Paradox of Ship Recycling as Green Industry: Bangladesh Perspective

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To turn the world's discarded ships into scrap, equipoise impetus has been contributing to the fast growing of recycling to meet the demand of iron in Bangladesh, India and China since the beginning of 1990's. It provides 90% of steel contents and 10% assortment of matters like brass, copper, lead, asbestos, plastics, pipes, cables, wood and wooden things supplying about 70% of raw materials to produce mild steel rod and other products particularly in Bangladesh. A man bearing a terrible load on his shoulder, working in mud in the tropical heat with severe dangers of explosion, hauling the metal up the beach, lifting great weights with skinny arms, carrying steel ropes and heavy pipes and filth for a pittance is the common portrait of persons working in the yards of ship recycling in Chittagong, Bangladesh. Covering an area of 20 km with coastal Sitakunda, about 14 km from the center of the port city of Chittagong ship recycling generally is generally corrosive, noisy and dusty in nature and a threat indeed for emission of toxic and pollutants gases to both the terrestrial and marine environment and the human health hazards as well. The environmental issues relevant to Persistent Organic pollutants (POP's), asbestos, heavy metals, oil pollution of sea water and shore, impact on biodiversity and so on impacts ecological settings on one hand, and on the other should it be treated compatible with employment and revenue generation. How can it lead to address ship recycling to a substantive connotation of green industry from socio-economic benefits of recycling steel scrap, electrical cables, chilling compressors, engines, furniture, generators, re-roll able steel, motors, pipes, kitchen wares, spare parts, pumps etc. is the opening of the discourse of dilemma and the presentation is to explore the nature and extent of its facade.

Land and Soil Degradation in Bangladesh

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Agriculture in Bangladesh contributes about 19% of GDP and supports more than 60% of labour force. This sector is now threatened due to occurring of some land degradation processes. These processes are either natural or human induced. So, there is a scope of arresting land degradation. The present paper focuses on the extent and severity of land and soil degradation and the strategies for arresting land degradation in Bangladesh. There are a number of land degradation processes occurring in Bangladesh which include soil salinization, erosion, water-logging, acidification, heavy metal pollution and fertility depletion. Salinity is a major concern of land degradation particularly in the coastal regions of this country. The major saline affected districts are Satkhira, Khulna, Pirojpur, Barguna, Patuakhali, Noakhali and Cox's Bazar. Both magnitude and extent of soil salinity are increasing with time. In 1973 the salinity area was 0.83 mha and now it has become 1.06 mha. The critical challenge is to manage coastal resources and to adapt the production system with the climate change scenario. Physiographically, Bangladesh has three categories of lands: floodplains (80%), terraces (8%) and hills (12%). Hilly (Chittagong Hill Tracts) and terrace areas (Madhupur, Barind and Akhaura terrace) due to steep slopes are susceptible to soil erosion. Every year huge amount of soil loss occurs due to water erosion during monsoons. Soil acidity is another issue of land degradation. Geomorphologically acid sulphate soils, peat soils, acid basin clays, terrace soils and hill soils are moderately to strongly acidic in reaction. Acid soils with low pH values and aluminium toxicity are a big constraint to crop production in more than 30% area of this country. Depletion of soil fertility has arisen in this country due to intensive land use without appropriate nutrient management. With advancement of time micronutrient deficiency has arisen. Zinc and boron deficiency are now widespread. In Bangladesh, floodplain soils are formed due to action of four major rivers the Padma (Ganges), Meghna, Brahmaputra and Jumuna, and their tributaries & distributions. Flood and inundation are regular seasonal phenomena in this country. About 2.6 mha area is affected by water-logging which include bilis, jhils, haors and baors. Industrial discharge, sewage sludge and municipality wastes are the major sources of heavy metal contamination in Bangladesh soils. Lead, cadmium, arsenic, mercury, chromium and nickel are the significant contaminants. Industrials wastes and effluents are being discharged randomly onto soils, into canals, rivers, along the road sides or in the vicinity of the industrial areas without any treatment. All the issues stated above are presented in this paper.

International Environment Strategies in Kitakyushu

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Aquaculture Development Constraints and Potentials in Bangladesh in the Perspective of Environmental Impact and Change

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Bangladesh is naturally rich in fisheries resources. The fisheries sub-sector has been contributing significantly to national economy, nutrition, and poverty alleviation through employment generation. While inland fisheries focuses largely the domestic market, the coastal and marine fisheries is gradually becoming more and more export oriented. Though the overall fish production has been increased many folds during the last five decades, contribution of capture fisheries has been declined significantly from 88% to 34% and that of aquaculture has been increased from 12% to 47%. In the context of increasingly vulnerable capture fisheries, aquaculture is becoming increasingly necessary to maintain fish supplies for domestic demand as well as to growing export market.

Shrinking and unplanned alteration of natural water resources, water pollution, indiscriminate fish catch, fluctuations in seasons, etc. are the major reasons making the capture fisheries vulnerable. All these factors are also affecting aquaculture in many ways, particularly in supplying with quality broodstock resources and seed. With the pace of development, aquaculture also raises certain environmental and social concern, particularly in destruction of mangrove and wetlands, self-aqua pollution, salination, use of water and other resources, use of antibiotics, drugs and chemicals, etc. However, environmental damage by aquaculture so far is no greater than that of many other human activities of equal or smaller scale, but there are several reasons why culture methods should be improved. Some of the climate change impacts such as increased precipitation, water logging, increased temperature, etc. may positively be utilized for increase fish production practicing suitable aquaculture systems.

The aquaculture production systems in Bangladesh mainly comprised of homestead and entrepreneurial pond fish farming, cage fish farming and rice-fish farming in freshwater environment, and shrimp farming in brackishwater environment. Though a significant progress has been achieved in case of freshwater aquaculture, with a production range of 3-40t/ha, and of brackishwater aquaculture, with a production range of 150-700 kg/ha, there is further scope of intensification for increased production. The paper presents the current status and constraints of aquaculture development in Bangladesh, and discusses the future potentials considering the possible climate change consequences and environmental impact.

Betel Leaf Cultivation on Forest Loss in the Teknaf Peninsula

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Forest degradation in the Teknaf Peninsula has become critical. It is said that a cause of such forest destruction is over-exploitation of the forest for fuel wood, especially, by the poor for living. While the influence of fuel wood collection on the forest is serious, our research has found that betel leaf cultivation also a significant impact on the condition of the forest in the peninsula. We have conducted surveys in a village (MB) on the west coast of the peninsula in 2010 & 2011. I reported a preliminary result of the study in the last year’s ICEAB12. I will present the result of further analysis of the role of betel leaf cultivation in the village and to estimate its influence on the forest.

While rice is the major crop of this village’s agriculture, due to the characteristics of land form of this area, the extent of rice field is limited in narrow strips along the coast, and its productivity is low compared to that of fertile delta areas. As a result, the production of rice in the village does not seem to fulfill its needs. A total rice yield is 55.5 tons in a total of 23.8 ha (0.11 ha per household), or only 280 kg per households. Therefore, in order to sustain the livelihood, many households need other sources of income.

Betel leaf is cultivated in facilities called “pan boroz.” A total area of pan boroz in the village is only 9.3 ha, about 25% of the rice fields. But, if it is successfully done, betel leaves produced in a one-half kani (0.08 ha) plot can be worth about 70,000 taka. A total yield of the 9.3 ha pan boroz would be 8.1 million taka. This amount would buy 270 tons of rice (30 taka/kg), or 5 times as much as its rice production. Therefore, betel leaf cultivation may appear to be able to compensate the short fall of the livelihood.

On the other hand, the construction of pan boroz requires forest resources, such as poles and sticks. Because it is difficult to estimate the weight of small parts of pan boroz, only major poles for the framework is calculated. There are 152 pan boroz in the village and their average size is 0.38 ha. In these pan boroz, it is estimated that a total of 170,000 poles are used. Using 1 kg per pole, it would be 170 tons. This village has about 130 ha of the forest, and the annual production of organic materials by the forest of this area is 3718 tons per year. Therefore, 4.6% of all annual production would be consumed by pan boroz.

Another way of influence of betel leaf cultivation on the forest is the fact that many pan boroz are constructed in forest area. Trees may have cleared when a pan boroz was constructed and as long as the pan boroz exists the forest would not come back. Of the 152 pan boroz, 41 are located in the flat land, and 111 in the slopes where the forest used to have been. Since the total area of these 111 pan boroz is 7.0 ha, this 7 ha will not go back to the forest. Thus, the influence of pan boroz on this aspect is 5.4 % of the forest area.

