occupational health and safety, modern practices of handling chemicals, etc. should be conducted for tannery staff and operators. Information about safety, health and environment should be visibly displayed in the workspace. The appropriate environment friendly technologies should be adopted according to the particular needs and conditions of particular tanneries. Improvement in drainage system to avoid the formation of hydrogen sulphide gas inside the tanneries is suggested (Rajamani et. al., 1995). Proper arrangements should be made to stop the use of tanned solid waste in the preparation of poultry feed. Chemical re-cycling should be practiced. The presence of chrome in wastewater from tanneries has serious environmental as well as economic consequences. It makes both economic and environmental sense to seek chrome recovery and reuse in Bangladesh's leather sector. It is recommended that in-house improvements should be undertaken immediately. This has the potential to reduce the pollutant as well as the hydraulic load to a tolerable level. Proper sanitation facilities are needed for slum areas of Hazaribagh as they are significant source of fecal contamination. In this context, cost effective simple pit latrines should be implemented at safe distance from river bank. The settlement along river banks should be prohibited and slum dwellers might be moved to some permanent areas. The slum dwellers should be encouraged to practice hygiene. Efficient solid waste management should be implemented in the slum areas. A sustainable approach should be taken to minimize the adverse effects of tanneries. Establishment of central effluent treatment plant for treating the waste water may be a good option for tannery industries (Azam et. al., 2012). Bangladesh Government has taken a decision for shifting tanneries from Hazaribagh to tanneries to Harindhora area of Tetuljhora and Hazratpur union under Savar upazila. If the whole tannery industry is shifted at a time, the industry may suffer a loss of a huge foreign exchange. The other constraint is that a large number of workers will be unemployed due to relocation of tanneries. Again a huge amount of funds will be needed to make a new environmentally sound tannery industry. The Department of Environment has already served notice several times to tannery industry owners of Hazaribagh for shifting their industry. The tannery associations continue to seek even greater compensation than the amount initially agreed upon from the government for the relocation. Bangladesh Government, the environmental organizations are working for relocation as early as possible. 155 plots already have been allocated in favour of the same number of industrial units in Hazaribagh areas. Land development works of that area already has been completed. A China-Bangladesh joint venture project has already started their works to construct a central effluent treatment plant in the area within 2013 for Tk 477.46 crore (source: internet) Overall, during the planning and implementation of relocation of tannery industry, all the stakeholders should be taken under consideration so that the environment of the new location can be kept free from severe pollution from tanneries.

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M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.27 (1-5)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Solid Waste Charecterization and Management System in Pharmaceuticals Industries

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ABSTRACT

Pharmaceuticals is one of the important industries which is producing lifesaving drugs in our country as well as earning large amount of foreign currency. Although about 250 pharmaceutical companies are registered in Bangladesh but 101 companies supply their products. Solid waste of the pharmaceuticals is important for management. The aim of the study is to characterize the solid wastes and their management system through environmentally friendly way. To accomplish this aim, the study has been conducted in APC pharmaceuticals, Lakhpur, Bagerhat. Based on the questionnaire survey and secondary study has been performed for finishing the work. Total waste is classified into three types solid, liquid and gaseous. The collection, separation, treatment and disposal techniques are used for management of waste. Recycle, reuse, current cell, manufacture take back, remodeling, creating sense training etc. types of management tools are followed here. This study will provide the knowledge of solid waste character produced in a pharmaceutical companies and a better management system suitable for all of them. The study will also increase the awareness against toxic pharmaceuticals solid waste and its tremendous effect on our Environment.

1. INTRODUCTION:

Most of the waste from pharmaceutical industry may be contaminated waste and poses infectious risk to the environment and engaged persons who handle it for collection, treatment and disposal process (CDC, 1985; Rutala, 1993). Since 1980s pharmaceuticals have increasingly been recognized and reported as chemical pollutants and serious problem for the environment (Daughton, 2003; Daughton, 2007). Spinosa *et al.* (1984) reported that the sludge characteristics which are important to know strictly depend on the handling and disposal methods adopted. Many physical, chemical and biological parameters and tests are available for the characterization of waste, thus allowing its behavior when processed and impact on the environment when disposed or used to be evaluated. Furthermore, conventional parameters are often specific to the method of treatment and disposal or use adopted so parameters and tests able to give more basic information on the waste in question would be needed. According to the report of Georgia statewide, (2005) waste characterization study Due to the importance of waste composition data in solid waste system planning and design, the Georgia DCA urges counties to use locally-developed waste composition data in preparing their respective solid waste master plans that are filed periodically with the State. (Charlotte *et al* 2010) To develop a better understanding of the regulatory and environmental reasons for managing pharmaceutical waste more stringently .To review the ten step blueprint for managing pharmaceutical waste. To understand how federal hazardous waste rules impact pharmaceutical waste management in hospitals. Pharmaceutical waste characterization is an important stage of the research process since it provides a deep knowledge of the material which is crucial to answer questions, understand behaviors and propose solutions of toxic waste for the next steps (Gomes *et al.*, 2005). Pharmaceuticals that can no longer be used must be managed as waste. To evaluate each drug generated at the facility to determine whether it is a solid waste, hazardous waste, infectious waste and/or radioactive waste and then dispose of or otherwise manage it accordingly. All pharmaceutical waste evaluations must be documented and available for inspection (DNR, 2008). According to the Environmental Conservation Rules, 1997 four categories industries are present. Among them the Pharmaceutical industry falls in Red category. So it is so much essential to manage the waste of it. For establishing a pharmaceutical industry the ETP plan, including the layout, proper waste management plan and location is essential for managing its waste (GoB, 1997). The pharmaceutical industry includes the manufacture, extraction, processing, purification, and packaging of chemical materials to be used as medications for humans and animals. Pharmaceutical manufacturing is divided into two stages: the production of the active ingredient or drug, primary processing, and secondary processing, the conversion of the active drugs into products suitable for administration. The pharmaceutical industry manufactures bulk substance pharmaceutical intermediates and active ingredients, which are further processed into finished products. So a proper management system is mostly required for this type of industry (EIA, APC 2009).

1.1 OBJECTIVES OF THE STUDY

- ✓ Characterization of solid waste in pharmaceuticals industry.
- ✓ Find out a general, cost effective and environmentally friendly management system.

2. MATERIALS AND METHODS

Like many other industries the pharmaceutical productions produce a wide variety of products. This industry uses both inorganic and organic materials as raw materials, the latter being either of synthetic or of vegetable and animal origin. Some of the pharmaceutical plants do not discharge liquid at all, some discharge small but concentrated liquid waste, while some other discharge high alkaline and toxic liquid wastes. Therefore, it is very difficult to make any generalization in regard to the characteristics of the pharmaceutical plant wastes.

2.1 Primary data collection

All types of primary data are collected in many ways. Some procedures are followed here like questionnaire survey, Sampling procedure and experimental study in laboratory. In field sample was collect from the industry in proper ways by following collection method.

2.2 Secondary data collection

The secondary data collection and information were based on the articles, books, review of published literature on the concerned topic and the thesis papers Khulna University, Bangladesh University of Engineering and Technology. Journals, papers and articles relevant to the study were collected from central library and seminar library Khulna University as well as internet. Maps and other standards regarding to the study were collected from internet. Factory location, Necessary snaps, Waste statistical data and other necessary information were collected from the authority of APC Pharmaceuticals.

3. RESULTS AND DISCUSSION

3.1 Waste Identification

The APC pharmaceuticals produce huge amount of tablets, capsule, Syrup (liquid), Syrup(dry) and some of other products. They collect the raw materials and use the machines, and then production is being processed. After completing the production they wash away the machines every day, packaging the medicines and then send them to market. So the waste is produced in some ways, Raw Materials Waste (very few), Production Time Waste (Gaseous Waste), After Production Waste (Liquid waste, waste water, Major waste), during packaging time waste (Broken glass, Packets, papers), Workers waste (gloves, working cloths). General Solid waste Produced in Industry they are Packets, Gloves Broken glasses, Clothes, Cartons Sacks, bags, old official equipment etc.

3.2 Waste Characterization and Analysis

In the APC pharmaceuticals three types of major waste are founded. They are Solid waste, Liquid waste, and Gaseous waste. Total working day in a year is 270 days. Their total waste quantification is showing below. Mainly three types of solid wastes are founded. They are
From industry- Broken syrup glasses they are toxic (daily 70 pics, 18900 paces yearly), packaging cartons are nontoxic (40 pics perday average 10800 pics), packets some toxic and some are nontoxic (120 pics daily, 32400 pics yearly), sacks nontoxic (30 pics daily 8100 pics yearly), plastics bottles are toxic (32 pics daily 8640 pics daily) etc. watch the table no 01. **From office** – Stationary papers, old files, computer wastes etc. **From workers** – Old dress are toxic (15 pics daily 4050 pics yearly), gloves are toxic (1200 – 1250 pairs yearly).

3.3 Waste Management

The prevention and avoidance of the production of certain hazardous wastes or hazardous substances, sometimes by regulation. The economic reduction of the volume of waste during production, by means of different processes or clean technology. Some basic technique is used for the waste management procedures they are Collection Method, Separation Method, Treatment and Disposal Method

3.4 Collection method

Among some of collection method the permeable is Container collection system. According to this system some container will be located in some special places for collecting the waste. Like papers, bottles, broken glasses etc. Implementing this procedure containers location is important. Near the syrup packaging room, capsule, room, office room, laboratory, quality control room and every room get a container for claiming all the solid waste produce from those places.

Paper

Paper-fiber materials can be recycled to produce such products as tissue & toilet paper, newspaper, writing and office paper, and cardboard packaging. Predominant sources of recycled paper would include newsprint, magazines, cardboard, packaging, white office paper and liquid paperboard.

Glass

Recovered glass can be resold to the manufacturer. New glass bottle manufacture can contain over 90% recyclable glass (cullet), replacing virgin materials such as sand. It is also possible to use glass in the manufacture of bricks and the production of asphalt. Plate glass can be used in the production of sandblasting materials and sandpaper. Cullet must be sorted into three separate color streams of amber, white and green. With new technology, color sorting can be automated.

Plastic

A major difficulty with the recycling of plastics is the need to separate different types of plastic, as these have different melting points. Mixed plastic will not form a uniform and stable material. However, processes are being developed for the automated separation of plastics and also for fusing and subsequently laminating shredded plastics to make plastic sheets for use as wallboards and similar applications. Recycled waste plastic materials can also be used to generate electricity at Waste to Energy plants. Recyclable plastics include polypropylene, polystyrene, polyurethane, polyethylene, perspex, and polycarbonate.

Metal

Metal recycling is already an accepted activity where metal scrap is generally sold to merchants, who in turn supply homogenous and some mixed scrap to steel mills and foundries for re-use. Tin, steel and aluminum cans, used for aerosols, food and beverages, can also be recycled.

3.5 Separation technique

Separate part by part through some system. Such as, broken glass collects from packaging room Carton collect from raw materials side and main packaging site Bottle and papers collect from every place. Glasses separated by using gloves, plastics bottles separate, large glass jar collected for washing.

3.6 Treatment

For treatment process we should follow some major sites.
Solid waste - Repair & Reuse**:** The collection of used items, such as glasses, paper, cartons, torn cloths sell them local market for reuse and repurpose them. Reduction of waste sources is the most preferred method because it can reduce system costs and resource consumption. Source Reduction stops waste at the source because it avoids that item’s entry into the waste stream. **Recycle & New Product Feedstock:** This method is the collection of materials that might become waste, such as glass, aluminum, steel, plastic, paper, etc. and the sorting and processing of these to manufacture as new products. When recycled, these materials create new product feedstock instead of using virgin resources. The new products may or may not be similar to the original product. This method prevents items being put into landfills and conserves natural resources. **Manufacturer take-back:** A program in which manufacturers take back older items, Such as some medicine get date expired for long time staying in market. Allocate them in a specific site regard for disposal immediately.

3.6 Disposal method:

The process of burning solid waste under controlled conditions. All types of old dresses, gloves, some papers etc. burn into the incinerator. **Landfill:** The disposal of back medicine and burn solid waste by burying in the ground between layers of earth and deep ground water.

4. CONCLUSIONS

Pharmaceuticals industries are one of the pioneering industries which is playing very important role in formulating live saving drugs as well as able to earn large amount of foreign currency. At present, it would provide essential drugs and medicines for fulfilling the minimum health care facility in the country. Pharmaceuticals industries always produce toxic and nontoxic solid wastes in various ways.Broken syrup glasses they are toxic (daily 70 pics, 18900 paces yearly), packaging cartons are nontoxic (40 pics perday average 10800 pics), packets some toxic and some are nontoxic (120 pics daily, 32400 pics yearly), sacks nontoxic (30 pics daily 8100 pics yearly), plastics bottles are toxic (32 pics daily 8640 pics yearly) etc. are founded. Stationary papers, old files, computer wastes etc. Old dress are toxic (15 pics daily 4050 pics yearly), gloves are toxic (1200 – 1250 pairs yearly) are originated. Solid wastes are collect through collection technique from the room and other side, Separate them and recycle or for reuse. All of the combustible firstly waste cremate with incinerator. Then buried into the earth by looking at eye into the earth and groundwater level. If we can handle the solid wastes in the industries then the industry will become more valuable sustainable and environment friendly. In this field also need more works to ensure the solid waste management.

5. ACKNOWLEDGEMENTS

Firstly thanks to my honorable supervisor Dr. Abul Kalam Azad, Hena voumuk, (MD APC pharmaceuticals) and Rezaul Haidar to give a chance for visiting their industries, Juwel, Sumon , Ahsan and other of my helpful friend to conclude the study. Finally thanks for the Secretary of the Seminar Organizing Committee for providing me a chance to submit the work.