In summary, betel leaf cultivation is a major source of subsistence in MB; without it, many people may not survive. Pan boroz for betel leaf cultivation consumes a large amount of forest resources, equivalent to 4.6% of annual regeneration, or 6 ha of the forest. Pan boroz constructed in the forest area also keeps the forest regenerating; it affects 5.6 % of the (former) forest or 7 ha. A total of 13 ha, or 10.0% of the forest is consumed by betel leaf cultivation.
**SPECIAL TALK - 07**

**Rapid Screening of Organic Micro-pollutants in the Aquatic Environment**

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**SPECIAL TALK - 08**

**Utilization of Field Monitoring Information to Agriculture - Potential of Informatization Agriculture in Bangladesh**

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**SPECIAL TALK - 09**

**Recycling Method of TSUNAMI Sediment Caused by Tohoku Region Pacific Coast Earthquake**

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**SPECIAL TALK - 11**

**BEN, BENJapan & BAPA : Impact on Environmental Aspects of Bangladesh**

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Dwindling Freshwater Bounties of Bengal Delta: Bleak State of Fish and Habitat Diversity

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The lives of Bangladeshis centre around and depend upon fish and water. The country is a transitional zone of flora and fauna, because of its geographical settings and climatic characteristics. It is natural that the water resources of the existing extent and magnitude should harbour and support populations of a large variety of vertebrate and invertebrate aquatic living organisms. Bangladesh’s water bodies are known to be the habitat of 270 freshwater fishes, 475 marine fishes, 23 exotic fishes and a number of other vertebrates and invertebrates. The number of openwater species, however, is declining at an alarming rate with some species, in recent years, having become extinct due to a number of reasons. Many species are already in crisis and despite mere conservation initiatives it may already be too late to save them from extinction. Sadly, most Bangladeshis are oblivious to the diversity of species that inhabit its innumerable waterbodies – how sad it is to think that a significant proportion of these splendid, vibrantly coloured fish could be lost forever – their names unknown, their beauty and value never fully appreciated.

Bangladesh is most at risk from climate change. The country will face the biggest risks from global warming in the next 30 years. Poverty and large low-lying coastal regions prone to floods and cyclones were among factors making Bangladesh the number one exposed country to climate change. Climate change impacts gradually over a wide range of livelihoods in different settings. Drought and siltation together are reducing open water habitat for the fish species resulting in less recruitment into the growing field to grow open water inland fisheries. Reduced water flow in the Ganges rivers basin has resulted in a severe depletion of fisheries. Due to the decrease in groundwater and surface water, tremendous pressure has been exerted on wetlands to convert them to agricultural land, resulting in a serious decline in the numbers of fish species and the fish production as a whole. Indeed, there may be no where in the world where effects of climate change and other natural/anthropogenic activities on fish biodiversity are more apparent than Bangladesh. The floodplains of the country are now among the fastest disappearing of all ecological systems. Fishing pressure from an ever-growing population has increased dramatically and has seriously affected the abundance of nearly half of the inland fishes of Bangladesh, particularly small fishes like minnows, catfishes, parchlets, gobies, featherbacks, snakeheads and eels.

Most of the indigenous fish are migratory and rely on seasonal flooding for spawning cues and access to larval rearing habitat (floodplain). Almost all dams and embankment interfere directly with the successful completion of the fish migration (breeding and feeding). Agriculture (excessive removal of surface water and extraction of groundwater for irrigation), pollution (domestic and industrial), and unregulated discharge of untreated industrial and farm effluents, habitat destruction also have significant impact, as does the regular overflooding and lack of flooding rain in the last few decades. Introduced species (primarily tilapia, Chinese carp, African catfish) are significant contributors to aquaculture production, but also threaten the biodiversity of indigenous fishes. In past, stocking of rivers and floodplain is carried out with both indigenous and introduced species by government and through different projects. The effectiveness of stocking activities has generally not been well assessed. Furthermore, the impacts of aquaculture (both commercial and small scale) have not been accurately assessed in this country. Capture fisheries in inland waters which are based on natural productivity generally have reached the level of overexploitation. The inland open water fisheries, where the floodplains assume an important position in the livelihoods and nutrition of the rural poor have now been under serious threat of resource depletion due to various man-made and natural causes. The majority of the waters of this type have been depleted to an alarming state and warrant urgent interventions for conservation and sustenance. Some rivers and floodplains have been modified to a level where they are only recognized as narrow ditches and paddy fields. During 1960s, the inland capture fisheries contributed about 90% of the country’s total fish production. Due to the rapid increase of aquaculture production and sharp decrease of capture fishery production, in 2007-08, the aquaculture contributed almost equally (about 40%) as inland capture fisheries in total fish production of the country. Since 1970, the annual flooding of approximately 2-3 million ha of floodplain has been either controlled or prevented altogether by means of sluice gates or pumps positioned along earth embankments or levees. This reduction in area is believed to be one of the major reasons for declining floodplain fisheries in Bangladesh.

There are serious concerns surrounding the slow decline in the condition of openwater fish stocks which have been negatively impacted upon through a series of natural and anthropogenic induced changes. These include disturbances resulting from rapid growth of population coupled with lack of proper management policy, water management programmes including the large scale abstraction of water for irrigation and the construction of water barrages and dams, human activity resulting in the overexploitation of fish including use of harmful fishing gears and system (fishing by dewatering, poisoning, using explosives), road communication, siltation of water bodies by natural process, the unregulated introduction of alien stocks and pollution from industry and agrochemicals. As a consequence, many Bangladeshi species have become critically endangered like – Hemibagrus menoda, Barilius barila, Dermogenys brachynopterus, Botia dayi, Raimas bolas, Psylorhynchus suciato, Scistura corica, Labeo pangusia, Labeo angra, Botia lohachat, Barilius barila, Chagunius chagunio, Gogangra viridesences, Silonia silondia, Setipinna phasa, Laguvia shawi, Crossochilus latius or many more. Biodiversity status of many of the fishes have now changed from that listed in the IUCN Red Book almost a decade ago. The results of the survey conducted by FMBC (2011) found following fishes as extinct from Bangladesh water - Neoeucirrhichthys maydelli, Pangio pangia, Salmostoma sardinella, Esomus lineatus, Garra annandalei, Neolissochilus hexagonolepis, Osteochilus hasseltii, Raimas gattatus, Mystus armatus, Laguvia shawi, Pseudecheneis sulcata, Ailia punctata, Ambassis nalu, Channa barca and Pseudophromenus capuans and a few more.

In recent years, GoB and the donors have placed major emphasis on capture fisheries, conservation, management, and development of institutional framework and need-based training. All concerned and working for the betterment of the fisheries sector of Bangladesh – the fishers, fish farmers, general people, local leaders, researchers, policy makers, GO and NGO workers should come forward to conserve the precious fish and ecosystem diversity of the country and to increase the fish production through effective coordination, long-term programme and sustainable approaches. This is the high time to care for the aquatic biodiversity – both habitat and species – the pride, heritage and livelihood of Bangladesh before they are lost forever. The national and international bodies should come forward to conserve aquatic ecosystems and organisms using both in situ and ex situ approaches.
The State of Arsenic Mitigation in Bangladesh and Estimate of the Size of Risk Population and of Unidentified Arsenicosis Patients

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ABSTRACT

All kinds of arsenic mitigation activities have been carried out in Bangladesh since the recognition of arsenic contamination of ground water in 1992. These efforts have provided safe water to millions of people and treated tens of thousands of arsenicosis patients. Despite of these activities, it seems that there are many more people who still have no access to safe water, and there are many more arsenicosis patients remained undetected. This study screens related statistics and analyzed related data generated by intensive arsenic mitigation projects carried out in Jessore district in order to estimate the size of population still at risk of arsenic, and the number of still-undetected arsenicosis patients. It finds that about 20 million people in Bangladesh seem to still use arsenic contaminated water, and that 300 to 600 thousand undetected patients may exist.

INTRODUCTION

Ever since arsenic contamination of ground water was discovered in 1992 in Bangladesh, there have been many projects implemented in order to mitigate the calamity of arsenic contamination. These mitigation activities are classified into two major categories: (1) safe water supply and (2) arsenic awareness. The first type is, of course, the most urgent so that people do not intake arsenic contaminated water. Nonetheless, the second type is also very important because people need to know the danger of arsenic before they can act on avoiding arsenic intake. Knowing the danger is especially important because arsenic has no color and no taste, which means that people may not be able to sense the presence of arsenic. In the last almost 20 years, therefore, these two types of mitigation activities have been carried out by the Bangladesh Government, international organizations, those in the public sector, such as UN organizations and foreign governments, as well various international and national NGOs.

Despite of these efforts, there are many people who are still exposed to arsenic contaminated water, and many people suffer from arsenicosis. As a result of the intake of contaminated water, the poor suffer more from this calamity, and arsenicosis patients would become even poorer.

The purpose of this paper is two-fold: first, to estimate the size of population who are not using arsenic safe water by reviewing published statistics; and, second, to estimate the number of arsenicosis patients who have not been identified by any public institution, and therefore, have been received little support and treatment. In order to make the argument clearer, this paper first briefly describes the structure of arsenic mitigation in Bangladesh. In other words, it schematically shows that each kind of mitigation activity is directed to what kind populations.

MATERIALS AND METHODS

Basis of the following discussion is mainly from published reports on statistics of arsenic mitigation. Especially, a detailed compilation of relevant statistics made by a DPHE-JICA report called “Situational Analysis of Arsenic Mitigation in Bangladesh 2009” (hereafter referred as SA) [1] provides a comprehensive set of information to this exercise.

In order to the estimate of patients, SA used mostly existing records at Directorate General of Health Services (DGHS), supplemented with interviews with Upazila Health Complexes. These records have been generated as by-products of routine activities of health personnel, rather than systematic surveys. Therefore, in order to estimate yet-identified arsenicosis patients, patient data based on systematic surveys by two Asia Arsenic Network (AAN)-led arsenic mitigation projects conducted in Jessore District are used [2, 3]. The occurrence rates of patients in different degree of arsenic contamination in these data sets are used to generate projections of the number of patients to be found.

RESULTS

A. The Structure of Arsenic Mitigation

Groundwater arsenic contamination becomes a problem when it imposes grave health risk on people who use contaminated water for drinking and cooking. Therefore, a simple solution to this problem is that no people intake contaminated water. But, this simple solution may not be easily achieved.

Fig. 1. Schematic diagram of relevant populations to arsenic mitigation

A schematic structure of arsenic mitigation is presented in Fig. 1. The first column of the figure indicates the entire population, in which two groups of people exist: One group consists of those who are exposed to arsenic (Group A); and the other is not (Group B). The first step of arsenic mitigation is to reduce the number of people who drink contaminated water (Group A). In order to achieve that goal, there are mainly two ways of doing. The first method is the provision of safe arsenic-free water. The other is to be achieved through people’s awareness of arsenic risks, so that they would avoid contaminated water.

The second column of Fig. 1 includes only the exposed population (Group-A). Among them, a certain proportion of population develops arsenicosis (Group C), and the remaining people have not been clinically affected by arsenic yet, in spite of their exposure (Group D). Among Group C, only a portion of this group has been recognized as arsenicosis patients by public medical-health institutions. Arsenic mitigation is 1) to identify those who did go through the first net to develop arsenicosis as soon and as many as possible, and 2) to regularly monitor those arsenicosis patients for providing proper care not to become more serious.
The third column of the figure contains all arsenicosis patients (i.e., Group C), both already identified (Group E) and unidentified (Group F) patients. Arsenicosis patients as patients of other chronic illness tend to suffer from not only health problems but financial problems because their capability of earning diminishes.

B. Exposed Population

A first estimate of exposed population in Bangladesh was released by British Geological Survey (BGS) & Department of Public Health and Engineering (DPHE) in 2001 [4]. According to this estimate based on samples of tubewell testing, the number of people who were exposed to arsenic contaminated water with more than 0.05 ppm of arsenic was between 30 million and 40 million. In 2002, the Bangladesh Government conducted more detailed estimate by different types of water sources yielded a figure of 29.24 million. Therefore, the following analysis uses 30 million as the size of population exposed to arsenic contamination in Bangladesh.

Since the confirmation of arsenic contamination in 1993, Bangladesh Government and international organizations have conducted many projects for arsenic mitigation. Especially since the Bangladesh Government set a national policy for arsenic mitigation in 2004, the size of population who has access to safe water has been increasing.

Despite of such efforts, a substantial size of population who has no access to safe water still exists. Situational Analysis (SA) [1] published by DPHE&JICA in 2010 estimates that 54 % of the exposed population have access to safe water. According to this result, the size of risk population who still drink arsenic contaminated water would be 13.8 million people (originally exposed 30 million x 0.46 = 13.8 million).

On the other hand, a drinking water survey conducted by Bangladesh Statistical Bureau and UNICEF [5] shows that among 13,301 drinking water samples tested, 12.6 % of the samples contain arsenic of 50 ppb or higher concentration. Because the drinking water survey was conducted regardless of arsenic contamination, the result of the survey represents the entire population of Bangladesh. Assuming the size of population in Bangladesh at the time of the survey in 2009 as about 150 million [6], those who are in risk by drinking arsenic contaminated water would be 150 million x 0.126 = 18.9 million.

The difference between the two estimated of risk population, approximately 5 million, may represent people who do not use alternative safe water devices even if they are available, or alternative safe water devices in their vicinity are out of use for some reason.

Using these results of analyses and surveys, approximately a little more than 10 million people have become free from arsenic contamination of drinking water because of 20 years of arsenic mitigation activities. On the other hand, about 20 million people are suspected to still use contaminated water.

C. Unidentified Arsenicosis Patients

Whereas the primary aim of arsenic mitigation is to prevent people from developing arsenicosis, unfortunately, a certain portion of population has become arsenicosis patients (Group C in Fig. 1). These people are, first, to be identified, and then they should receive medical and other supports. Based on information provided by DGHS and interviews conducted at upazila health complexes, SA estimated arsenicosis patients having characteristic skin lesions as 37,039 in 2009 [1]. But, there seem to be more unidentified patients. The following is a trial calculation of how many arsenicosis patients actually exist.

The scope of SA’s analysis is based on 301 upazilas where arsenic contamination is severe. SA compiled the number of patients per 100,000 people by different levels of arsenic contamination (Table 1).

Table 1. Population, the number of patients, the proportion of patients, and patients per 100,000 people

<table>
<thead>
<tr>
<th>Arsenic Contamination</th>
<th>Population</th>
<th>No. of Patients</th>
<th>Patients per 100,000 population</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20%</td>
<td>43,464,588</td>
<td>5,390</td>
<td>12.3</td>
</tr>
<tr>
<td>≥20% to &lt;40%</td>
<td>11,681,173</td>
<td>5,000</td>
<td>42.8</td>
</tr>
<tr>
<td>≥40% to &lt;60%</td>
<td>7,614,753</td>
<td>3,780</td>
<td>49.6</td>
</tr>
<tr>
<td>≥60% to &lt;80%</td>
<td>7,572,934</td>
<td>4,197</td>
<td>55.4</td>
</tr>
<tr>
<td>≥80%</td>
<td>11,004,897</td>
<td>18,672</td>
<td>169.7</td>
</tr>
</tbody>
</table>

To begin with, the number of patients in the area outside of the SA calculation is examined. There are 486 upazilas in Bangladesh, and the total population at the time of SA survey (2009) was 149,772,364 (about 150 million) [6], while SA only dealt with 301 upazilas and 82 million people. Although the contamination rate of the 175 upazilas excluded from SA’s scope should be low, there must exist a certain number of patients. Since the contamination rate of the area outside of SA’s study area should be lower than 20%, if we use the half of the patient rate of the 20% area (6.1 patients per 100,000), the number of patients in the remaining area would be 4,163. With this estimate, a total number of patients would be roughly 41 thousand.

There is an indication, however, that SA’s estimate should be regarded as minimum, and that an actual number of arsenicosis patients would be much more than these identified number of patients.

Asia Arsenic Network (AAN) conducted an arsenicosis patient support project (PSP) in Abhaynagar Upazila, Jessore between 2010 and 2012 funded by JICA [2]. The number of identified patients by DGHS in Abhaynagar was 179 (76.2 patients per 100,000 people) before the PSP project started. During the project, the number of patients in the upazila increased by 122 to 301, a 68% increase. The contamination rates in Abhaynagar are not very high, and range from 9% to 30%.

In addition to this, data from the Chaugachha Upazila are compiled, where thorough recording of arsenicosis patients was performed by DGHS and another arsenic mitigation project by AAN with JICA project [3]. These results are presented in Table 2.

Table 2. The number of arsenicosis patients per 100,000 in Abhaynagar before and after PSP projects, and that in Chaugachha.

<table>
<thead>
<tr>
<th>Contamination Rate</th>
<th>Before PSP</th>
<th>After PSP</th>
<th>Chaugachha</th>
<th>SA</th>
<th>Difference in factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>6.4</td>
<td>21.3</td>
<td>65.2</td>
<td>12.3</td>
<td>1.7~5.3</td>
</tr>
<tr>
<td>≥20% to 40%</td>
<td>122.2</td>
<td>177.8</td>
<td>345.0</td>
<td>42.8</td>
<td>4.2~8.1</td>
</tr>
<tr>
<td>≥40% to 60%</td>
<td>N/A</td>
<td>N/A</td>
<td>1068.8</td>
<td>49.6</td>
<td>21.5</td>
</tr>
</tbody>
</table>

Contamination rate; 1Patient rate before PSP; 2Patient rate after PSP; 3Patient rate in Chaugachha; 4Patient rate in SA’s 301 upazilas; 5Differences in factors between SA and the two intensively surveyed areas.

As Table 2 shows, the difference between SA’s figures and those based on intensive projects is not very large at the class of low contamination rate (less than 20%). The patient occurrence rates of the intensive projects are 1.7 and 5.3 times as much as that of SA. But, the differences become larger as the contamination rate becomes higher. The patient occurrence rates of the intensive projects are 4.2 and 8.1 times higher than that of SA. In the category of the highest contamination of this table, the difference between the Chaugachha Project and SA is 21.5 times.
These results seem to suggest at least two things. One is that there would be more patients if an area is more closely surveyed. Another indication is that currently missed patients by public registration would incrementally increase as the rate of contamination becomes higher. Therefore, because intensive arsenic mitigation projects are still limited in extent, many arsenicosis patients still remain to be identified.

Then, how many arsenicosis patients actually exist and wait for help? Table 3 is a result of trial calculations using patient occurrence rates recorded in those intensive project areas. For the population excluded from SA, approximately 68 million, the one half of the lowest rate of SA (12.3 per 100,000) is used for its patient rate for all trials. A moderate estimate uses the lower Abhaynagor-PSP numbers. Because there exist only two contamination classes, the remaining rates for this estimate are projected using SA’s rates. The higher estimate is generated by using rates in Chaugachha, and again, rates for the last two classes are project using SA’s rates. The results of these estimates suggest surprisingly high number of patients who have not been detected, and are left out suffering from the effects of arsenicosis. The lower PSP-based estimate for a total number of patients is about 330,000, and the higher Chaugachha-based estimate is almost 650,000 patients.

**CONCLUSION**

After 20 years of arsenic mitigation, 16 million among the 30 million exposed population have access to some kind of safe water. Therefore, it means that the remaining 14 million people use contaminated water. On the other hand, another statistics suggests that 19 million people are still to be identified.