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7. TABLES AND FIGURES:

Table No. 01 : Waste amount in the industry

Types	Types	Quality	Yearly Amount
Broken syrup glasses	Solid	Toxic	18900 paces
packaging cartons	Solid	Non toxic	10800 pics),
packets	solid	Toxic	32400 pics
sacks	Solid	Toxic	8100 pics
plastics bottles	Solid	Toxic	8640 pics
Old dress	Solid	Toxic	4050 pics
gloves	Solid	Toxic	1200 – 1250 pairs yearly

Source: APC official data

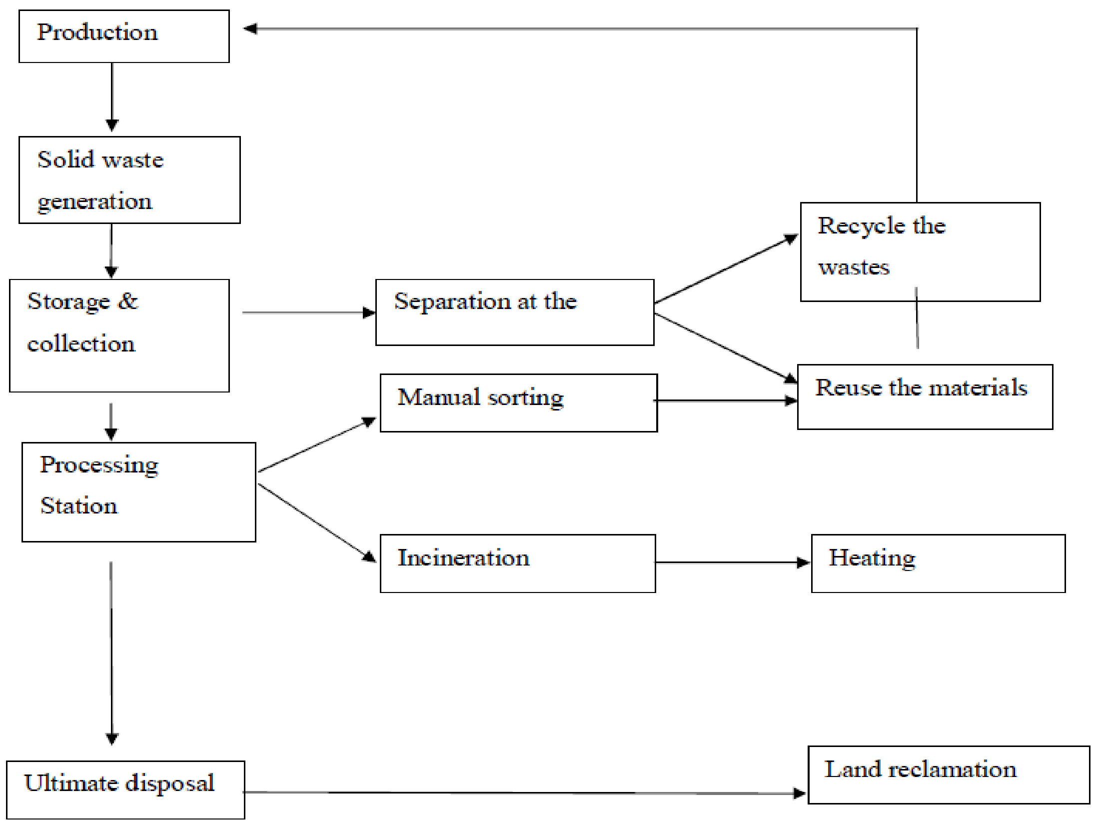

Figure No. 01: Functional element of Pharmaceuticals solid waste management

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ISBN: 978-984-33-7045-7, PI. 57 (1-8)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Scenario of Waste Management in Bangladesh Cables Factory and Its Environmental Impacts

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ABSTRACT

Environmental Impact Assessment (EIA) is one of the environmental management tools contributing to green the development projects. This study aims at investigating the environmental impacts of Bangladesh Cables Factory at Shiromoni industrial area in Khulna city. Annually, near about 65000 kg of wastes were generated in the factory. A large portion of these waste materials was found to be recycled or reused in different purposes. Insulation wire, steel tape, color master, alu-tape, copper, and black poly-ethylene had been found to be reused intensively. Cooling water and burnt fuel had been frequently disposed to the nearby Bhairab River. Moreover, yearly 500 kg of petro jelly was dumped in a ditch inside the cables factory campus. For performing EIA of the factory, environmental evaluation system (EES) has been adopted. Around, 25 parameters were selected for the EES procedure and all were assigned different weightage for their environmental quality. The major environmental parameters were reservoir fisheries, downstream fisheries in nearby Bhairab river, bank stability, temperature stratification, biochemical oxygen demand (BOD) in River water, public sanitation, water quality, recreation, etc. Finally, adopting the EES technique, it was seen that the Cables Factory had net positive impacts on the environment. The positive score of impacts was mainly due to socio-economic benefits for human interest parameters. However, adverse impacts were found for the physico-chemical and ecological parameters.

INTRODUCTION

Environmental degradation and the depletion of natural resources induced by human activities have attracted steadily growing concerns in the last decades. Such concerns made evident the necessity for the planning authorities to count on sound information about the possible environmental consequences of development actions. One of the tools available to satisfy this need is represented by the procedure of Environmental Impact Assessment (EIA). This procedure involves the systematic Identification and evaluation of the impacts on the environment caused by a proposed project. EIA is now applied worldwide. Its potential role in attaining sustainable development objectives was explicitly recognized during the 1992 Earth Summit held in Rio de Janeiro.

Bangladesh is a major developing country that is particularly vulnerable to environmental change. Since independence in 1971, Bangladesh has implemented a number of environmental initiatives, and is prominent in the global push for sustainable development (Glasson, 1997). Environmental impact assessment (EIA) has a key role in achieving this goal. EIA has recently been introduced through the Environment Conservation Act, 1995 and the Environment Conservation Rules, 1997. Although there are a number of inadequacies with the current process but few works have been done recently such as, Chatak cement factory made an environmental statement through EIA. This type of work is heavily influential to get the required permission of establishing any chemical based factory.. This paper experimentally examines the waste management system evaluation of EIA in Bangladesh Cables Shilpa Ltd.

Bangladesh Cables Shilpa Ltd. a telephone cable making company is a well-recognized industry in the world. It was established in 1967.It is situated near the bank of the river “Bhairab”. It provides employment to nearly 300 people. The factory is well maintained by a group of highly talented engineers. There are so many production steps & in every step some wastes are produced. Each waste material may have different impacts on the environment. Some of them are disposed & some are reused in other purposes. The specific objectives of this study are to investigate the manufacturing process flow-path for Bangladesh Cables Factory Ltd, to identify the management technique for various types of generated wastes in the factory and Environmental Impact Assessment of the factory based on Environmental Evaluation System (EES)(battelle,1972).

Raw copper 2.1 mm

Coiling alu-tape using petrojelly

Tandem line

Final output of the factory (cable)

Figure 1: Some pictorial view from cables factory

METHODOLOGY

EES Procedures

A checklist of environmental parameters related to the factory has been identified by a group of experts. After that they assign weights to these parameters according to their relative importance in relation to the project. A total of 1000 units are distributed between all the parameters. Next the experts construct scaling mechanisms, termed "value functions" for each parameter. The value function graphs are then used for transforming factor measurements into subjective evaluations. i.e., objective measurements are transformed into a subjective interpretation of environmental quality (EQ) based on a scale of 10 for good quality and 0 for poor quality. An index expressed in Environmental Impact Units (EIU) is then developed for each project alternative (i.e. with project) and baseline environmental conditions (i.e., without project).Mathematically this is represented (Battelle, 1972) as,

$$EI = \underbrace{\sum_{i=1}^{m}(V_i)_1 W_i}_{\text{EIU (with pjt.)}} - \underbrace{\sum_{i=1}^{m}(V_i)_2 W_i}_{\text{EIU (without pjt.)}}$$

EI = Environmental Impact
$(V_i)_1$ = Value in EQ of parameter 'i' with project
$(V_i)_2$ = Value in EQ of parameter 'i' without project
W_i = Relative importance weight unit

m = Total no. of parameters
If the net value is (-) ve = Adverse Impact } To proposed
If the net value is (+) ve = Beneficial Impact } development project

Identification of Parameters and Distribution of Weightage

Table 1: Environmental impacts of cables factory
Total Environmental Impacts: 1000

Terrestrial: 89 • Wildlife (46) • Species Diversity (43)	Land: 33 • Bank Stability (33)	Health: 101 • Parasitic Diseases (45) • Public Sanitation (56)
Aquatic: 100 • Reservoir Fisheries (37) • Downstream Fisheries (34) • Migratory Fish (29)	Surface Water: 267 • Flow Variation (41) • Evaporation (17) • Temperature Stratification (37) • Dissolved Oxygen (24) • Turbidity (27) • BOD (37) • Heavy Metals (47) • pH (37)	Socio-Economic: 214 • Water Supply (56) • Power Supply (68) • Navigation (53) • Highway Relocation (37)
	Ground Water: 47 • Water Table (47)	Aesthetic & Cultural: 79 • Water Quality (35) • Recreation (44)
	Atmosphere: 70 • Climatic Changes (38) • Air Quality (32)	

Construction of Value Function Curve

Value function curve is an essential element for EES evaluation of any project. For the construction of value function curve, the first step is to collect information on the relationship between parameter and the quality of the environment (EQ). The EQ parameter scale is normally kept as the abscissa, so that the lowest value is zero. Then, the EQ scale is divided into equal intervals ranging between 0 and 10. Thus, the appropriate value of the parameter for each interval is determined. This process is to be continued until a reasonable curve may be drawn. Several value function curves were constructed by the experts for the environmental evaluation of Bangladesh Cables Factory (Figure 2). The value function curve for “Wild life” is the first representation in Figure 2. While the possibility of wildlife before the project imagined 6 and in the contrast high possibility of decreasing amount of wildlife with project expressed as 3. Considering environmental quality with responding to the wildlife a curve is drawn. The “Y” or “N” symbol in figure 2 represents the term “with project” and “without project” respectively. Similarly the value function curves for other ecological parameters such as species diversity; reservoir fisheries and downstream fisheries etc. are drawn. It was seen that the curves were different because of the versatile characteristics of the parameters.

ISBN: 978-984-33-7045-7, PI. 57 (1-8)

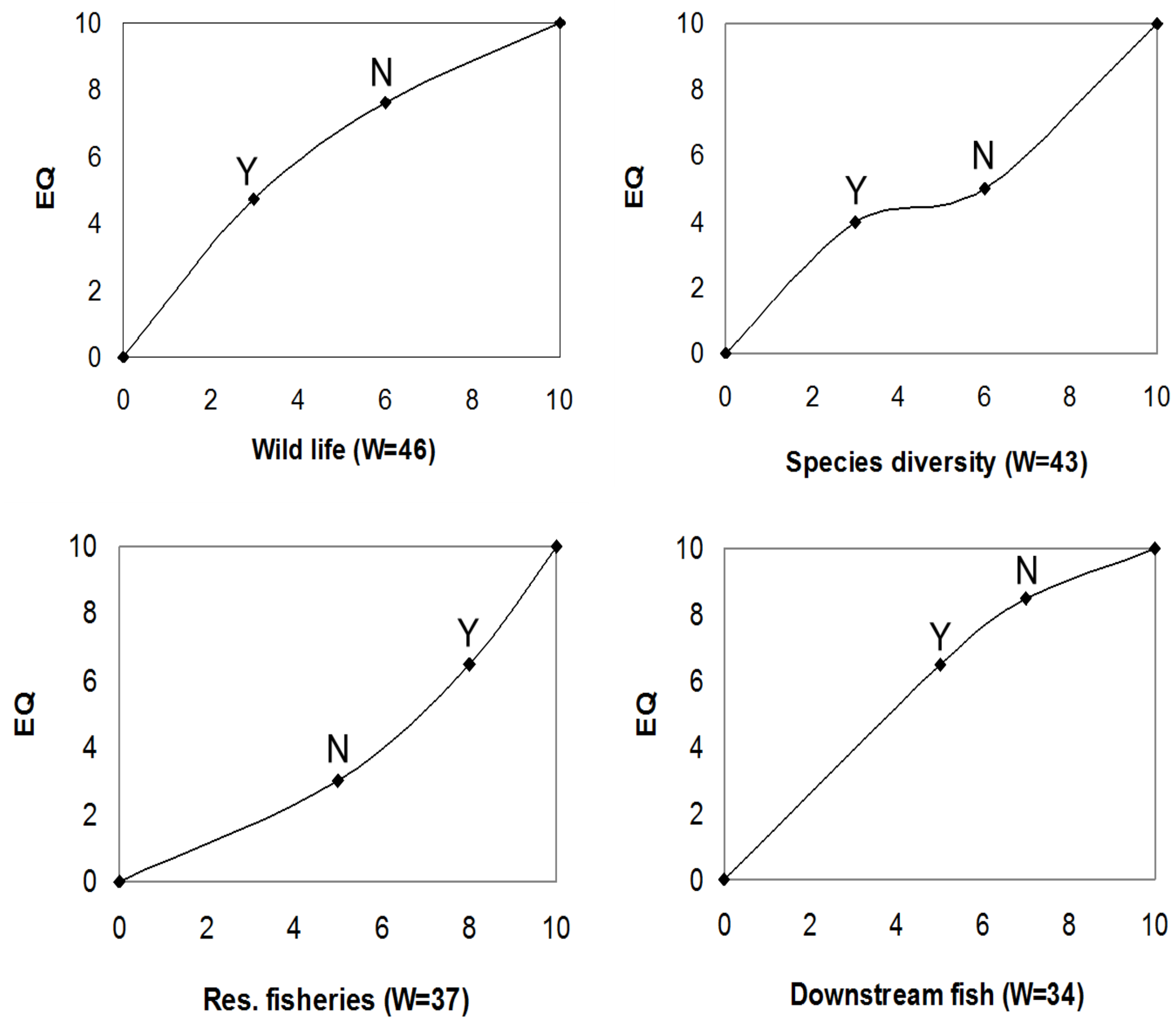

Figure 2: Value Function Curves for Different Ecological Parameters

Value for EQ Obtained From Value Function Curve

Ecological parameters

From the figure 2 we have found some ecological parameters vs. EQ graph. On the basis of those graphs a simple valuation of the EQ can be found with respect to different parameters. For an example, before the project the wildlife was expressed up to 6 out of 10 and environmental quality was found 7.6 from the curve and after project it was obvious that the amount of wildlife decreases to 3 and EQ fall down to 4.7 which is shown in Table 3.