While the prevention of arsenicosis is first and foremost important, many people have developed illness due to arsenic poisoning. Therefore, arsenicosis needs to be detected as early as possible, so that the illness can be treated at an early stage. At present, approximately 40,000 patients have been recognized by DGHS and upazila health complexes. The comparison of statistics between the registered patients and intensive arsenic mitigation project carried out in Jessore District reveals two points. One is that there are more patients to be found when people are screened more closely. The second is that the rate of missed patients becomes higher as arsenic contamination becomes higher. Estimates that this study conducts based on the data generated by those intensive arsenic mitigation projects suggest that the currently registered patients may be only a fraction of actual arsenicosis patients.

**ACKNOWLEDGMENT**

Patient data are compiled from two arsenic mitigation project conducted by Asia Arsenic Network funded by Japanese International Cooperation Agency (JICA).

**REFERENCE**


Effect of Upstream Dams of Teesta River on Surface Water Bodies in Northwest Bangladesh: A Satellite Remote Sensing Approach

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ABSTRACT
The study area includes Teesta River floodplain and its downstream in Northwest part of Bangladesh. The prime objective was to delineate land-covers (LC) and monitor surface water bodies from 2000 to 2009 by using NDVI (vegetation index) and NDWI (Water index) methods in our study area. We used Landsat ETM+ image of 19/02/2000 and Landsat TM image of 03/02/2009. We divided the LC into four types based on NDVI values as water body, bare land, mixed and vegetated land. The results showed that surface water bodies were reduced about 61-78% coverage area from 2000 to 2009 within the Tista River and its downstream part of our study area. Area of water bodies were also reduced about 81-86% within the Teesta River floodplain during the study period. Consequently, the vegetated region had been increased significantly about 68% due to reduce water level within the floodplain region. Though mixed land area was unchanged but bare land reduced and converted to agricultural land. Otherwise, vegetated land were also increased about 8 times from 2000 to 2009, that may be due to increased rice/corn/tobacco production using groundwater within downstream region of Teesta River in Bangladesh.

INTRODUCTION
The study area, ‘Teesta River and its downstream region’, is about 4270 sq. km situated to the Northwest part of Bangladesh (Fig. 1). We also studied only Teesta River floodplain here about 540 sq. km area as a separate case study of whole Teesta River in Bangladesh. Teesta River originates from Chitamut Lake in the Sikkim Himalayas at an altitude of about 7,200 m, enters into Bangladesh at the Kharbari border of Nilphamari district and then, after passing through Lalmonirhat, Rangpur, Kurigram and Gaibandha districts falls into the JAMUNA River south of Chilmari riverport [1]. The total length of Teesta River is about 315 km, of which nearly 115 km lies within Bangladesh. There are a number of dams and barrages have been built on the river Teesta on its 315 km journey from its source in Sikkim to the coast of Bangladesh i.e., Teesta Barrage in Bangladesh, Teesta Barrage Project at Gojoldoba in West Bengal, two hydro-electricity dams in Sikkim — one at Kulekhani and other at the upstream. The Indian government is also planning to construct two more hydro-electricity dams over the Teesta. The Teesta Barrage was built in 1998 at Doani, Lalmonirhat with an ambitious objective to bring 750,000 hectares of land under irrigation command area with net irrigation area of 540,000 hectares to augment agriculture production. But presently the Teesta has been drying up at different points during the dry season threatening the boro cultivation in six northern districts in Bangladesh. Once the mighty Teesta is now bereft of water following construction of a number of upstream dams and barrages at Gojoldoba point in Jalpaiguri of the Indian state of West Bengal. The average lowest discharge of Teesta was above 4000 cubic metre/sec before construction of the two barrages — one at Doani in Bangladesh and other at Gajoldoba in West Bengal but after construction of two barrages the lowest discharge has drastically reduced to 529 cubic meter/sec in 2000 and just after five years in 2005 it came down to just 8 cubic meter/sec [2]. Recently, the daily newspaper published an article about decline of Teesta River water flow [3]. Due to the shortage of water flow in Tista River, farmers are switching rice to tobacco/nuts/corn production now in this region. Such information is our motivation to monitor the spatial distribution of surface water bodies using satellite remote sensing techniques in our present research work in this area. Satellite remote sensing techniques provide us important capabilities to map landuse-landcover and monitor the dynamics of surface features including water bodies. Landsat TM/ETM+ images have been used extensively for many environmental studies i.e., vegetation studies, land-use change studies, landscape ecology, and urban planning within the last 30 years [4].

The objectives of our study were: (1) to delineate land-covers on the floodplain of Teesta River and its downstream region of Bangladesh using NDVI (Normalized Differential Vegetation Index) and NDWI (Normalized Differential Water Index) methods; (2) to monitor surface water bodies both in the flood plain of Teesta River and its downstream part in the NW Bangladesh using vegetation and water index from 2000 to 2009.

MATERIALS AND METHODS
We used two Landsat images on the basis of availability; one was Landsat ETM+ image of 19 February 2000 and other was Landsat TM image of 03 February 2009 for our study region. Both are multispectral 8 bands satellite images where 4 visible, 2 SWIR, 1 TIR bands are 30 meter in resolution and 1 PAN band is 15/30 m (ETM/TM) in resolution. The Landsat images were acquired under highly clear atmospheric condition, and the image was acquired through the USGS Earth Resource Observation Systems Data Center, which has corrected the radiometric and geometrical distortions of the images to a quality level of 1G before delivery. The Landsat images was further rectified to a common geographic (Lat/Lon) coordinate system based on 1:24,000 scale topographic maps, and was resampled using the nearest neighbor algorithm with a pixel size of 30 by 30 m for all bands including the thermal band. The resultant RMSE (root mean square error) was found to be less than 0.5 pixels. We applied the following our image processing steps for land-cover mapping using Landsat images; firstly, we have analyzed all images for atmospheric correction process; then, in second steps, we applied the formula for calculating reflectance value for each band with band specific information from header file and Landsat user handbooks by using the ERDAS imagine 9.3 module; in the third steps, we calculated NDVI which is a process for calculating the vegetation index of any region, that is the ratio of reflectance value of red (band 3) and near infrared (band 4) region of electromagnetic spectrum [5]. Actually, NDVI is the indication factor of vegetation growth state, used as an index of vegetation abundance, which is related to biomass, chlorophyll content and water stress. In general case,
Vegetated areas have high reflectance in the near infrared and low reflectance in the red visible region. The NDVI value ranges from -1 to +1. In this index green vegetation has high values, water has negative values and bare soil has value around 0. Finally, we calculated the normalized difference water index (NDWI) by using the McFeeters (1996) method of NDWI calculation, defined as: 

\[ \text{NDWI} = \frac{\rho_{\text{green}} - \rho_{\text{NIR}}}{\rho_{\text{green}} + \rho_{\text{NIR}}} \]

where \( \rho_{\text{green}} \) and \( \rho_{\text{NIR}} \) are the reflectance of green and NIR bands, respectively. The NDWI value ranges from -1 to 1. McFeeters [6] set zero as the threshold, i.e., the cover type is water if NDWI >0 and it is non-water if NDWI ≤0.

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**Fig. 1.** Location map of study area at Teesta River and its downstream region centered at 25° 44' 04.44"N, 89° 04' 23.20"E taken from Google earth image of 6 April 2012. Study area boundary shown with a bold maroon color polygon.

**Fig. 2.** (a) Land-covers of our study area in 2000, (b) LC in 2009, (c) water bodies shown with blue color and land with grey in a 2000 thematic map, and (d) water bodies with blue and land with grey color in a 2009 thematic map shown of our study area.
RESULTS AND DISCUSSION

First, we analyzed the images for land-cover (LC) mapping of our study area using NDVI method. We divided into 4 types of land-covers such as water body (NDVI<0), bared land (NDVI=0.2), mixed land (NDVI=0.2 to 0.5) and vegetated land (NDVI>0.5). Results showed that LC was found about 0.89% of water bodies (3803.7 hectares), 35% bared land (147758 hectares), 61% mixed land (261362.9 hectares) and 3% vegetated land (14033 hectares) in 2000. In the year of 2009, the results of LC showed about 0.34% area coverage’s for water bodies (1461 hectares), 10% bared land (41551.5 hectares), 61% mixed land (259562.8 hectares) and 29% of vegetated land (124259 hectares) of our study area (Fig. 2). We estimated surface water bodies’ area by using NDVI method. The NDVI value less or equal to zero was used for water and above zero was for land. We found about 8.7% of our study area (4702.6 hectares) as surface water bodies in 2000 but we obtained only 1.2% (640.7 hectares) water bodies in 2009. We also applied the same NDVI and NDWI methods to monitor the changes of LC within the Teesta River water bodies and its floodplain in Bangladesh portion. We found that about 7% and 8.7% of the study area were water bodies in NDVI and NDWI methods respectively in 2000 but in 2009, water bodies were about 1.3% and 1.2% respectively for NDVI and NDWI analysis which corresponds to about 540 sq. km Teesta floodplain in our study area (Fig. 3). Because of decreasing water bodies within the Teesta River, vegetation coverage in the floodplains was increased about 68% from 2000 to 2009. Although the area of mixed land type was unchanged but bared land areas were reduced about 49% within the Teesta River floodplain from 2000 to 2009. From our study we could infer that the vegetated coverage areas were increased surprisingly within the Teesta river bed and its floodplain reduced area of water bodies within this period of our study area. Otherwise, winter season agricultural production is depending nowadays on ground water as scarcity of Teesta river water flow and also increases IRRI/BIRI rice crops by using deep tube wells in our study area. Another reason of increased vegetation in 2009 is that rice cultivation is switching to tobacco/corn fields during our study time. Teesta river water flow may also be reduced for using ground water excessively by deep tube wells in this region.