Table 2: Value for EQ Obtain from Value Function Curve in case of Ecological Parameters

Serial no.	Parameters	Without Project(EQ)	With Project(EQ)
1	Wildlife	7.6	4.7
2	Species Diversity	5	4
3	Reservoir Fisheries	0	6.5
4	Downstream Fisheries	8.5	6.5
5	Migratory Fish	5	2

Human interest (HI) parameters

As the figure 2, different curve for HI parameters and Physico chemical parameters could be drawn and the outcomes of these curves are shown below in table 3 and table 4.

Table 3: Value for HI Parameters EQ Obtain from Value Function Curve

Serial no.	Parameters	Without Project(EQ)	With Project(EQ)
1	Parasitic Diseases	6	2
2	Public Sanitation	5	10
3	Water Supply	1	7
4	Power Supply	2	8
5	Navigation	1	7
6	Highway Relocation	8	5
7	Water Quality	6	4
8	Recreation	3	9

Physico-chemical parameters

Table 4: Value for Physico-chemical Parameters EQ Obtain from Value Function Curve.

Serial no.	Parameters	Without Project(EQ)	With Project(EQ)
1	Bank Stability	2.6	4
2	Flow Variation	6	4
3	Evaporation	5	2
4	Temperature Stratification	8	7
5	Dissolved Oxygen	8.5	7
6	Turbidity	8	6.5
7	BOD	10	6
8	Heavy Metal	6	5
9	pH	10	7
10	Water Table	8	3
11	Climatic Changes	6	3
12	Air Quality	8	7

RESULTS AND DISCUSSIONS

Project Description

Raw materials are the key ingredient of any factory. Every year the factory estimates the annual requirement of the raw materials. After using these materials all year long some are remained as wasted. Then the factory keeps the record of this amount and tries to find a suitable way to diminish the wastage. Table 5 shows the used raw materials and amount of annual wastes (kg) of cables factory.

Table 5: Raw materials used in the factory and generated waste (annually)

Serial no.	Raw materials	Annual req. (kg)	Annual wastes(kg)
1.	copper	8,16,436	1,488
2.	HDPE	1,01,309	30,182
3.	foam	49,662	1,200
4.	petro-jelly	1,49,959	2,000
5.	black PE	2,97,841	17,260
6.	alu-tape	62,241	3,078
7.	polyester foil	11,684	975
8.	polital foil	992	50
9.	color master	3,291	1,450
10.	steel tape	21,116	6,500
11.	PVC insulation	650	85
12.	PVC jacket	1,425	175

REUSE OF WASTE

Insulation wire

It is used in BITAK, Shiromoni, Khulna for the purpose of their practical classes. Computer Science and Engineering Department of KUET also used it for their practical classes. It is also used in electronic motor shop.

Black PE

Black PE is melted and then form into plastic and sold to the local market.

Copper

Copper is a demandable product. It is either used by the factory or sold to the local market. Another cable making company BRB cables buy the cables and then they processed it for the raw copper.

Steel tape, color master, alu-tape

The entire wasted product is collected by the shop according to bidding.

Dumping Of Waste

Petro jelly

Petro jelly is sometimes not fully sold and dumped into a specific place safely. There are no agricultural land or fruit trees nearby. There is also little chance of ground water contamination because it was well pre planned. Annually near about 500 kg of petro-jelly is being dumped.

Water

Water used in different purposes in the factory such as cooling the machine and then dumped into the nearby river. About 80,000 liter water dumped in the river daily.

Fuel

The used fuel has been thrown to the river after use.

According to the equation of EES calculation described in EES procedure the following calculation has been done. In Table 6 the EQ for without project and with project found by value function curve are multiplied with the given weightage. It is done for all 25 parameters. At first the weightage was multiplied with the EQ for without project and then EQ for with project was multiplied. Finally the net values for each parameter were obtained by the difference between the value of with and without project. These values may be positive or negative. These positive values indicate the beneficial or environment friendly impact by the parameters while the negative means the opposite.

Table 6: Results of Application of EES to the Above Project

Serial no.	Parameters	Without project	With project	Net change
1	Wildlife	350	217	-133
2	Species Diversity	215	172	-43
3	Reservoir Fisheries	0	241	241
4	Downstream Fisheries	289	221	-68
5	Migratory Fish	145	58	-87
6	Bank Stability	86	132	46
7	Flow Variation	246	164	-82
8	Evaporation	85	34	-51
9	Temperature Stratification.	296	259	-37
10	Dissolved Oxygen	204	168	-36
11	Turbidity	216	176	-40
12	BOD	370	222	-148
13	Heavy Metal	282	235	-47
14	pH	370	259	-111
15	Water Table	376	141	-235
16	Climatic Changes	228	114	-114
17	Air Quality	256	224	-32
18	Parasitic Diseases	270	90	-180
19	Public Sanitation	280	560	280
20	Water Supply	56	392	336
21	Power Supply	136	544	408
22	Navigation	53	371	318
23	Highway Relocation	296	185	-111
24	Water Quality	210	140	-70
25	Recreation	132	396	264

From calculating the total summation of net impact change in table 6 the effective result was found. In Table 7, the impacts on terrestrial, aquatic, land, surface and ground water, atmosphere, health, socio economic, aesthetic and cultural parameters were highlighted. Considering this result we could find that the factory creates negative impacts on terrestrial, surface water, ground water and atmosphere. All that impacts connected with the waste disposal to the river and the reduction of wildlife due to proper habitat crisis. On the other hand it is positively working on aquatic, land, health, socio-economic, aesthetic and cultural point of view.

Table 7: Environmental Impacts of the Above Project on the Various Environmental Components

Categories	Components	Without Project EIU	With Project EIU	Net Change in EIU
Ecological	Terrestrial	565	389	-176
	Aquatic	434	520	86
Physico - Chemical	Land	86	132	46
	Surface Water	2069	1529	-540
	Ground Water	376	141	-235
	Atmosphere	484	338	-146
Human Interest	Health	550	650	100
	Socio-Economic	541	1492	951
	Aesthetic & Cultural	342	536	194

Final Impact Result

The net change in environmental impact unit in Table 8 shows that the ecological condition is slightly worse than the nominal environment. Due to chemical based factory it was somehow affecting the physico-chemical environment but in Bangladesh perspective it was much necessary for human interest. So the final EIU shows that the factory was well viable and could easily be continued on the way of prosperity.

Table 8: Environmental Impacts of the above Project on the Various Environmental Categories

Categories	Without Project EIU	With Project EIU	Net Change in EIU
Ecological	999	909	-90
Physico-Chemical	3015	2140	-875
Human Interest	1433	2678	1245
TOTAL	5447	5727	+280

CONCLUSIONS:

The flow diagram of manufacturing process clearly indicates that the process operation is highly automated and the process control is also computerized. This has been well taken care of by the management of the factory by adopting the most advanced technology for both process operation and pollution control. Therefore, operators will be able to work in a healthy atmosphere. As the process is controlled by automatically the amount of waste is less than the manual process.

Various types of waste were generated in the factory. The wasted material is then sold by the factory to the local sellers by a bidding programme. After the handover of the waste, they were recycled or reused in different purposes. Insulation wire, Steel tape, color master, alu-tape, Copper, Black PE, etc. had been found to be reused intensively. BRB cable factory was a major customer for copper recycling. Cooling water and burnt fuel had been disposed to the nearby Bhairab River. Moreover, nearly 500 kg of petro jelly as well as domestic household wastes had been dumped together in a ditch inside the cables factory campus.

The main environmental impacts of the Project are the surface water. It affected little bit for the waste oil by Berge and the oil used for generator or vehicle. Finally, adopting the EES technique, it was seen that the Cables Factory had net positive impacts on the environment. The positive score of impacts was mainly due to socio-economic benefits for human interest parameters. However, adverse impacts were found for the physico-chemical and ecological parameters. As long as the waste management properly operated and maintained the impacts of the Project could be maintained at an acceptable level. The creation of a green belt all around and buffer zone will significantly improve the environment. On overall considerations the environmental evaluation or EES clearly indicates that the cables factory is a very viable project and will ensure socio-economic benefit both in the short and long term. The Project will provide cable at a lower price than the current price in the market today. Cable availability in the market will be also higher. It will meet the demand for the telephone cable in the country and will also be able to earn an enormous amount of foreign exchange.

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M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI. 58 (1-9)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Effects of Using Arsenic-Iron Sludge Wastes in Brick Making

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ABSTRACT

The arsenic-iron sludge generated in most of the treatment systems around the world is discharged into the nearest watercourse, which leads to accumulative rise of arsenic and iron concentrations in water. In this study, attempts are made to use the arsenic-iron sludge in making bricks and to analyze the corresponding effects on brick properties. The water treatment plant sludge is extremely close to brick clay in chemical composition. So, the sludge could be a potential substitute for brick clay. This study involved the addition of sludge with ratios 3%, 6%, 9% and 12% of the total weight of sludge-clay mixture. The physical and chemical properties of the produced bricks were then determined and evaluated and compared to control brick made entirely from clay. Results of different tests indicated that the sludge proportion and firing temperature were the two key factors in determining the quality of bricks. The compressive strength of 3%, 6%, 9% and 12% sludge containing brick samples were found 2041.67 lb/in^2, 2196.96 lb/in^2, 1363.63 lb/in^2 and 1025.64 lb/in^2, respectively. These results indicate that the compressive strength of prepared bricks decreased with the increase of sludge proportion. Leaching characteristics of burnt bricks were determined with the variation of pH at a constant temperature. The optimum amount of sludge that could be mixed with clay to produce good bonding of clay-sludge bricks was found 6 % (safely maximum) by weight.

INTRODUCTION

The serious arsenic as well as iron contamination of groundwater in Bangladesh has come out recently as the biggest natural calamity in the world. The people in 59 out of 64 districts comprising 126,134 km^2 of Bangladesh are suffering due to the groundwater contamination. Seventy five million people are at risk and 24 million are potentially exposed to arsenic contamination. Most of the recognized stages of arsenic and iron poisoning have been identified in Bangladesh and the risk of poisoning in the population is increasing day by day. The millions of shallow and deep wells that had been sunk in various parts of the country are dispensing their own special brand of poison. In consequence, a large number of populations in Bangladesh are suffering from the toxic effects of arsenic contaminated water. On the other hand arsenic in combination with various heavy metals (such as iron, lead) causes serious environmental problems which adversely affect the health of millions of people in Bangladesh. To minimize these adverse effects available technologies and water treatment have been made which helps to remove arsenic and iron from drinking water. Therefore, a sludge is got that will contain this arsenic and iron. Most of the focus has been on awareness building and the development of water treatment system removing arsenic from drinking water. The disposal of arsenic rich sludge generated from the treatment processes is one of the issues that have received little attention from the sponsors of the technologies and the users (Eriksen et al., 2001). At present, 18 large scales arsenic and iron treatment plants are working actively in Bangladesh. Each treatment plant generates about 60000-cft arsenic rich sludge per year (Basak and Islam, 2008). They have sufficient removal capacity (> 90%) as well (Hemal and Zinia, 2001).Landfills are commonly used for disposal of sludge in Bangladesh. But rapid urbanization is gradually making it difficult to find suitable landfill sites (Lin and Weng, 2001). At some places, it is disposed off to nearby rivers or low laying areas, which is likely to pollute surface and groundwater. As environmental regulations become more stringent and volume of generated sludge continues to increase, traditional sludge disposal methods are coming under increasing pressure to change and therefore, there is a strong demand for environmentally safe reuse and effective disposal methods for iron and arsenic contaminated sludge out of water treatment plant due to the increasing amount of sludge generated by the water treatment plants in Bangladesh to decrease arsenic toxicity and protect the health of rural inhabitants in acute problem areas in and Bangladesh. Incineration is costly and contributes to air pollution and landfill space is becoming scare. A possible long term solution appears to be recycling of the sludge and using it for beneficial purposes. One technique that is available to treat hazardous waste is solidification that stabilizes and solidifies components of waste. The solidified product is disposed off to a secure landfill site or it can be recycled as construction material like bricks if it meets the specific strength requirement and can be shown to leach toxic pollutants within acceptable limits (Rahmat, 2001).

In this paper, an attempt is taken to use the arsenic-iron contaminated sludge by making bricks. For thousands of years, bricks have been made from clay. The water treatment plant sludge is extremely close to brick clay in chemical composition. So, the sludge could be a potential substitute for brick clay. Use of arsenic-iron sludge in making brick is one of the low-cost technologies available in Bangladesh which helps in reducing the adverse environmental effects of arsenic and iron. Performance of this technology depends on the concentration of arsenic-iron sludge used as brick ingredient and burning temperature and technique of those bricks. Brick produced from this technology are generally lightweight. Lightweight bricks are considerably lighter than the standard bricks. Lightweight bricks are generally preferred because they are easier to handle and thus their transportation costs are lower. The development of lightweight bricks allows brick manufacturers to reduce the total clay content through the introduction of holes or incorporation of combustible organic waste particles that reduce the mass of the brick while maintaining the required properties. All the tests of this study were performed in the laboratories of the Department of Civil Engineering, Khulna University of Engineering & Technology.