CONCLUSION

Both NDVI and NDWI analysis results showed that the total surface water bodies decreased about 0.55-1.3% of our whole study area from 2000 to 2009; and water bodies were also reduced about 5.63-7.5% of total Teesta River floodplain from 2000 to 2009. Although the area of mixed land was unchanged but the bared land reduced about 25% of total study area from 2000 to 2009. Surprisingly, vegetated regions also augmented about 8 times area of 2000 in 2009 in our study region. In conclusions, because of surface water scarcity in this area, the rice cultivation reduced on this region using surface water and as a result, agricultural productions are depending on ground water. Alternatively, farmers are also switching from rice production to tobacco/nuts/corn production with groundwater. If this trend of reducing Teesta River flow continues, ultimately the region could be an arid region in future.

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We would like show our sincere acknowledgment to USGS Landsat archives for providing the images data with free of cost.

REFERENCE

Assessment of Water Quality Index of Water Bodies Along Dhaka-Mawa-Bhanga Road
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ABSTRACT
The objective of this paper is to find out water quality index (WQI) of several water bodies to sum up huge amounts of water quality data into understandable language. Water quality parameters of 6 different water stations along the Dhaka-Mawa road and 6 different water stations along the Mawa-Bhanga road were collected to determine water quality index. Six most important parameters - pH, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD) and electrical conductivity (EC) were taken for the calculation of WQI. The calculation of WQI was made using weighted arithmetic index method. According to the arithmetic mean method WQI values vary between 59 to 129. The values of the WQI showed that the water of the maximum stations are poor and very poor in condition, no one can be referred as good or excellent for human consumption and other uses. Physico-chemical parameters were monitored for the calculation of WQI for the pre-monsoon season. The result revealed that although WQI of most of the water bodies along the Dhaka-Mawa-Bhanga road are beyond acceptable limit but they are still usable and it is essential to purify when they will be used for domestic and drinking water purpose.

INTRODUCTION
WATER is the principal need of life on earth, and is an essential component for all forms of lives, from micro-organism to man [1]. Water has no alternatives, in fact the essence and sustenance of life is based on water [2].

Quality of water is defined in terms of its physical, chemical and biological parameters. However, the quality is difficult to evaluate from a large number of samples, each containing concentrations for many parameters [3]. One of the most effective ways to communicate information on water quality trends is with indices. Since then a great deal of consideration has been given to the development of index methods. A water quality index (WQI) provides a single number that expresses overall water quality at a certain location on several water quality parameters and turns complex water quality data into information that is understandable and useable by the general people [4].

The objective of an index is to turn complex water quality data into information that is understandable and useable by the public [5]. Importance of water bodies along the roadside is evident in terms of water quality, biodiversity conservation and use for aquaculture, as maximum of the water bodies of Bangladesh are expected to be productive (esrondia.com). So utilization of the existing resources is very much vital. In the way to improving the condition of these water resources, its proper management is very much necessary and for doing this all information on the resources namely physico-graphic, chemical and biological characteristic of these water resources must be collected. The objective of this paper is to determine the WQI of 6 water bodies along Dhaka-Mawa road and 6 water bodies along the Mawa-Bhanga road. Drinking water contamination and variation of drinking water quality in pre-monsoon is the basis of calculated values of WQI as concentrations of different water quality parameters tend to be at its worse condition during pre-monsoon season. Based on the WQI an assessment was made whether these water bodies are acceptable for domestic use and even for drinking purpose. Local people living along this road are completely dependent on these water bodies as there is no proper water supply made to meet their needs. For this reason, this analysis is extremely necessary so that people living in these areas can mark out the best water source available. Also if they need more water badly they can also determine which water bodies can used after proper treatment is done. Similar type of studies have been done in India by Avnish Chauhan and Suman Singh, where WQI values were determined in several stations along Ganges River so that quality of water can be seen along the river [6]. Also several studies have been performed by Raphael to determine water qualities along streams where effluents come from industries [7]. But this study has its individual significance as WQI values of 12 stations were taken along a road’s length. In Bangladesh this type of study has been done by same authors along Faridpur-Barisal Road [8]. In some places a confined research may be done like determining WQI of local ponds. But along roadside water bodies this type of research, we believe is rare to find.

MATERIALS AND METHODS
The present study was conducted along Dhaka-Mawa-Bhanga (N8) road which is a 60 Km existing road touching Dhaka, Munshiganj, Madaripur and Faridpur districts covering 8 upazillas namely, Keraniganj, Serajdikhan, Sreenagar, Lohajang, Shibchar, Faridpur sadar, Sadarpur and Bhanga. The parameters pH, dissolved oxygen, total dissolved solids (TDS) and electrical conductivity (EC) of 12 different locations along Dhaka-Mawa-Bhanga road during pre-monsoon (March-April, 2011) were analyzed immediately at the sampling site using standard equipments given in Table 1. For BOD measurement, a 500ml bottle was used for collection of water samples and the oxygen was fixed at the sampling site using standard equipment given in Table 1.

![Fig. 1. A satellite view of the sampling area](image)
The examination and analysis of the water bodies including laboratory analysis was done as per the standard methods of USEPA, (2004) and Trivedi and Goel, (1986) [9-10]. The calculation of WQI was made using weighted arithmetic index method [11]. Finally assessment of surface water quality based on water quality index was done. Table 1 shows the details of analysis methods and necessary equipment.

Table 1. Details of the analysis methods and required equipment for the physico-chemical parameters.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Parameter</th>
<th>Method</th>
<th>Equipments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>Visible</td>
<td>Sensaso-CL410, HACH, USA</td>
</tr>
<tr>
<td>2</td>
<td>Dissolved Oxygen</td>
<td>Visible</td>
<td>Dissolved Oxygen Meter (Model-YK22 DO), USA</td>
</tr>
<tr>
<td>3</td>
<td>BOD</td>
<td>Laboratory</td>
<td>Dissolved Oxygen Meter (Model-YK22 DO), USA</td>
</tr>
<tr>
<td>4</td>
<td>Conductivity</td>
<td>Visible</td>
<td>Conductivity Meter (Model CD4302, USA)</td>
</tr>
<tr>
<td>5</td>
<td>TDS</td>
<td>Visible</td>
<td>Sensaso-CL410, HACH, USA</td>
</tr>
</tbody>
</table>

A. WQI Calculation

For calculation of WQI selection of parameters has great value. The water Quality index will too widen if too many parameters are used. Importance of various parameters depends on the intended use of water. Five physicochemical parameters namely - pH, TDS, EC, DO, BOD were used to calculate the WQI by the weighted arithmetic index method. Several steps are given below in the following steps:

a) Calculation of Sub Index of Quality rating (qn)

Let there be n water quality parameters where the quality rating or sub index (qn) corresponding to the nth parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value [12]. The value of qn is calculated using the following expression.

\[ q_{n} = 100 [(V_{n} - V_{io}) / (S_{n} - V_{io})] \] (1)

Where, \( q_{n} \) = quality rating for the nth water quality parameter; \( V_{n} \) = estimated value of the nth parameter at a given sampling station; \( S_{n} \) = standard permissible value of nth parameter; \( V_{io} \) = ideal value of nth parameter in pure water; All the ideal values \( V_{io} \) are taken as zero for drinking water except for pH = 7.0 and dissolved oxygen = 14.6 mg/L. (Sissodia2006)

b) Calculation of Quality rating for pH

For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following relation:

\[ q_{\text{pH}} = 100 \left[ (V_{\text{pH}} - 7.0) / (8.5 - 7.0) \right] \] (2)

Where, \( V_{\text{pH}} \) = observed value of pH during the study period.

C. Calculation of Quality Rating for Dissolved Oxygen

The ideal value \( V_{DO} \) for dissolved oxygen is 14.6 mg/L and standard permitted value for drinking water is 5 mg/L. Therefore, quality rating is calculated from following relation:

\[ q_{\text{DO}} = 100 \left[ (V_{\text{DO}} - 14.6) / (5 - 14.6) \right] \] (3)

Where, \( V_{\text{DO}} \) = measured value of dissolved oxygen; D. Calculation of Unit Weight (Wn): Calculation of unit weight \( W_{n} \) for various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

\[ W_{n} = K / S_{n} \] (4)

Where, \( W_{n} \) = unit weight for nth parameters; \( S_{n} \) = standard value for nth parameters; \( K \) = constant for proportionality

c) Calculation of WQI: WQI is calculated from the following equation.

\[ WQI = \sum_{n=1}^{n} q_{n} W_{n} / \sum_{n=1}^{n} W_{n} \] (5)

RESULT

A. pH

pH is one of the most important factor that serve as an index for the pollution [13]. The experimental water bodies were found to be approximately neutral or slightly alkaline. The highest value of pH was 9.45 at Thandu Chowdhury pukur along the Mawa-Bhanga road and lowest was 6.8 at Pachchor Bajar khal along the Mawa-Bhanga road. The mean value of pH was 7.9 along the Dhaka-Mawa road and 7.65 along the Mawa-Bhanga road. A pH between 6.7 and 8.4 is suitable, while pH below 5.0 and above 8.3 is detrimental. In the present investigation pH values were within the ICMR standards (7.0-8.5) [13]. Maximum water quality sub-index for pH is found 25 at Bawor pty sharok o janapath station along the Dhaka-Mawa road and 37 at Thandu chowdhury er pukur along the Mawa-Bhanga road according to Brown’s method. Minimum Sub water quality index for pH was found -3.0 at Pachchor Bajar khal according to Brown’s method.

B. Total dissolved solids

The TDS level found to fluctuate from 169.4 mg/l to 306 mg/l within the water bodies along the Dhaka-Mawa road and 97 mg/l to 340 mg/l along Mawa-Bhanga road. The TDS content was maximum at Dhaleshwari along the Dhaka-Mawa road and at Bogail Beel along the Mawa-Bhanga road. The amounts of total solids are influenced by the activity of the plankton and organic materials. Slightly high value of TDS were recorded at only one sampling stations and other values were less than the WHO limit. Water containing more than 500 mg/L of TDS is not considered desirable for drinking water supply. Water quality sub index for TDS is found almost 0 for all stations.

C. Dissolved oxygen

The value of DO varied from 1.3 mg/l to 10.4 mg/l. The maximum DO value (10.4 mg/l) was recorded in Thandu Chowdhury er pukur and minimum value (1.3 mg/l) was recorded in Shirajdkhan, Kuchiamra. The mean value of DO was 4.7 mg/l. Concentrations below 5 mg/L may adversely affect the performance and survival of biological communities and below 2 mg/L may lead to fish mortality. Water without adequate DO may be considered wastewater. Maximum water quality sub-index for DO was found 50 at Pachchor Bajar khal and minimum sub water quality index for DO was found 17 at Pachchor Bajar Khal.

D. Biochemical oxygen demand

BOD varied between 0.7 mg/l to 9.8 mg/l among the different sampling stations. The minimum values were found in Sirajdikhan, Kuchiamra which is in Dhaka-Mawa road. The Maximum value was recorded in Thandu Chowdhury er pukur which is along the Mawa-Bhanga road. The mean value of BOD was 3.6 mg/l. Maximum water quality sub-index for BOD was found 75 at Thandu Chowdhury er pukur. Minimum water quality sub index for BOD was found 5 at Sirajdikhan Kuchiamra (Brown Method).

E. Electrical conductivity

Conductivity is measured in terms of conductivity per unit length, and meters typically use the unit micro Siemens /cm. [14] The values of water conductivity (2ms) varied from 203 μs /cm to 632 μs/cm among the water bodies. The value of
conductivity was recorded lowest in Dhaleshwari along the Dhaka-Mawa road and maximum in Pulia Bajar along the Mawa-Bharga road. The mean value was 503 μs/cm. Sub water quality index for Electrical Conductivity is almost 0 at all stations (Brown’s Method). Standard and ideal values of different water quality parameters have been shown in Table 2. Guidelines are recommended by World Health Organization (WHO) and Indian Council of Medical Research (ICMR).

Table 3. Status of water quality based on Arithmetic WQI method (Brown et. al.1972) [Quoted by Mishra and Patel, 2001]

<table>
<thead>
<tr>
<th>Water Quality Index</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>Excellent</td>
</tr>
<tr>
<td>26-50</td>
<td>Good</td>
</tr>
<tr>
<td>51-75</td>
<td>Poor</td>
</tr>
<tr>
<td>76-100</td>
<td>Very poor</td>
</tr>
<tr>
<td>Above 100</td>
<td>Unsuitable for drinking and propagation of fish culture</td>
</tr>
</tbody>
</table>

Table 4. Location wise calculated values of Water Quality Index for pre monsoon period on Mawa-Mawa Road

<table>
<thead>
<tr>
<th>Station Name</th>
<th>WQI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bawor bity sarok namapather pokur</td>
<td>89</td>
</tr>
<tr>
<td>Dhalashri (1)</td>
<td>81</td>
</tr>
<tr>
<td>Dhalashri (2)</td>
<td>80</td>
</tr>
<tr>
<td>Shirajdi Khan Kuchiamara</td>
<td>64</td>
</tr>
<tr>
<td>Chaltipara Pokur</td>
<td>75</td>
</tr>
<tr>
<td>Masurgowkhal</td>
<td>67</td>
</tr>
</tbody>
</table>

Table 5. Location wise calculated values of Water Quality Index for pre monsoon period along Mawa-Bharga Road

<table>
<thead>
<tr>
<th>Station Name</th>
<th>WQI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacchhor bajar khal</td>
<td>59</td>
</tr>
<tr>
<td>Thandu Chowdhurir Pokur</td>
<td>129</td>
</tr>
<tr>
<td>Arial Kha</td>
<td>73</td>
</tr>
<tr>
<td>Pulia bajar pokur</td>
<td>102</td>
</tr>
<tr>
<td>Bogail Beel</td>
<td>63</td>
</tr>
<tr>
<td>Bhanga Khal</td>
<td>66</td>
</tr>
</tbody>
</table>

Table 6. Maximum, Minimum and Average values of different water quality parameters

<table>
<thead>
<tr>
<th>Groups</th>
<th>Maxm</th>
<th>Minm</th>
<th>Avg.</th>
<th>Std. Dev</th>
<th>Std. Err</th>
<th>Variance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.66</td>
<td>7.37</td>
<td>7.90</td>
<td>0.48</td>
<td>0.19</td>
<td>6.08</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>5.4</td>
<td>1.30</td>
<td>3.93</td>
<td>1.51</td>
<td>0.62</td>
<td>38</td>
</tr>
<tr>
<td>BOD (mg/l)</td>
<td>3.7</td>
<td>0.70</td>
<td>2.55</td>
<td>1.05</td>
<td>0.43</td>
<td>41.18</td>
</tr>
<tr>
<td>Conductivity (2ms)</td>
<td>632</td>
<td>353</td>
<td>536.7</td>
<td>108.67</td>
<td>44.37</td>
<td>20.25</td>
</tr>
<tr>
<td>TDS</td>
<td>306</td>
<td>169.4</td>
<td>260.2</td>
<td>53.26</td>
<td>21.7</td>
<td>20.5</td>
</tr>
</tbody>
</table>

F. Assessment of Water Quality Based on WQI

WQI has been classified into 5 classes quoted by Mishra and Patel, 2001. Table.3 represents the 5 classes of water quality based on WQI. The observed range of water quality index along the road in pre monsoon is 59 to 129 by the arithmetic mean method. Maximum WQI was 129 at station Thandu Chowdhuryr pokur and minimum is 59 at Pacchhor Bajar. Not a single Station’s water quality can be expressed as excellent. Water quality of station Shirajdhikhan, Chaltipara and Mashurgow Khal along the Dhaka-Mawa road and water quality of water bodies namely Bhanga Khal, Bogail Beel, Arial kha, Pacchhor Bajar along the Mawa-Bharga road can be expressed as poor water. Water quality is unsuitable in Thandu chowdhuryr pokur and Pulia Bajar pokur. Rest of the water stations can be classified as very poor. Stations with WQI values more than 90 can be classified as unsuitable for both domestic and aquaculture purposes. So that Thandu Chowdhuryr pokur and Pulia Bajar pokur turned out to be unsuitable as WQI value is more than 90. But rest of the stations water can be used for both domestic and aquaculture purpose by taking proper disinfection procedure.

Table 4 and Table 5 show the WQI values of the 12 stations measured in pre monsoon period. Pacchhor Bajar khal can be classified as the best stations among all though it has been classified as poor water. Table 6 represents the maximum, minimum and average value of different water quality parameters.

CONCLUSION

It is important to remember that the WQI alone should not be used to make hasty decisions to clean up a water body. For instance, should an impairment to the water quality of a system be noticed, this is an indication that further investigation is needed into the potential problem area. WQI of the stations along the Dhaka-Mawa-Bharga road for the pre monsoon season was found high according to the Brown method, as concentration of water quality parameters are maximum during pre-monsoon. In accordance with Brown method it was found from the calculation that parameter which shows the highest favorable value gives a low statistical value to the index. BOD, DO were found to be the most important parameters as it contributes the most for the WQI calculation among the five parameters. All the 12 water bodies bear potential to become a source of drinking water with proper treatment.

REFERENCE

Grain Sizing Survey on River Bed by Computational Photography

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ABSTRACT
Computational photography method has been suggested as a modern high-efficiency survey of river bed grain sizing, and the reliability for understanding fluvial phenomenon is discussed from the standpoint of sediment hydraulics. This high-efficiency method actualizes high spatial resolution information of grain size distribution. Thus, photography method brings much information and has availability to express the stream flow condition better than traditional grain sizing methods. The grain sizing by image processing provides the appropriate result which has a good agreement with stream condition qualitatively. Moreover we estimate critical diameter from hydraulic figure in order to compare to observed diameter. According to the result, complete agreement is not found between them. However observed mean diameter indicates the intermediate figure against variation of critical diameter along longitudinal distance. Meanwhile discontinuity of distribution curve is seen at 13.2 mm diameter which is distinguishing either photography or sieving. This result indicates that it is necessary to give the threshold diameter much larger than the limit of image processing.