This study mainly aims at blending arsenic-iron sludge waste with clay for making bricks and to study the physical properties and leaching characteristics of the developed bricks for its potential use in construction works. Guidelines were given depending on this project result but this reusing technique required more technological support for the proper utilization of arsenic-iron sludge as a potential substitute for brick clay.

METHODOLOGY

The arsenic-iron sludge waste used for this study was collected from arsenic-iron removal plant (AIRP) at Manikganj. Manikganj water treatment plant use to dispose the sludge into the bank of a nearby water body. As a result, during rain the sludge drains into the water body and increases the concentration of arsenic, iron and other elements. To reduce such increment, the utilization of sludge as a manufacturing product will be a very effective step. On the other hand, brick clay for desired bricks was collected from nearby brick field at Fultola of khulna district. After collection, sludge samples were oven dried for 24 hours at 105^0C. Then the sludge sample and collected brick clay were crushed in the laboratory. Crushing of the samples is required to have uniform distribution of all particles. After drying and crushing, the moisture content & heavy metal content i.e. arsenic and iron of the sludge were determined in the laboratory. Arsenic content of the sludge was determined by field test using color coding. The iron content was measured by using spectrometer. For the manufacture of bricks, a specific dimension and molds are required. In case of this study, specific dimension of brick was selected to be 10in. × 5in. × 3in. Two frame made of wood were used as brick mold. Thickness of the side walls of the mold was 0.5in. The lower end of the mold was fixed with a plate of wood to facilitate the pouring process. A total of 4 brick samples of sludge-clay mixture in varying proportion (3%, 6%, 9% and 12%) were prepared in the laboratory. For the preparation desired bricks, the mixture of clay and sludge was placed into the mold and then compacted well to get the desired strength. Drying of the brick sample was done in three stages. At first the sample was oven dried at a temperature of 105^0C for 2 days. Secondly the oven dried brick was burnt into the furnace at 500^0C for 12 hours. Finally the temperature was increased at about 1000^0C and in this stage the sample was burnt for 12 hours. In this study, 3-satges burning process was applied to avoid firing shrinkage of sample. It was observed from previous studies that sudden rise in burning temperature is responsible for fracturing the surface of brick sample. A laboratory furnace was used for burning of prepared brick samples. After burning, prepared bricks were taken to the laboratory to check physical and chemical properties. Available tests (i.e. moisture content, specific gravity, water absorption capacity and compressive strength test) of brick were performed to determine the physical properties. It has been observed in this study that the performance and quality of prepared bricks generally depend on the degree of compaction, selection of burning temperature and concentration of sludge.

Figure-1: Sludge collection from arsenic-iron treatment plant at Manikganj

RESULTS AND DISCUSSION

After the collection of sludge sample, chemical characteristics i.e. arsenic & iron content and pH were measured in the laboratory. Test results shows that the arsenic and iron content of the sample are very high (arsenic 0.1 mg/L & iron 7.5 mg/L). Experimental result shows that the sludge has a pH of 6.5, indicating that the sludge can be treated as neutral material. From the above test results it can be said that the contribution of treatment plant sludge in groundwater is much higher. When desired bricks were prepared, physical and chemical properties of prepared bricks were tested in the laboratory to justify their quality. Quality of brick depends upon its water absorption capacity, moisture content, specific gravity and compressive strength. Figure-2 represents the variation in physical properties with the variation of sludge concentration. Test results indicate that with the variation of sludge concentration physical properties accept compressive strength show slight variation. With the increase in sludge proportion, the water absorption capacity and specific gravity of the prepared bricks increases but the moisture content decreases. In case of compressive strength the variation is much higher. Compressive strength of the prepared bricks increases up to a certain limit and then decreases gradually with the increase in sludge proportion.

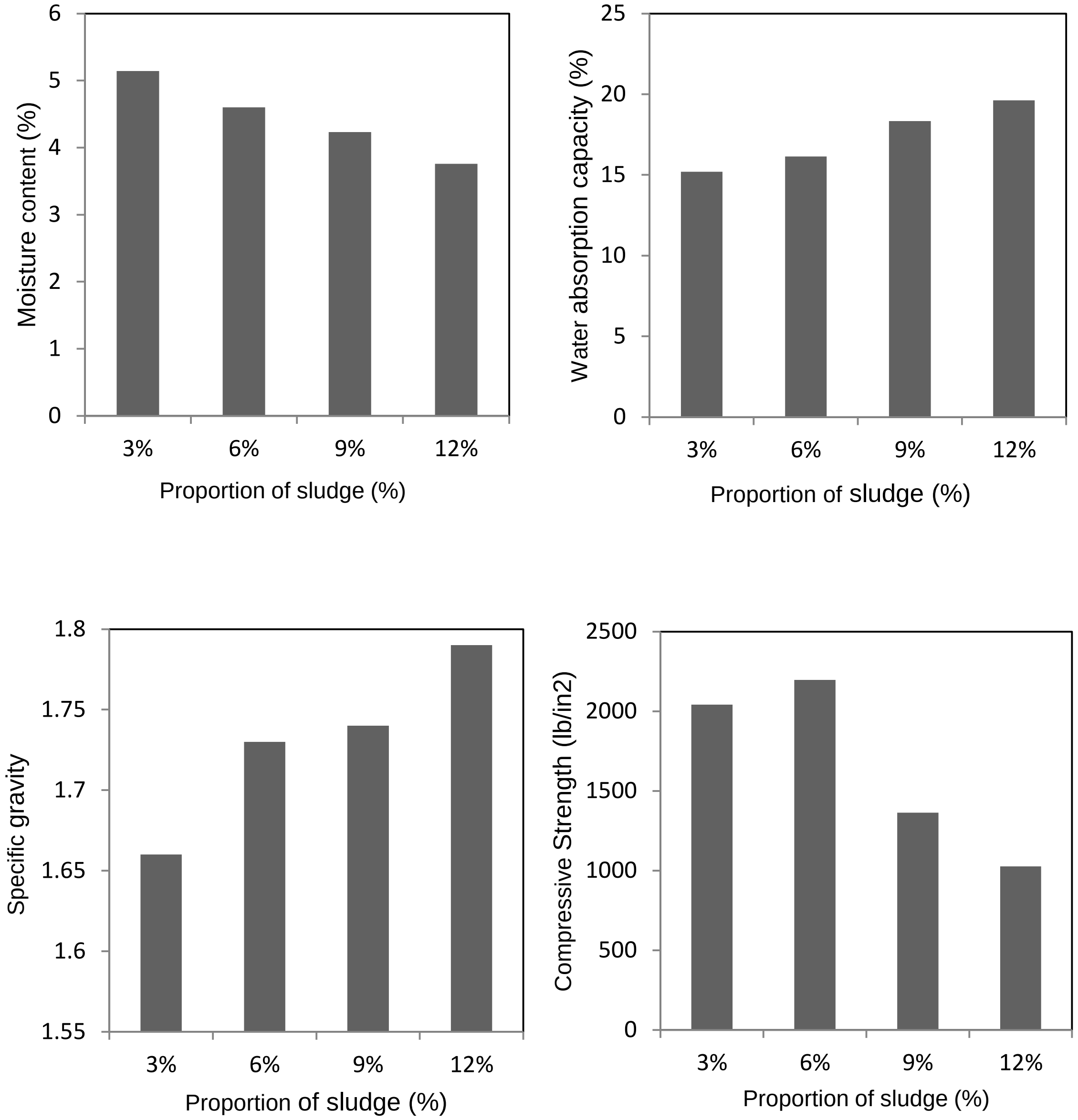

Figure-2: Variation in physical properties of prepared bricks with the variation in sludge proportion

TEST RESULTS ON LEACHING CHARACTERISTICS

In this study tests on chemical characteristics are designed to identify the hazardous concentration of arsenic & iron which likely to leach out from the prepared bricks. Leaching characteristic of burnt bricks was measured with the variation in sludge concentration and pH at a constant temperature. Three different conditions were selected to analyze the leaching characteristic. These conditions are acidic condition, alkaline condition and normal condition. Table-1 represents the variation in the amount of leaching of arsenic and iron with variation in Sludge proportion. The proportionality between sludge concentration and amount of leaching can be clearly observed from the above test results. Rise in the concentration of sludge increases the leaching amount of arsenic and iron. Test results in table-1 show that leached arsenic content is less than the hazardous concentration limit (0.05 mg/l) at the time of 3% sludge-mix. When 6% sludge mix was used, it exceeded the allowable limit and for further increase in sludge concentration, the amount of leached arsenic content increased rapidly. Above results in table-1 also indicate that leached iron content is less than hazardous concentration limit (0.3~1.0 mg/l) but it is also observed that there is a slight increase in the amount of leached with the increase in sludge proportion.

Table-1: Variation in the amount of leaching of arsenic & iron with the variation in sludge proportion

		Proportion of sludge in prepared bricks (%)			
		3%	6%	9%	12%
Amount of arsenic leaching (mg/L)	After 24 hrs	0.001	0.001	0.025	0.025
	After 72 hrs	0.025	0.025	0.075	0.100
	After 120 hrs	0.050	0.050	0.100	0.250
	After 168 hrs	0.025	0.075	0.250	0.500
	After 216 hrs	0.025	0.075	0.500	0.500
Amount of iron leaching (mg/L)	After 24 hrs	0.177	0.175	0.218	0.280
	After 72 hrs	0.000	0.355	0.315	0.384
	After 120 hrs	0.000	0.025	0.183	0.284
	After 168 hrs	0.000	0.190	0.177	0.159
	After 216 hrs	0.000	0.080	0.127	0.082

In this study, it was observed that the amount of leaching decreases with increase in the value of pH of the medium. At a low pH medium, leached arsenic content is very higher than the hazardous concentration limit (0.05 mg/l). In case of normal solution, leached arsenic content of the bricks also exceeds the allowable limit. But in high pH medium leached arsenic content was found less than the hazardous concentration limit for 3% & 6% sludge-mix. For 9% & 12% sludge-mix, it also exceeded the allowable limit. Leached iron content generally less than the hazardous concentration limit (0.3~1.0 mg/l). But in case of 9% & 12% sludge-mix in acidic solution, leached iron content exceeded the allowable limit. Leaching characteristic test results in different pH medium for 3%, 6%, 9% & 12% sludge concentration are as follows:

Acidic Medium

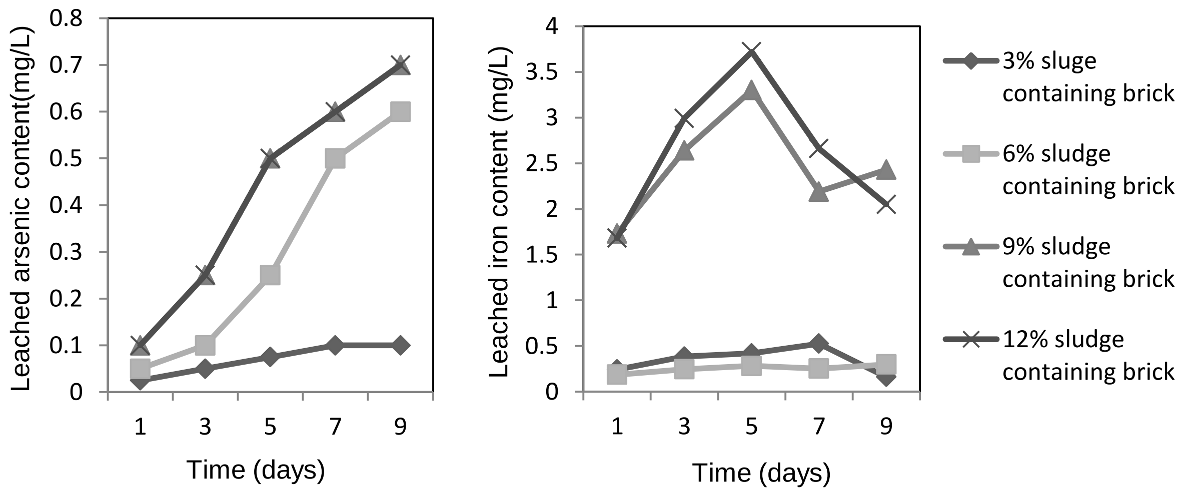

Figure-3: Leaching of arsenic and iron with variable sludge proportion at acidic medium

To obtain an acidic solution, the value of pH was selected to be 3.0 (adding H_2SO_4). Bricks having 3%, 6%, 9% & 12% sludge mix showed large variation in leaching behavior. The results of leaching tests at acidic medium (Figure-3) indicate that leaching of arsenic and iron from burnt bricks increases with the increase in sludge proportion. For 3% sludge containing brick, the rate of leaching was lower than the 6%, 9% & 12% sludge containing bricks. In acidic medium the rate of leaching was very high. Leached arsenic and iron content of burnt bricks exceeded the allowable limit very quickly. So it can be said from above discussion that the burnt bricks should not be exposed in acidic medium.