INTRODUCTION
Image processing technology is being applied to many industrial products. In river engineering or erosion control engineering, image processing technique for grain sizing which is measurement of river bed material size is suggested [1]. It has been pointed out that the measurement accuracy of the image processing technique is uncertain. The uncertainty is caused from technical or theoretical issue. The technical issue is a limit of image recognition against grain shape and the recognition error becomes problem in automated grain sizing especially [2]. The grain sizing procedures are a transforming, a filtering, shape recognition of grain and converting from pixel to actual size unit sequentially (Fig. 1). The automated shape recognition of grains does not have enough accuracy to measure on natural river bed condition yet. The theoretical issue means that the measurement by only vertical image as two dimensional information is not available to get volume as three dimensional information [3, 4] (Fig. 2). Therefore estimation is necessary to calculate grain volume from image and it is considered that these estimations bring measurement error. Nevertheless, photography method has meaningful not only for survey efficiency and a fiscal cost, but the survey efficiency is also capable to complement the accuracy of measurement by the quantity of sampling conversely. Thus we are trying to investigate whether photography method for river bed grain sizing is helpful for understanding fluvial phenomenon.

METHODS

A. Outline of Study Area
Our study area has a 150 m length meandering stream whose catchment is about 2 km² and there is a check dam, which was built for keeping sediment from flowing out, at downstream terminal. Although the check dam is not full of sediment, it seems that the dam would be full in near future. Stream bed material is composed of gravel whose mean diameter is about 100 mm. Hence, it is considered that the most of bed material was transported as bed load. (Fig. 3) shows a relative height contour map, surveying transverse sections and bed material sampling points in study area. Stream gradient between the transverse sections 0-10 m, 10-50 m and 50-150 m are about 18 %, 3.0 % and 2.5 %, respectively.

B. Surveying of grain size distribution
Grain size was surveyed from 0 m to 50 m every 5 m longitudinally and 3 samples at center of stream and its both sides were taken transversely in each transverse section. The sampling was conducted by using two methods. Photography method was applied to coarser grain than 13.2 mm by instruments mentioned above, and sieving test was applied to finer grain. This 13.2 mm threshold is defined from both sieve size and a resolution of photo image. In photography method, contours of grain ware determined by computer mouse manually in order to avoid recognition error. Number of samples is determined as 196 for keeping statistical significance [5] and contours of grain by Manual Grain Sizing (MGS) as shown in Fig. 4A and Fig. 4B. From coordinate of points of contour, projected area of grain is calculated. Under a
hypothesis that grain has spherical shape, volume or mass of grain is estimated by sediment density $2650 \text{ kg/m}^3$.

\[ d_c = \frac{\sigma}{\rho - 1} g r_{sc} \]  

where, $r_{sc} = \rho u_{sc}^2$, $\rho$ and $\sigma$ are density of water and sediment, respectively, $u_{sc} = 80.9 d$ if diameter $d \geq 0.3030$ cm by using Iwagaki’s equations and mean diameter $d_m$ is substituted for $d$. Shear velocity $u_c = \sqrt{g R \gamma}$, hydraulic radius $R$ is approximated as water depth $h$, $g$ is gravitational acceleration and $\gamma$ is energy gradient. Water surface profile, given latest flood discharge, are analysed [6], and shear velocity converged into steady state is accepted as $u_c$ in (1).

RESULTS AND DISCUSSION

A. Characteristics of grain size distribution

Fig. 5 shows grain size distribution at each transverse section where the center and the both sides were surveyed. In all transverse sections, discontinuity of distribution curve is seen at 13.2 mm diameter which is distinguishing the analysis method. It is considered that this is a human error due to sampling the larger grain relative to the smaller one unintentionally. This fact indicates an importance of decision a threshold diameter larger enough than aphoto resolution for shape recognition. According to Fig. 3, the stream flows through the right side towards the downstream. Such flow condition is reflected in grain size distribution and it is evident that grain size is coarser on the right side where stream flow lies. Fig. 6 and Fig. 7 show mean diameter by only MGS and

\[ d_m \geq 13.2 \text{ mm} \]
by MGS-sieving test combined, respectively. Only MGS data is homogeneous transversely and changing smoothly along the longitudinal distance. Conversely MGS and sieving test data has a large deviation transversely. It seems that coarser grain has been transported as bed load broad under the flood condition, and with a decrease of discharge at the left bank side, where water depth is small relatively, finer sediment has deposited.

![Fig. 7. Mean diameter by MGS (d ≥ 13.2 mm) and sieving test (d ≥ 13.2 mm) of each transverse section](image)

![Fig. 8. Calculated water surface under flood discharge by supercritical and subcritical flow analysis](image)

![Fig. 9. Estimated water head](image)

B. Appropriateness of grain size in sediment hydraulics

We tried to compare between observed and critical diameter for inspection of appropriateness in sediment hydraulics. Water surface profile is calculated giving the closest recorded flood discharge and shown in Fig. 8. The result of surface indicates super- and subcritical flow state including hydraulic jumps. An analysis below ignores adverse gradient points in which a hydraulic jump occurs because of calculation in order to let energy gradient positive, and it is shown in Fig. 9. Therefore result of critical diameter \( d_c \) is indicated as Fig. 10. We have to pay attention to the mention that calculated \( d_c \) is transverse average value. The observed \( d_m \) lie at intermediate variation of \( d_c \) along longitudinal distance.

![Fig. 10. Comparison between critical diameter and observed diameter](image)

**CONCLUSION**

We tried to investigate whether photography method which has high survey efficiency for river bed grain sizing is helpful for understanding natural phenomenon. An approximate whole surface surveying was conducted applying the high-efficiency. The result of grain size distributions indicated a good agreement between stream flow condition and diameter size qualitatively. Furthermore, in a comparison by using water surface profile analysis between observed and critical diameter, the result did not shows a complete agreement between them. Nonetheless, observed mean diameter lay on the intermediate of variation of critical diameter along longitudinal distance. Meanwhile discontinuity of distribution curve is seen at 13.2 mm diameter which is distinguishing either photography or sieving. This result indicates that it is necessary to give the threshold diameter larger enough than the limit of photo resolution.

**ACKNOWLEDGMENT**

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**REFERENCE**


Environment Regeneration Policy for Buriganga River Watershed Area in Bangladesh

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Abstract

Industrial pollution is a growing concern of the present days. The watershed environment of Buriganga River in Bangladesh is under increasing pressure from the hazardous industrial wastes, emanating from Hazaribagh tanneries. A large amount of toxic wastes from Hazaribagh have eaten up all oxygen in Buriganga and the water quality parameter, Dissolved Oxygen (DO) has fallen down drastically. But Hazaribagh tanneries play a significant role in Bangladesh economy in terms of its export contribution. Along with the increase in export of leather sector, water quality of Buriganga deteriorated severely. There exists trade-off relation between the export trend of leather sector and DO values in Buriganga. Inadequate wastewater management system, insufficient capital, lack of effective pollution control measures and their strict enforcement may be largely responsible for this alarming problem. Improved policies for the maintenance and regeneration of Buriganga watershed environment are the needs to be considered urgently.

Introduction

RIVER pollution is viewed as one of the top environmental problems in Asian region. Many of the rivers get polluted with industrial effluents, municipal waste, agricultural waste, sewage disposal, etc. The Buriganga River in Bangladesh is subject to severe pollution and considered as one of the most polluted rivers in the world. In the context of South Asian region, specifically in Nepal, India and Bangladesh, pollution of surface waters has become more severe and critical near urban stretches due to huge amount of pollutant load discharged by developing and industrial activities.

From past decades, Bangladesh has been facing the problem of environmental degradation of Buriganga and other linked rivers around the capital city Dhaka. Especially, the development of tannery industry at Hazaribagh, which is a great factor for the development of Bangladesh economy, is causing pollution and the disruption to the watersheds environment and ecosystems of Buriganga. Hazaribagh tanneries discharging their solid wastes and liquid effluent containing toxic chemicals, heavy metals, suspended solids, organic matters etc., in most cases drain directly to the Buriganga without any treatment [1]. Ministry of Environment (MoE) reports that the tanneries collectively dump 22,000 liters of toxic waste including cancer-causing chromium into Buriganga everyday [2]. But it is a potentially rich manufacturing sector in terms of both financial return and social benefits (Ahmed, 2005) as Bangladesh earned US$ 401.64 million in 2009-2010 from this leather sector.

Global studies have indicated that many rivers are polluted by large amount of heavy metals like mercury, cadmium, chromium contamination due to the industrialization and urbanization. Water contamination has negative effects on human health through food cycle. The infamous Itai-itai disease in Japan pointed out the danger of environmental cadmium exposure and has led to a plethora of publications (Lalor, 2008). J.S. Amarnath and S. Krishnamoorthy (2001) analysed various negative externalities on land, water, crops, human and animal health including socio-economic consequences due to untreated or improperly treated tannery effluent at Tamil Nadu in India. The uncontrolled dumping of huge industrial wastes of point and non-point sources is even extremely hazardous when the pollutants are heavy metals and cannot be treated easily by conventional methods. The tanneries of Hazaribagh, are such point sources of the city environment. The specialist speculates that a vast number of people will die in this area in near future. But economy is being given priority to environment, which is very common in any developing country. Failure to improve the wastewater treatment and management systems, lack of development and effective implementation design of policies for maintenance and regeneration of the environment and inadequate sewerage and infrastructure facilities are leading to worsening of the situation. The main objective of this study is to consider some environment regeneration policies for Buriganga watershed area.

Toxic Effects on Buriganga River

During Mughol regime (1526-1858s) and afterwards, the surrounding area of Buriganga was the hub of all social, economic and recreational activities of the Dhaka dwellers. It was the breeding place for all types of fish. It was once the main source of drinking water for the residents of Dhaka and the water treatment plant at Chandanighat produced 17 million liters per day (MLD) of drinking water drawn from Buriganga [3]. But now it is like a tank of toxic black gel and there is no fish or aquatic life apart from zero oxygen survival kind of organisms [4].