Alkaline Medium

To obtain an alkaline solution, the value of pH was selected to be 12.0. Bricks having 3%, 6%, 9% & 12% sludge mix showed large variation in leaching behavior. Corresponding test results and their graphical representation are given below:

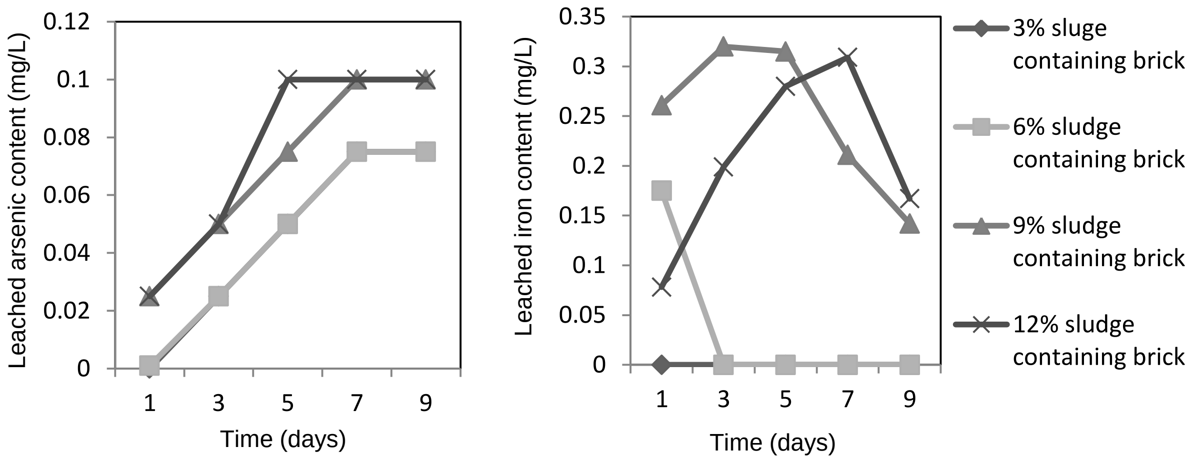

Figure-4: Leaching of arsenic and iron with variable sludge proportion at alkaline medium

In alkaline medium, the leached arsenic and iron content of burnt brick samples was found within the allowable limit at the initial stages (Figure-4). In case of arsenic, rate of leaching increases as time passes and finally it exceeded the allowable limit. On the other hand, the leached iron content was found within the allowable limit (0.3 ~ 1.0 mg/L). Although initially the rate of leaching increases slowly but as the time passes, the rate of leaching decreases gradually. It can be observed that in alkaline medium the rate of leaching is less than that in acidic medium. Leached arsenic and iron content of burnt bricks exceed the allowable limit due to the increase in proportion of sludge or due to long time exposing.

Neutral Medium

To obtain a normal solution, the value of pH was selected to be 6.50. Bricks having 3%, 6%, 9% & 12% sludge mix showed large variation in leaching behavior. Figure-5 indicates that in normal medium the rate of leaching changes with the proportion of sludge in the brick sample. For small proportion of sludge, the amount of leaching was very low. but the rate of leaching showed different characteristics. In case of arsenic the leached arsenic content of 3% sludge containing brick sample did not exceed the allowable limit. While for 6%, 9% & 12 % sludge containing brick samples, leached arsenic was found to exceed the allowable limit after 120 hours, 72 hours and 24 hours respectively. On the other hand, the leached iron content of burnt brick samples in normal condition was found within the allowable limit (0.3 ~ 1.0 mg/L). For 3% sludge containing brick, leached iron content was not found after 72 hours. For 6%, 9% & 12% sludge containing brick samples, there was an increase in the amount of iron leaching. Although initially the rate of leaching increases slowly but as the time passes, the rate of leaching decreases gradually.

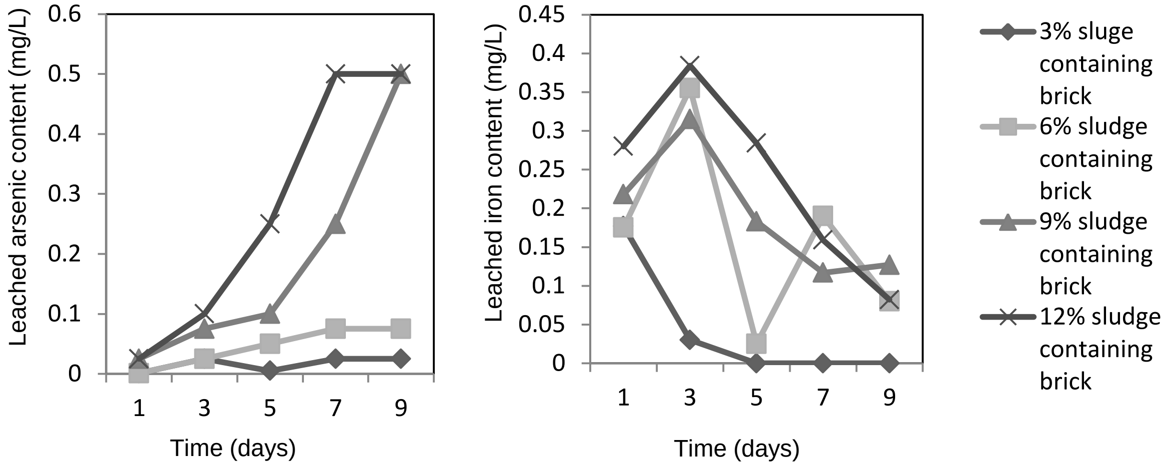

Figure-5: Leaching of arsenic and iron with variable sludge proportion at neutral medium

Effects of Firing Temperature

The firing temperature is another important parameter affecting the degree of shrinkage. Test results of this study indicate that there is an inverse relation between firing temperature & the proportion sludge. The temperature of burning should be selected in such a manner that it neither very low nor very high. It has been observed from this study that burning temperature ranges between 900^0C~ 1200^0C. Bricks which were burnt at low temperature do not seem to have high compressive strength. On other hand at very high temperature, brick seems to have fractured surface. So, an optimum range of temperature is required for brick burning.

With the increase in sludge proportion, temperature of firing shrinkage decreases, because the swelling of the clay is much lower than that of sludge, an addition of sludge to the mixture widens the degree of firing shrinkage. Follow figure indicates the relation between sludge proportion and firing temperature:

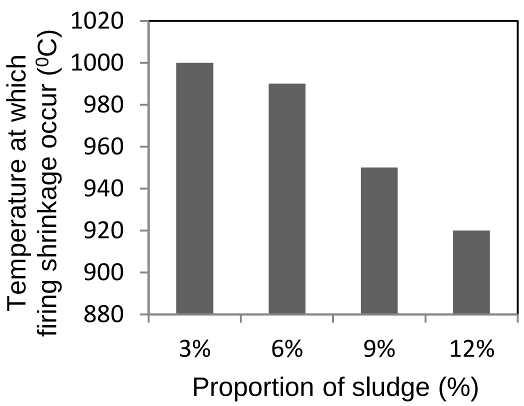

Figure-6: Relation between sludge proportion & firing temperature.

Figure-6 represents the inverse relationship between the sludge proportion and the firing temperature. It can be observed from above figure that when sludge proportion is 3% then the firing shrinkage occur at a temperature of 1000^0C. For further increase in sludge proportion, there is a drop in the temperature of firing shrinkage. Finally for 12% sludge containing brick temperature of firing shrinkage was found around 920^0C.

Moreover, properties of a brick (i.e. moisture content, specific gravity, water absorption capacity and compressive strength) completely depend on its burning temperature. For this reason, bricks which are burnt in a brick-field show better qualities than the laboratory-burnt bricks. In this study bricks are burnt in a laboratory furnace so the appearance of firing shrinkage is much quicker.

Characteristics of Prepared Clay-Sludge Bricks

In this study, the quality of prepared bricks was determined on the basis of laboratory tests. Four brick samples have been made and various tests were performed on those bricks to justify the effectiveness of arsenic-iron sludge as a substitute for clay. It can be said on the basis of test results that properties of prepared bricks are slightly different from the properties of controlled bricks. So the variations in properties between controlled bricks and prepared bricks are required to compare.

The durability of the brick is largely dependent upon their water absorption. The water absorption of control clay brick generally ranged between 9.94 and 11.18 %. In case of this study, test results show that water absorption capacity of prepared bricks ranges from 15.20% to 19.62%. The apparent specific gravity of controlled clay brick generally ranged between 1.84 and 1.95. But apparent specific gravity test results of prepared bricks ranged between 1.66 and 1.79. Compressive strength determines the potential for application of the bricks. Compressive strength is usually affected by the porosity, pore size, and type of crystallization. It is usually defined as the failure stress measured normal to the bed face of the brick. AASHTO standards for brick requirements: 150 kg/cm^2 (2129.028 lb/in^2) for a first-class. In this study the compressive strength test results of sludge-brick were found to be ranged from 1025.64 lb/in^2 to 2196.96 lb/in^2. From the above comparison it can be said that these brick types were of Series B and C.

Proposals for Clay-Sludge Bricks

On the basis of test results of this study, it can be said that quality of sludge-brick depends upon the sludge concentration, technique of molding, degree of compaction, method of burning & firing temperature. In order to yield a good quality brick, the proportion of sludge and the firing temperature are the two key factors controlling the shrinkage in the firing process. Specific gravity, moisture content and compressive strength of the burnt brick samples are also dependent on the sludge proportion and the firing temperature. As the amount of leaching and toxicity of the burnt bricks are higher both in acidic and alkaline mediums, the prepared bricks should not be exposed to these mediums. In this study, hand molding was used for the preparation of bricks. For future works, mechanical molding should be used to compare the brick properties. Again for burning laboratory furnace was used in this study. It is also recommended that for future works, brick samples should be burnt in the brick field and the change in brick properties should be observed. On the other hand in this study, leaching characteristic of burnt brick samples was determined with the variation in pH at a constant temperature. Future study should involve the variation of temperature in combination with the variation in pH to check the leaching behavior of prepared bricks and Toxicity characteristics leaching procedure (TCLP) test should be performed. The rate of increase in firing temperature is also considered to be a key factor. Sudden increase in temperature affects the shrinkage in the firing process. So the rate of increase should be slow to avoid firing shrinkage.

CONCLUSIONS

This work tries to demonstrate a feasible way of using arsenic-iron contaminated sludge as a clay substitute. Different measurements of both clay-sludge mixtures were carried out to evaluate the factors that could affect the brick quality.

The results of compressive strength tests on the bricks indicate that the strength is greatly dependent on the amount of sludge in the brick and the firing temperature. In this study, results of compressive strength tests on the 9% and 12% sludge content bricks shows that desired strength cannot be found. This is due to the increase in sludge concentration. Again specific gravity, water absorption capacity of prepared bricks was found to increase with the increase in sludge proportion. Test results also indicate that moisture content of the prepared bricks decreases with the increase in sludge proportion.

Tests on leaching characteristic show that, in acidic medium amount of leaching from prepared bricks were much higher than the alkaline and normal medium. On the other hand the amount leaching increases with the increase in sludge concentration. Arsenic & iron content in the raw sludge was found to be almost double than that present in the prepared bricks.

Based on the laboratory test results, it can be said that Arsenic sludge can be used as a suitable raw material for brick making. The optimum amount of sludge that could be mixed with clay to produce good bonding of clay-sludge bricks was found 6 % (safely maximum) by weight. On the other hand, if

6 % of sludge is mixed to the clay soil, the firing shrinkage of the bricks would not be affected. The amount of leaching in 6 % sludge content brick is also lower in comparison to other bricks.

Thus, utilization of arsenic-iron sludge should be encouraged as one of the most cost-effective alternative material that could be used in fired clay brick manufacturing.

ACKNOWLEDGEMENTS

Appreciation goes to the Department of Civil Engineering, KUET for the financial support to complete this project.

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M. Alamgir, I.M. Rafizul, S.M.T. Islam, M.I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.119 (1-10)

Proceedings of the WasteSafe 2013 – 3rd International Conference on
Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Industrial Waste Management in Dhaka

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ABSTRACT

Environmental pollution is one of the major problems associated with the rapid growth of urbanization, industrialization and rise in the living standards of people. Dhaka the capital of Bangladesh is experiencing a rapid growth and the industrial wastes seem to be a by-product of growth. Industrial wastes are those which are the unwanted materials from industrial operation causes air, water and sound pollution.

Bangladesh being a poor country is facing problem due to the lack of finance and technology for waste management. Despite legislations, effluents, toxic waste, untreated industrial waste are often released directly to the environment or dumped without treatment at municipal landfills in Dhaka. The main objective of this paper is to assess of the present industrial pollution scenario in some major polluting zones in Dhaka like Tejgaon, Hazaribagh and thus analyzing the existing industrial pollution management system and give initial identification of appropriate interventions in order to improve the industrial pollution control system and compliance in Dhaka thereby to enhance the level of awareness among the industries to reduce the pollution load in the environment.

Keyword: *industrial waste, environment, pollution, Dhaka, waste management*

INTRODUCTION

After the liberation of Bangladesh in 1971, Dhaka became the capital city of the country. As a result, the city experienced a major boom in industrialization and commercial activities. Presently, it is estimated that there are over 7,000 industries in Dhaka Metropolitan Area alone. Most of these industries are located mainly in 3 ZONES: Hazaribagh, Tejgaon, DND area including Fatullah and Narayanganj (WBR 2005).With the growth in population and industrialization, Dhaka witnessed a rapid fall in water quality of the numerous rivers, khals and other water bodies. The main reason is the indiscriminate discharge of industrial effluents and domestic waste without treatment. Industrial pollution has now emerged as the main threat to Bangladesh land, water and air. It is disappointing that the government has not yet been able to make industrial owners install effluent treatment facilities (ETF) at their enterprises. Among the principal industrial polluter zones in Dhaka, Tejgaon and Hazaribagh being the most ones. Besides the contribution of domestic pollution from a large area, the Norai Khal gets full wastewater contribution from the Tejgaon Industrial Area having several large industries. (WBR 2005) The industries are discharging their wastes untreated into either the sewerage system or the peripheral river system directly. In general, the lack of facilities of industrial waste management causes hazard for both environment and public health in Dhaka city. The main types of impact and hazards entailed by urban and industrial waste are changes in the landscape and visual discomfort, air pollution, pollution of surface waters, changes in soil fertility as well as in the composition of the adjoining biocoenoses.

OBJECTIVE

The objective of the study is an assessment of the present industrial pollution situation, analysis of the existing industrial pollution management system, initial identification of appropriate interventions and options to improve the industrial pollution control and compliance in Greater Dhaka.

METHODOLOGY OF AUDITING

The methodology followed in auditing the industries is as follows:

Step 1:

Site Audit – an assessment of site condition and the extent of pollution problem which required Site inspection, Sampling and analysis of sample, Measurement of the discharge of effluent, Review of past and present production process, Review of pollution control measures, Review of industrial performance of the industry

Step 2:

Waste Minimization/ Pollution Prevention Audit– examination of the production and waste management system to identify the extent of pollution.

Step 3:

Compliance Audit – addresses the issue of compliance with existing industrial policy and regulatory requirement.

PROBLEMS OF INDUSTRIAL WASTE MANAGEMENT IN DHAKA

Legal aspect

Though there are some laws to control industrial wastes, they are not active on Governmental level or in city level and the capability to enforce the rules and regulation are very poor here.

Technological aspect

There is no collective waste treatment or disposal facility for both industrial wastes and hazardous wastes in Dhaka. Some industrial wastes, either hazardous or nonhazardous, are disposed together with ordinary municipal waste, it is hard to distinguish industrial waste from the other waste. Moreover, there is no specific data on such practices, or information regarding location and amount of waste pile illegally dumped, or information on the environmental condition around the sites.

Lack of awareness and knowledge

Once the factory discharges wastes into the public dustbin, then DCC has total responsibility for transporting and disposing of them. The factory does not care where and how the wastes are dumped. Awareness of factory on waste treatment is low and nearly the same as other industries. There are several major problems created by industrial waste. The waste materials are dumped into landfill sites. These sites will bury these products. This is good when all the waste materials are degradable. But a great percentage of industrial wastes are non-biodegradable. These pollute the land and affect the underground water. When the non-biodegradable products are burned they emit gases that diminish the ozone layer in the atmosphere. This will result in more ultraviolet radiations reaching the living atmosphere which is very dangerous.

INTERVENTION STRATEGIES

The interventions could be classified in three broad categories:

Policy interventions may include

Ensuring effective environmental assessment of industries, enforcing public involvement, promotion of cleaner production and introducing pollution charges/ permits system.

Management interventions should include

Internalizing environmental management within industries and waste minimization in industrial processes including avoidance of generation of wastes and productive utilization of generated wastes.

Technical interventions

Segregation of stronger effluent streams (from scouring, bleaching and dying) from weaker streams and employing appropriate treatment for each stream (in individual or common treatment plant).Segregation of process wastewater containing recoverable chemicals from storm-water and domestic sewage and treating them separately. Changing raw materials and processes within the industry to eliminate specific pollutants.*(Reference: Industrial Environmental Compliance and Pollution Control in Greater Dhaka by world bank report,2005)*

DESCRIPTION OF IMPORTANT INDUSTRIAL WASTE

Table-1 comparison analysis from different collected data:

Area Type	Food Waste	Paper	Polythene	Cloth	Garden Trimming	Brick Wood Metal Glass	Leaves Branches	Shredded Skin Leather	Density
CA	35.77	13.33	12.85	29.57	0.00	4.77	3.73	0.00	450
IA	19.89	33.77	18.50	0.27	0.00	1.09	0.25	26.19	456
HIG-R	69.52	6.60	6.32	1.83	2.18	5.00	8.56	0.00	518
UMIG-R	56.72	4.30	16.42	7.64	2.30	7.50	3.84	1.30	438
LMIG-R	73.01	7.06	15.32	1.55	0.00	1.49	1.67	0.00	468
LIG-R	89.25	1.89	6.39	1.38	0.00	0.00	0.43	0.00	650

Ref: Solid Waste Management in Dhaka, Bangladesh Innovation in Community driven Composting; Mushtaq Ahmed Memon; October1, 2002
CA - Commercial Area
UMIG-R - Upper Medium Income Group-Residential
IA - Industrial Area
LMIG-R-Low Medium Income Group Residential
HIG- High Income Group Residential
LIG-R - Low Income Group-Residential

Table-02 Average Composition of Solid Waste Collected from Different Locations of Dhaka:

Location Type	Vegetable matters and remaining of fruits (%)	News Paper (%)	Card hoard (%)	Tree trimming and straw (%)	Metal (%)	Glass (%)	Stone ceramics and debris (%)	Plastics and polythene (%)
Mixed area	70.12	4.16	0.16	10.76	0.13	0.25	4.29	4.71
Industrial	26.37	7.59	0.00	4.32	0.00	0.00	9.49	6.03
Commercial	62.05	6.28	0.00	2.86	0.28	0.37	3.79	4.62
Residential	59.91	11.21	0.00	8.76	0.15	0.00	2.30	17.67

Ref: Solid Waste Management in Dhaka, Bangladesh Innovation in Community driven Composting; Mushtaq Ahmed Memon;October1,2002

From Table-1 it has been found that among the other wastes like High Income residential or commercial areas the wastes like Paper, Polythene, and Shredded Skin Leather produced mostly in Industrial areas. But from Table-2 it has been seen that, except polythene none of the others are composting in well manner.

Table-03 Soil Contamination by Heavy Metals in Selected Industrial Area

District	Major industry	Heavy Metals (mg/Kg soil)
Hazaribag	Tannery	Cr:25,014 ,Zn:330 Cu 1,156
Tejgaon	Food,chemicals,textiles	Ni:84-146 , Cd:163
Tongi	Battery	Zn: 2,026
Narayanganj	Power,metal,steel	Pb:171-158 , Ni:84-146

Source: S. M. Ullah, Heavy Metals and Industrial Pollution in Bangladesh, in 1st national Conference on Environmental Health, 19-20 February 2002.

In table-3 it has been found that there are several heavy metals produced in industrial areas are contaminating the soil.

Chromium(Cr) and Zinc (Zn)

Widely use in Chromium and Zinc are found in Hazaribag. The effect of chromium in environment and health are like skin rashes, upset stomachs and ulcers, create respiratory problems, weakened immune systems, damage Kidney and liver, causes lung cancer. Water is polluted with zinc, due to the presence of large quantities of zinc in the wastewater of industrial plants. This wastewater is not purified satisfactory. One of the consequences is that rivers are depositing zinc-polluted sludge on their banks. Zinc may also increase the acidity of waters. Some fish can accumulate zinc in their bodies, when they live in zinc-contaminated waterways. When zinc enters the bodies of these fish it is able to bio magnify up the food chain.

Nickel (Ni) and Cadmium (Cd)

There is also a wide use in Nickel and Cadmium is found in Tejgaon industrial areas. Allergy of the skin and lung causes by nickel, in certain circumstances of exposure in refining, there may be a risk of cancer of the paranasal sinuses and of cancer of the lung. Cadmium strongly adsorbs to organic matter in soils. When cadmium is present in soils it can be extremely dangerous, as the uptake through food will increase. Health effects that can be caused by cadmium are diarrhea, stomach pains and severe vomiting, bone fracture, reproductive failure and possibly even infertility, there are also damage to the central nervous system, to the immune system are found, psychological disorders, possibly DNA damage or cancer development caused by Cadmium.

CURRENT SITUATION OF WASTE MANAGEMENT IN TWO MAJOR INDUSTRIAL AREAS IN DHAKA

Tejgaon Industrial Area

General Description

Tejgaon industrial zone is located within the central part of Dhaka city, the price of land in the Tejgaon area has become very high in recent years. As a result, over the last decade, the land use pattern of the Tejgaon area is gradually changing, with establishment of more and more commercial establishment. About 129 different types of industries are operating in this zone. Different types of textile industries, dying, printing, composite, or washing, constitute the largest number followed by steel mills. Apart from these, there are 5 chemical industries, 5 bakeries, 3 bitumen emulsion factories, 1 insecticide, 2 leather, 5 plastics, 1 oil mill, and 3 soap factories that might be generating considerable pollution loads.(WBR 2005)

The pollution movement path is as below:

Pollution from Tejgaon Industrial Area -> Begunbari Khal

Begunbari Khal + Mohakhali Khal + Banani Khal + Gulshan Lake -> Rampura Khal

Rampura Khal -> Norai Khal

Norai Khal -> the Balu River.

Fig-01(source: Banglapedia - National Encyclopedia)

The industrial pollutants of Tejgaon have to travel about 8 km before being discharged ultimately into the Balu River.

Pollution Control Strategies in Tejgaon Industrial Zone

Land use pattern

Pollution control interventions must consider the changing land use pattern of the Tejgaon industrial area. It is necessary to create the area into commercial space, the transformation is already processing by rising land price of that industrial cluster and by relocating the garments industries.

Changing raw materials

Technical interventions would be required that may include recovery of process chemicals Segregation of stronger and weaker waste streams and separate disposal system for each stream.

Hazaribagh Industrial Zone

General Description

Hazaribagh tannery cluster is the biggest tannery cluster in Bangladesh. This tannery cluster, located on the bank of the river Buriganga, in the western part of Dhaka city. This industrial cluster is a mixed residential/ industrial area. The total size of this area is about 25 hectares.(WBR 2005)The leather industry of Bangladesh is contributing significantly in the country's economy especially from earnings through export. But there are concerns raised about the environmental sustainability of the leather making activity. According to a survey report of UNIDO in 1999 about 85% of the country's total production of hides/skin is produced here, there are about 185 tanneries in this cluster.. on average, about 74,000 tons of raw hides/skins are processed in this tannery cluster. At present the combined maximum wastewater flow from the tanneries amount to 21,600 m3/day. The Ministry of Environment has categorized the leather industry as more hazardous than textile, pharmaceutical, fertilizer and paper industries. (sos-arsenic.net) About 240 tons (400 tons during peak season) of raw hides is processed every day, which generates a huge volume of effluents. There is no separate drains for rainwater which gets mixed with up with the process water. No tannery has got any system for treatment of effluent generated. Due to insufficient control of process parameters, a good proportion of tanning salt is discharged with effluent. No organized system of chrome recovery and reuse of direct recycling of liquor are practiced. Chrome shavings are dumped in big piles close to the embankment of river Buriganga. Chrome savings are also destroyed in the open land at the dumping sites to dispose them off. Some of these marginal operators make cooking oil from the residues of meat and fat that are discarded when animal skins are turned into leather.

Figure-02 Hazaribagh tannery (source internet)

Figure-03 Hazaribagh tannery (source internet)

Figure 02 and Figure 03 described the untreated effluent gushing out of a Hazaribagh tannery and eventually reaches a stream that flows into the Buriganga River.

Figure 4(source internet) hazaribagh tanneries used water

Figure 04 shows the tanneries used water directly from the river and pump the waste directly out again. The color of the water changes and becomes toxic.

Solid Waste Production at Hazaribagh Industrial Zone

Table-04: Solid waste produced in Hazaribag industrial area

Solid Waste	Weight in Kg
Fleshing	300
Trimming	100
Unusable Chrome split	107
Chrome shavings	99
Chrome off cut	20
Buffing dust	1
Leather off cut	5
Crust leather waste	5
Sludge	350
Total	987

(Reference:Industrial Environmental Compliance and Pollution Control in Greater Dhaka by world bank report)

The affected area of Hazaribagh, where 240 tanneries are located on 25 hectares of land. Most of the tanneries are 30-35 years old and use mineral tanning processes that discharge about 6000 cubic meters of liquid effluent and 10 tones of solid waste every day, according to figures from the Bangladesh government and the Food and Agriculture Organization.

Management of Solid Waste

The estimated total solid waste production is 260 tons/day. A portion of this is reused in some cottage industries for production of glue, low-cost leather products etc. This accounts for 67 tons/per day. The total quantity of leftovers is about 193 tons/day. Some of the leftovers are collected by Dhaka City Corporation along with household or other wastes. The wastewater also produces some sludge which eventually finds its way to the nearby canal and river causing siltation. The estimated quantity of sludge is 61,000 tons/year. *(Reference: Industrial Environmental Compliance and Pollution Control in Greater Dhaka by world bank report)*

Pollution Control Strategies

Enhancement of reuse of solid wastes can be done in a) Glue manufacturing; b) Making weaving mats/cheap carpets; c) Bio gas; d) Fertilizer; e) Poultry feed f) Handmade leather product. Considering the environmental hazards created by the Hazaribagh tannery industries the government of Bangladesh has recently decided to relocate the Hazaribagh tannery cluster to Hemayetpur, Savar (besides Dhaleswari river) which is located about 15 km from Hazaribagh. About 200 hectares of land has been acquired for this proposed tannery cluster. There are provisions for a Common Effluent Treatment Plant (CETP) of 20,000 m3/day capacity. Provision for solid waste dumping is also there. There is a proposal for separate drainage systems for rainwater and tannery effluent. *(Reference: Industrial Environmental Compliance and Pollution Control in Greater Dhaka by world bank report)*

TECHNOLOGY USED TO MANAGE URBAN SOLID WASTE

Traditional labor-intensive methods are used for waste management in Dhaka. Due to lack of specific guidelines to manage waste in the city, official initiatives to promote segregation of waste at the source is absent. Collection system is inadequate and involves 4 or 5 times of handling of a particular waste before it is finally disposed at an open dumping site. Waste recyclers further complicate the situation by going through the waste for recyclables and scattering it further. Collection coverage of waste is inefficient and as a result a great percentage of waste remains uncollected in the urban areas of Bangladesh. Uncollected waste accumulate on open lands, are piled along streets, fill drains and clog sewers. In sub-tropical monsoon climate these uncollected wastes provide ample habitat for flies, cockroaches, rats and other disease vectors. The stagnant water in the clogged drains provides breeding ground for mosquitoes; during flooding the health consequences become enormous. There is no separate collection system of toxic and hazardous waste from different sources, for these wastes in the city causing health risk for the city as a whole. Due to scarcity of land in large cities local authorities have been resorting to the practice of dumping garbage at certain selected locations without any consideration to the adverse effects of such dumping.

RECOMMENDATIONS ON INDUSTRIAL POLLUTION CONTROL MEASURES

A large-volume-waste-generator, if identified, requires some measures to control its waste coming to the DCC dumpsite. Although some of the tannery wastes are recycled to produce fish or animal feeds, most of them are considered to be directed to the dumpsite. If the industrial waste minimization can be done then the environment pollution can be handled .Generally, waste minimization techniques can be grouped into four major categories described below:

Improved Operations

Tracing of all raw materials, implementation of employees' training and management feedback, improving material receiving, storage, and handling practices.

Modification of Equipment

Installation of equipment that produce minimal or no wastes, modification of equipment to enhance recovery or recycling options.

Changes of production process

Elimination of sources of leaks and spills, separation of hazardous from non-hazardous wastes Redesigning or reformulation for products to be less hazardous

Recycling and Reusing

Recycling off site for use and Exchange of wastes. (Ahmed, 2002)

Promotion of 3r Principles

Reuse, Reduce and Recycle are the known 3Rs policies for reduction of pollution in the industries which plays an important role in waste minimization. Where:

Reduce: Source Reduction

Reuse : Product reuse

Recycling: Reprocessing of waste

The main objectives of 3R are to improve the efficiency of waste management systems, to recover Useable material, to recover conversion products and energy, government should promote 3R policies in the most polluted industries.

Importance of Recycling

Waste recycling is the reprocessing of old materials into new products. Basically, it is for the prevention of wastage of potentially useful materials. The detailed benefits of waste material recycling include: reduction of the usage of fresh raw materials, preserving natural resources, reduction of energy usage, less power consumption in recycling, reduction of air and water pollution, reduction of pollution caused by waste, reduction in the release of harmful chemicals and greenhouse gases from rubbish, raves space required as Waste Disposal Landfill, reduce financial expenditure in the economy, preserve natural resources for future generations

Landfill

Landfill means a disposal facility or a part of a facility where hazardous waste is placed in or on land. Land filling is still the major disposal method in many countries .Hence, continuous surveillance of the site and its surroundings must be maintained to check that the disposal of hazardous wastes can continue without posing a threat to the environment and to the general public. While preparing the lay-out of a land-fill site, it may be seen that it comprises the following units, vehicle weigh bridge, vehicle and instrument work-shop, laboratory for sample analysis, operational area, operational building with amenities, control systems, illumination, roads, fencing, trenches etc. Hazardous waste landfill is to isolate the waste materials within a restricted area and prevent uncontrolled leakage of liquid contaminants. Design of the facility requires provisions for a treatment system, and a suitable cover that is resistant to erosion and rainwater infiltration.

Land Zoning

Zoning has been an age old strategy used to reduce health impacts from industrial pollution. Use of land zoning for establishing industries reduce costs of pollution control as well as reduce impact of pollution. However, as the economy is growing, use of land zoning is not applied in that way as a strategy to reduce industrial pollution.

LAWS FOR POLLUTION CONTROL IN BANGLADESH

There is no independent law in Bangladesh to address the problems of industrial waste. The national policies, laws, rules and committees that Bangladesh have are all related to environmental issues. The important of them are-National Environmental Policy, 1995, Separate Directorate named Directorate of Environment, The Industrial Act, 1937 and 1992 to provide Regulations for industrial waste management, National Committee for Formulation of Integrated Environmental Guidelines.

CONCLUSION

The World Bank estimated Bangladesh could produce as much as 47,000 tons of waste by 2025 from the current 17,000 tones (http://news.xinhuanet.com/english/2003-02/13/content_726510.htm)

Measures are needed to be taken up to develop environmental awareness among employees and neighboring people. Pollution prevention and control can be profitable, which goes hand in hand with increasing in productivity, quality improvement. Cleaner Technology should be promoted more aggressively through demonstration projects and information propagation in order to enhance the level of responsiveness among the industries in order to reduce the pollution load to the environment.

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M. Alamgir, I.M. Rafizul, S.M.T. Islam, M. I. Nazir and S.R. Saha (Eds.)
ISBN: 978-984-33-7045-7, PI.126 (1-8)

Proceedings of the WasteSafe 2013 – 3rd International Conference on Solid Waste Management in the Developing Countries
10-12 February 2013, Khulna, Bangladesh

Bagasse as an Adsorbent for the Wastewater Treatment of a Composite Knit Industry

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ABSTRACT

The study was carried out for the establishment of a standard wastewater treatment process for a composite knit industry and its implementation in the laboratory scale using Bagasse as a bioadsorbent to remove the reactive dyes in which various parameters like contact time, amount of adsorbent and pH were considered. The adsorbent behavior can be explained on the basis of Langmuir adsorption isotherm model. For Bagasse maximum removal (95-98%) of dye was found at adsorbent mass of 1 g/100 ml, pH 6 and 90 minutes of contact time. From the results, it is possible to conclude that Bagasse could be a better bioadsorbent for the removal of reactive dyes form the wastewater.

INTRODUCTION

Textiles have been an extremely important part of Bangladesh's economy for a very long time for a number of reasons. The textile industry is concerned with meeting the demand for clothing, which is a basic necessity of life. It is an industry, that is, more labor intensive than any other in Bangladesh, and plays a critical role in providing employment for people. Currently, the textile industry accounts for about half of all industrial employment in the country and contributes significantly in total national income.

The Department of textiles (DOT) is the licensing and monitoring agency for the private sector industries while the industries under Bangladesh Textile Mill Corporation (BTMC) are directly controlled by the Government. Although this sector is one of the largest in Bangladesh and still expanding, but those authorities do not concern themselves with effluent qualities and its impact on environment (Rahman et al. 2003).

Effluent from the textile industry is a major source of environmental pollution especially water pollution. Among the various stages of textile industry, dying plant is the most pollutant producing stage. The textile dyeing waste contains unused or partially used organic compounds, strong color and high Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). The intensity of pollution depends on fabric. Beside that the dyeing sequence, dyeing equipment and the liquor ratio used in the textile industries can also affect the pollution intensity. The rate of pollution is increasing due to higher population growth and simultaneous growth of industries in the country. Generally, most of the industries are located near to the major rivers such as Buriganga, Shitalakshya, Turag etc.

surrounding the Dhaka city. The industrial effluents are directly discharged into the river or to the nearby lands. This waste water consists of organics, toxic materials and some other additives when disposed off into water body or land result in deterioration of ecology and damage aquatic lives. This wastewater causes not only environmental problems but also thermal pollution. Disposal of wastes into watercourses or into land, with or without treatment was not a big problem perhaps a decade ago. But in recent years, due to increasing number of industries and their subsequent untreated discharges, create a serious environmental pollution.

This led to an intensive search for the best available technology, which can be used for the removal and remediation of dyes. In addition, it makes the treatment of industrial effluent to be an important target for industry and environmental protection. Different treatment methods are available for improving the quality of the textile effluent including filtration, solvent extraction, biosorption, electrochemical treatment, flocculation, chemical precipitation, membrane separation etc. All these methods have significant disadvantages such as incomplete ion removal, requirements and production of toxic sludge or other waste products that require further disposal. Therefore, these methods do not suit the needs of developing countries. Moreover, most dyes are non-biodegradable in nature, which are stable to light and oxidation. So, either through traditional chemical and biological process the degradation of dyes in wastewater has not been very effective.

The adsorption process is a well established method for the removal of both organic and inorganic compounds and also metals. Adsorption system requires less investment in terms of both initial cost and land, its operation is easy and with a simple design. Furthermore, there is no threat from toxic substances and removes larger extent of organic waste constituents as compared to conventional biological treatment process (Albanis et al. 2000). Therefore, adsorption techniques employing commercial activated carbon (CAC) are effective for the removal of wide variety of dyes from wastewater. The adsorption capacity of CAC is mainly due to its structural characteristics and porous texture that attribute to large surface areas and its chemical nature that is easily modified by chemical treatment. However, in spite of all these structural and chemical natures, CAC has got some serious limitations that prevented its wide spread applications. It has high cost, ineffective against disperse and vat dyes, regeneration is expensive and result in loss of the adsorbent. These and other problems triggered researchers to find out more economic adsorbents (Chiou, Li. 2003, Crini 2006 and Hu 2006,).

In last few years, a vast number of publications have been dedicated to the removal of dyes from the wastewater by using adsorption technique with different low cost materials. The bioadsorbent made using sugar cane bagasse is basically built by macromolecules with humic and fulvic substances, lignin, cellulose, hemicelluloses and proteins that have adsorptive sites such as carbonyl, carboxylic, amine and hydroxyl groups, able to adsorb the dyes by the ion exchange phenomena or by complexation (Dávila-Jiménez 2005).

The aim of this research is to find out a cost effective wastewater treatment method for the composite knit industries by using bioadsorbent (sugarcane bagasse) implemented in the laboratory scale. In this study Zarjis Composite Knit Industries (Pvt.) Ltd. was considered as a typical composite knit industry uses reactive dyes for dyeing and wastewater from there was used as samples. The industry produces approximately 800000 Litres of wastewater per day. Most of wastewater was generated during dyeing. The adsorption capacity of bagasse was investigated for the removal of color from a pure reactive dye (Dychufix Turkish Blue G) solution and wastewater of a composite knit industry in order to improve their physic-chemical characteristics and color removal. The laboratory experiments were carried out in batches. The experiments were conducted in the laboratory of School of Environmental Science and Management, Independent University, Bangladesh. The effect of contact time, amount of adsorbent, pH, and initial concentration were studied. The Langmuir isotherm model was also investigated.

MATERIALS AND METHODS

1. COLLECTION OF ADSORBENT

The adsorbent used for this study are sugarcane bagasse. The Sugarcane Bagasse (SB) was collected from Kazipara bus stand (Mirpur).

2. PREPARATION OF ADSORBENT

- Adsorbent from Sugarcane Bagasse (SB)

The sugar cane bagasse was soaked in 0.1 M HCl solution for 18 hours and then washed with distilled water to ensure complete removal of all the dirt particles, lignin and coloring materials present. After that the Bagasse was dried in oven at 120-130 ^{O}C and further triturated using a mortar until uniform size particle was obtained. Then, the material obtained was packed in hermetically sealed containers and labeled.

3. Preparation of standard solution

A stock solution of pure reactive dye (Dychufix Turkish Blue G) was prepared by dissolving a mixture of 0.1 g of dye in a 1000 mL volumetric flask followed by dilution up to the mark addition of de-ionized water. Dye test solutions were prepared through proper dilution of the stock solution to the desired concentration. De-ionized water was used to prepare all of the solutions in this study. Dye solutions were prepared by stirring them at room temperature and filtered prior to use.

4. Equipment

A UV-vis spectrophotometer (DR/4000U Spectrophotometer, HACH, USA) was used for dye and wastewater analysis. The pH measurements were obtained using a portable multiparameter meter (Sension 156, HACH, USA). A LABTECH LMS-1003 magnetic stirrer was used for all adsorption experiments.

5. Adsorption experiment

Adsorption studies were performed by the batch technique. The adsorption of dye from a pure reactive dye solution and wastewater were studied. After the desired contact period for each Batch experiment, the aqueous phases were separated from the materials, and the concentration of dye was measured using an UV-vis Spectrophotometer. The following adsorption experiments were carried out:

Experiment 1. The effect of contact time: contact time ranged from 30-120 minutes, initial concentration was 20 mg/L, initial solution pH was 6 and adsorbent dose was 1 g/100 ml.

Experiment 2. The effect of pH: pH ranges from 4-10. The initial concentration was 20 mg/L, adsorbent dose was 1 g/100 ml. This experiments operates at optimum contact time which result from experiment 1.

Experiment 3. The effect of amount of adsorbent: adsorbent dose ranged from 1-4 g/100 ml at optimum contact time from experiment 1 and optimum pH from experiment 2. The initilal concentration was 20gm/L.

Experiment 4. The effect of initial concentration: initial concentration varied from 5-20 mg/L at optimum contact time from experiment 1, optimum pH from experiment 2 and optimum amount of adsorbent from experiment 3.

Experiment 5. Adsorption Isotherm for pure reactive dye onto bagasse: Experiment was set at the suitable conditions found in the previous experiments. The study used Langmuir isotherm to describe the reactive dyes adsorption onto bagasse.

Langmuir isotherm has been used by many worker to study sorption of a variety of compounds. The model assumes uniform energies of adsorption onto the surface and no transmigration of adsorbate in the plane of the surface (Gupta and Ali 2001). The Langmuir isotherm relationship is of a hyperbolic form as shown in equation (1). The Langmuir relationship can be linearized by plotting $1/q_e$ vs $1/C_e$. The linear form of the Langmuir isotherm is given by equation (2).

$$q_e = q_m K_a C_e / 1 + K_a C_e \quad (1)$$

$$1/q_e = 1/ K_a q_m C_e + 1/q_m \quad (2)$$

Where q_e is the amount of dye adsorbed per unit weight of adsorbents and C_e is the equilibrium concentration of the adsorbate (mg/L). Langmuir constants, q_m and K_a are related to maximum adsorption capacity and energy of adsorption through Arrhenious equation, respectively. q_m can also be interpreted as the total number of binding sites that are available for sorption. When $1/q_e$ is plotted against $1/ C_e$, a straight line with slope $1/ K_a q_m$ is obtained and intercept is correspond to 1/qm.
The essential characteristics of a Langmuir isotherm can be expressed in terms of a dimensionless separation factor, r, which describes the type of isotherm and is defined by Equation (3).

$$r = 1/ (1+K_a C_o) \qquad (3)$$

Where K_a is a Langmuir constant and C_o is the initial concentration of dye (Gupta and Ali 2000).

If, $r > 1$	unfavourable
$r = 1$	linear
$0 < r < 1$	favourable
$r = 0$	irreversible

RESULTS AND DISCUSSION

1. Effect of contact time

The time dependent behavior of dye adsorption between adsorbate and adsorbent was measured using conditions that were previously described in Experiment 1. The result was plotted in Figure 1 for bagasse. Adsorption of Dychufix Turkish Blue G proceeds rapidly and reaches a removal efficiency of over 98% for Bagasse after 90 minutes. After 90 minutes the removal efficiency was found to be decreased. Therefore, *90 minutes of contact time* was chosen for the subsequent experiments.

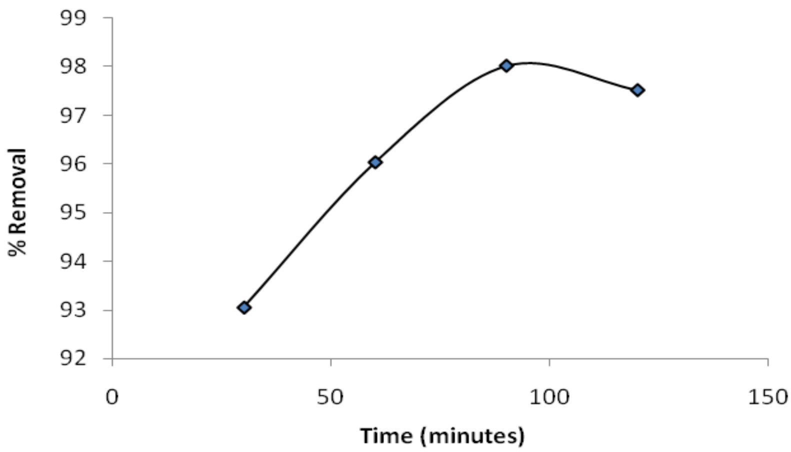

Figure 1 Effect of contact time on the removal of Dychufix Turkish Blue G by adsorption onto the Bagasse

2. Effect of amount of adsorbent

The effect of the amount of Bagasse on the removal of Dychufix Turkish Blue G was investigated. Figure 2 show that about 98.02% of Dychufix Turkish Blue G were removed with 1.0 g of Bagasse. The removal efficiencies of Dychufix Turkish Blue G decreased gradually with increasing amount of Bagasse. The adsorption capacity of Bagasse depends on the surface activity that is the specific surface area available for dye surface interactions which are accessible to the Dychufix Turkish Blue G. Therefore, *1.0 g of Bagasse* was chosen for the next experiments.

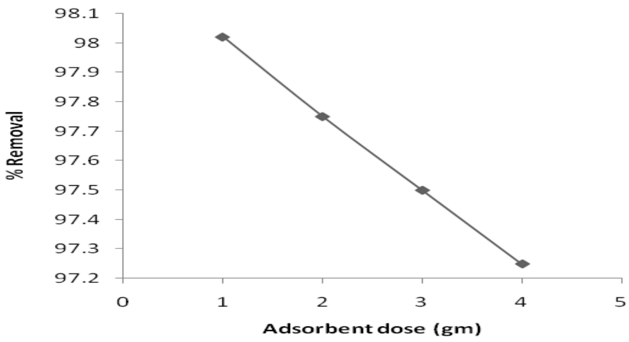

Figure 2 Effect of amount of adsorbent on the removal of Dychufix Turkish Blue G by adsorption onto the Bagasse

3. Effect of pH

The dye adsorption was strictly pH dependent, and so the pH of the aqueous solution is an important controlling parameter in the dye adsorption process. To investigate the effect of pH, the experiment of adsorption of dye was carried out at different pH values, viz., 4, 6, 8 and 10 using 0.01 M HCl and 0.01M NaOH aqueous solution.
The adsorption of Dychufix Turkish Blue G as a function of pH (4 to 10) for surface modified Bagasse is shown in Figure 3. In the assay, the maximum uptake (98.02 % for Bagasse) was observed at pH 6. As, adsorption is the highest at *pH 6 onto Bagasse*, this pH was used for further study.

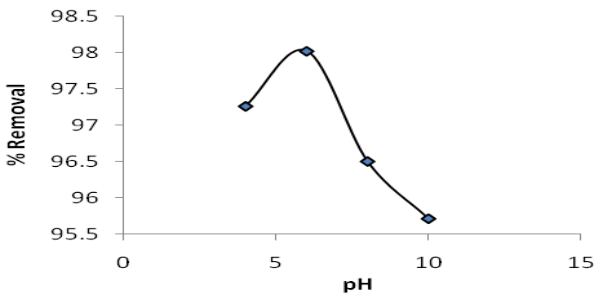

Figure 3 Effect of pH on the removal of Dychufix Turkish Blue G by adsorption onto the Bagasse

4. Effect of initial concentration

The removal efficiency is highly dependent on the initial concentrations of Dychufix Turkish Blue G in the sample solution. The effect of the initial sample concentration on the removal of Dychufix Turkish Blue G onto Bagasse was investigated. The initial concentration was evaluated in the range of 5-20 mg/L (ppm) and the results were illustrated in Figure 4. The removal efficiency decreased with increasing of initial concentration of sample solution. From this experiment, it is observed that higher removal efficiency was achieved using 5 mg/L (ppm) of dye solution.

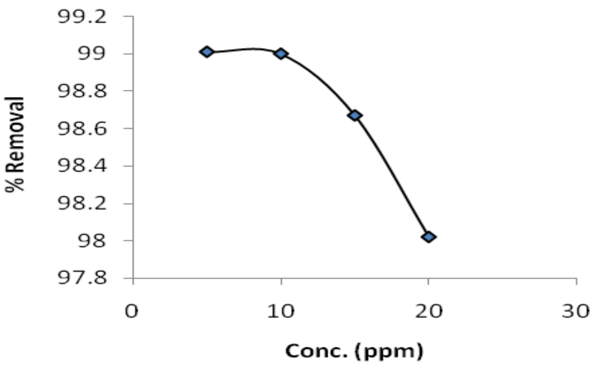

Figure 4 Effect of initial concentration on the removal of Dychufix Turkish Blue G by adsorption onto the Bagasse

5. Adsorption Isotherm

An isotherm for the removal of dyes onto bagasse is shown in figure 5. The linear isotherm constants q_m and K_a and the coefficient of determination, R^2 are presented in Table 1.
The isotherm is found to be linear over the entire concentration range studied with extremely high R^2 values. The R^2 values suggest that the Langmuir isotherm provides a good model of the sorption system. The sorption constant, K_a and the saturated monolayer sorption capacity, q_m onto Bagasse shows good result. Alternatively, Figure 5 show experimental data and the linear form of the Langmuir isotherm (Eq. 2). The linear isotherm constants, q_m, K_a and R^2 are also listed in Table 1.

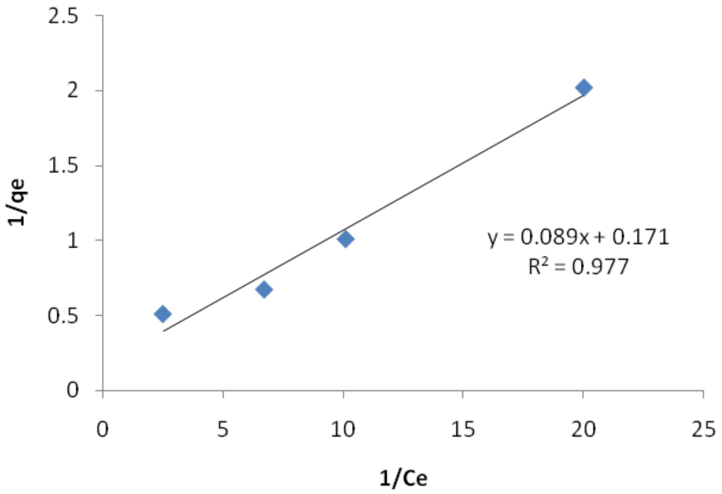

Figure 5 Langmuir isotherm of pure dye (Dychufix Turkish Blue G) sorbed onto Bagasse

Table 1 Linear regression coefficients of determination, R^2 and isotherm parameters

Adsorbent	Dye	$1/q_e = 1/K_a q_m C_e + 1/q_m$			
		R^2	q_m	K_a	r
Bagasse	Dychufix TurkishBlue G (Reactive dye)	0.977	5.85	1.92	0.025

- Spectrophotometric Determination of λ_{max} of Wastewater

The wastewater was investigated for the presence of characteristics dyes by UV-vis spectrophotometer. The determinations of λ_{max} of the dyes were obtained through scanning between wavelengths of 350-800 nm. The results are presented in the Table 2.

Table 2 Peaks, λ_{max} and absorbance of the wastewater sample

PEAK	λ_{max}	Absorbance
1	626	0.118
2	421	0.101
3	406	0.094

- Application of the optimized conditions to the wastewater

To investigate the dye adsorption capability of biomaterial (Bagasse) in Textile wastewater, the Bagasse was added into the wastewater samples. After addition of the adsorbent materials into the beakers, the experiments were performed separately. Table 3 gives a vivid picture of the application of method development.

Table 3 Removal of colors from the waste water by the Developed Method

Adsorbent	Absorbance After Treatment	Removal efficiency (%)
Bagasse	Peak-1: 0.005	95.76
	Peak-2: 0.003	97.02
	Peak-3: 0.002	97.87

Table 3 gives the adsorptive characteristics of Bagasse. 95-98 % of dyes in the wastewater sample was adsorbed by Bagasse. High percentages of dye removal in the wastewater samples are found for Bagasse. The method described here has the advantages of simplicity, rapidity, and a high concentration factor on the pre-concentration procedure and is applicable to the color removal in textile wastewater samples.

- Physical Characteristics of the Wastewater

The physical characteristics of the wastewater before and after treatment are presented in the Table 4.

Table 4 Physical Characteristics of the wastewater (before and after treatment)

Name of the parameter	Value		Standard for Inland Surface Water
	Before Treatment	After Treatment	
pH	8.5	6.5	6-9
Dissolved Oxygen	4.20 mg/L	7.16 mg/L	4.5-8
Biological Oxygen Demand	187.72 mg/L	5.56 mg/L	50 mg/L
Chemical Oxygen Demand	259.85 mg/L	21.35 mg/L	200 mg/L
Total Solids	1575 mg/L	980 mg/L	-
Total Dissolved Solids	1285 mg/L	870 mg/L	2100 mg/L
Total Suspended Solids	290 mg/L	110 mg/L	150 mg/L
Electrical Conductivity	1898 µm/cm	1651µm/cm	1800 µm/cm
Salinity	1.4 %	0.8%	-

From the above results it can be said that bagasse can be applied as an effective replacement for the current expensive methods of removing reactive dyes and improving the physicochemical characteristics of the wastewater as all the parameters were within the range of standards of Department of Environment (DoE). There are huge numbers of roadside sugarcane juice stalls in our country. So, disposal of bagasse is a serious environmental problem for our country. The aim of this research is to apply bagasse as bioadsorbent for the wastewater treatment of a composite knit industry which not only treat the wastewater but also solve the disposal problem of the waste.

CONCLUSION

In this research work, the removal percentage of reactive dyes from composite knit industry wastewater was carried out by the application of bioadsorbent (Bagasse). Bagasse has been found to be comparatively better adsorbent for its higher adsorptive capacity. For 90 minutes of contact time and at pH 6 the adsorption rate of Bagasse is very high and 98.02% removal of pure dye from the standard solution was observed. The adsorption capacity has been found to be dependent on initial concentration. The optimized conditions obtained from the study of pure dye were applied for the treatment of wastewater. Under those optimized conditions, Bagasse removes 95-98 % dyes from the wastewater respectively.

The adsorption results indicate that the bioadsorbent (Bagasse) alone can remove the organic dyes from the wastewater with considerable efficiency. Based on the experimental results, the following flow diagram has been suggested for the treatment of wastewater from composite knit industries.

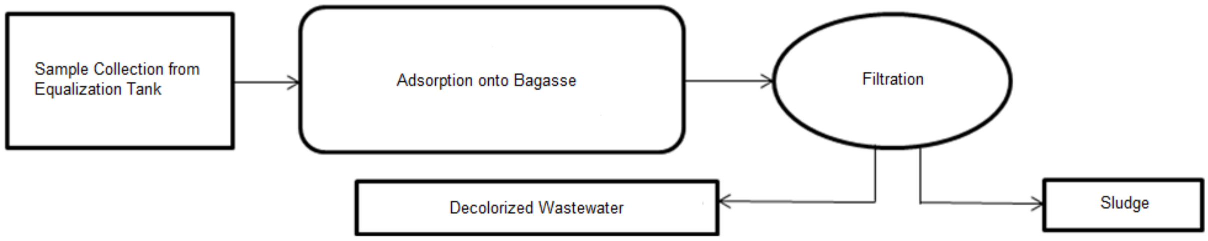

Figure 6 Flow diagram for wastewater treatment (suggested)

ACKNOWLEDGEMENTS

The authors wish to thank Prof. Dr. M. Ali Hossain, Head, School of Environmental Science and Management, Independent University, Bangladesh for his valuable advice, kind co-operation and guidance to complete the research. The authors also gratefully acknowledge Umme Farzana and Md. Rafiqul Islam for their valuable cooperation during the experimental study.

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