Thousands of industries along the Buriganga, are disposing their untreated wastes directly in the river. Hazaribagh tanneries are the most harmful among these, which dispose about 12,000 m3 of untreated wastes daily in the Buriganga [5]. Several studies have identified that the water quality of Buriganga is deteriorating at a rapid rate and other water quality parameter like Biochemical Oxygen Demand (BOD) concentration is much higher concentration than the Environmental Quality Standard (EQS, 1997). Analysis of data available from Department of Environment (DoE) demonstrates that the DO levels of Buriganga have gone down much the acceptable limit at many places during the past decades and the degradation values are very high. At present DO levels of Buriganga for all the critical locations become zero, which indicates severe water pollution and environmental degradation of Buriganga and other linked rivers around Dhaka. Thus it is said that Hazaribagh tanneries are killing Buriganga [6].

Contribution of Leather Sector in Bangladesh Economy

Hazaribagh tannery city was established in 1940-50s on just 62 acres of land. 90% of Bangladesh’ 270 registered tanneries are located in Hazaribagh [7]. The industries of 65-year-old tannery complex are processing 220 metric tons of hide a day. The tannery industry in Bangladesh is expanding from economic point of view despite of the environmental pollution. Development of tannery industry at Hazaribagh leads to the export trend of leather in Bangladesh economy. Bangladesh earns a good amount of foreign exchange from leather and leather goods. Leather sector accounts for 85% of total exports, combined with garments and shrimp (Dhaka Chamber of Commerce, 2010).
Commerce and Industry, 2005:3). This sector plays a very significant role in contributing GDP and alleviating unemployment in Bangladesh economy. Information obtained from a number of credible sources exhibit that in total 741,000 people are employed directly or indirectly in leather and its subsectors. But the unplanned tanneries at Hazaribagh, do not have supporting infrastructure facilities. Most of the tanneries are not properly modernized and are using non-mechanized or semi-mechanized systems and antiquated processing methods. No tannery in Hazaribagh has effluent treatment facilities, posing a grave threat to environment [8]. The tanneries dispose their liquid wastes directly to the open drains beside the roads without any treatment, which finally connect to the Buriganga. Buriganga receives in average 19 tons of suspended solids and 7.5 tons of BOD in one day from the tanneries. Industrial waste with such concentration of pollution is not allowed to be discharged in natural water bodies in any developed country [9]. Thus along with the development of tannery industries at Hazaribagh, water quality of Buriganga is degrading seriously.

CONSIDERATION OF ENVIRONMENT
REGENERATION POLICY

Hazaribagh tanneries discharge highly toxic wastes directly to the Buriganga without any treatment. Tannery effluents require elaborate treatment before disposal to prevent pollution of the receiving body of water. But there is no waste management system at Hazaribagh. Most of the tannery owners are poor and they are using primitive technology in their production process, which is very harmful for environment. Besides the low wage rate and poor enforcement of environmental laws and rules have given the country’s leather sector a comparative advantage in the world market [10]. Moreover, the country enjoys duty exemption under the GSP (Generalized System of Preference) from most of the importing countries of the developed world. Due to these advantages, Bangladesh has adopted an export-led growth strategy, for its economic development. But for sustainable development, a country has to consider the natural environment. If the tannery owners keep consideration to the environment, they have to install modern technologies in their production and waste management systems. The production cost will go up then and it may turn to be a big constrain for Bangladesh to compete with others in the global market. Due to this trade-off relation, environmental problems of developing countries cannot be solved so easily. Inadequate waste management systems, lack of capital and infrastructure facilities and insufficient open spaces can make the problem acute. In this situation it is very urgent to consider some environment regeneration policies for Buriganga watershed environment.

A. Innovating Cheap Waste Management System

For environmental regeneration, this policy is very important for any developing country. Government and concerned organizations should take a notice and step forward for a useful solution. If cheap modern technology is innovated, all tanneries can continue their production and survive in the export market without damaging the environment. The Government also has to concentrate on providing proper sewerage and infrastructure facilities. Hence the problems of lack of capital and infrastructural facilities may be removed.

B. Merging of Small Tanneries and Cooperative Production Structure

It is reported that at present, 114 units, large and medium by the local standards are registered to the Directorate of Industries. Others are mostly of small and cottage type and are not on the register. In this situation, different groups of medium and small tanneries can make co-operative or collaborate industrial structures to run their production. Then they can be able to maximize their production and minimize environmental degradation by installing modern technologies. Co-operative system is also fruitful in the area of waste management system. Japan has taken the lead in a co-operative production of value in the area of waste management. For almost 30 years Japan evolved waste management as a fundamentally co-operative process [11].

C. Strict Enforcement of Industrial and Environmental Rules and Policies

It may be possible to curb pollution by the policies. The existing rules should be amended by strict enforcement. Under this policy, all tanneries have to clean their effluents before disposal and install environmentally friendly technologies. Those who are unable to obey the rules have to close their tanneries and Governments have to support them to switch in other sectors. As a large number of tanneries get collapsed under this policy, the existing tanneries will get some open space to build Effluent Treatment Plant (ETP) and Central Effluent Treatment Plant (CETP). Thus the problems of inadequate waste management and insufficient open space can be solved.

D. Execution of Hazaribagh Relocation Project

Most of the European Union (EU) counties are set to pass new policies that will bar import of products from industries that pollute environment with harmful chemical agents and do not have CETP [12]. But Hazaribagh is too congested to build CETP and redevelop. The Government has launched a relocation project of Hazaribagh tanneries to a new area, located at Savar near Dhaka to save Buriganga. But this relocation project proves to go in vain because of unwillingness of the tannery owners to move and in terms of the cost effectiveness and potential environmental threat of the new area [13]. Though the Government is persuading the tannery owners to start shifting their factories from Hazaribagh to Savar, the CETP has not been built yet. Moving to Savar, without a CETP and proper infrastructure facilities, will result in the same way as Hazaribagh. So, the shifting should be completed as early as possible impending EU legislation keeping in mind, otherwise it may hurt this export-oriented industry.

E. Recycling Policy and Practice

Recycling is re-using of products, a mean of waste reduction. Government may introduce or innovate new technologies for recycling to reduce or manage solid wastes. It is possible to recycle the solid wastes from tannery industries as poultry and fish feed, hard board, glue etc. So recycling policy and practice may be a fruitful policy for environmental regeneration and developing activities.

CONCLUSION

Pollution of Buriganga is now reaching epidemic proportion. As the apparel industry and the leather product industry are being shifted from China to Bangladesh for its cheap labor cost, further pollution of the watershed environment is assumed. The improvement of the water quality of Buriganga, development and design of policies for the maintenance and the regeneration of the watershed environment are the nation’s important problem. But as Bangladesh is a developing country, the existing rules of proper industrial waste treatment have always been ignored by the owners of the industries. Lack of implementation of rules by the concerned Government agencies has aggravated the environmental pollution problem. DoE should take the leading role to implement the rules with the help of law enforcing agencies. However, political commitment is necessary to avoid and overcome the socio-political implications, which may curb pollution and regenerate the watershed environment of Buriganga River.
ACKNOWLEDGMENT

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REFERENCE


Study on Noise Pollution due to Traffic Flow in Sylhet

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ABSTRACT

The study was performed to obtain the Equivalent Noise Level, Traffic Noise Index (TNI), Noise Climate (NC) and hazard due to noise pollution at eight different intersections in the Sylhet city. Due to increase of population, road traffic is increasing day by day which causes noise pollution in the environment. Now-a-days it becomes a serious environmental issue. The study was carried out from 8:00 am to 8:00 pm to assess the noise level at various intersections in Sylhet city. The maximum Equivalent Noise Level was 78.00 dBA at Amberkhana during the period of 5:00 pm to 8:00 pm whereas Subidbazar was identified as noise prone area characterized with Traffic Noise Index (TNI) and Noise Climate (NC) of 77.70 dBA and 13.90 dBA respectively.

INTRODUCTION

The level of the noise pollution is very closely related with urbanization and motorization. Traffic noise can interrupt speech communication, sleep and relaxation and reduces the ability to perform complex tasks [1]. Surveys of many countries have shown that traffic noise is the principal environmental nuisance in urban areas [4]. Noise from the motors and exhaust systems of large trucks provides the major portion of highway noise and provides a potential noise hazard to the surrounding people and driver as well [3]. In Sylhet city, the main sources of noise pollution are the motors and exhaust systems of autos, smaller trucks, buses, and motorcycles. This type of noise can be augmented by narrow streets and tall buildings, which produce a “canyon” in which traffic noise reverberates [5].

Throughout dozens of studies, noise has been clearly identified as an important cause of physical and psychological stress [8]. Stress directly influences the activities of our body mechanism and thereby noise can easily be associated with many of the disabilities including heart attack, high blood pressure, headaches, fatigue and irritability [6]. Among the health hazards related to noise, hearing loss is the most commonly treated by health professionals [7]. Noise that causes annoyance and irritability in healthy persons may have serious consequences for those who are already ill in mind or body [2]. The other hazards are harder to pin down. The main objectives of the study were:

- To obtain the Equivalent Noise Levels at different intersections of the Sylhet city
- To obtain the Traffic Noise Index (TNI) and Noise Climate (NC) of the intersections
- Identification of the noise prone intersections among them
- To obtain public opinion ad their susceptibility to noise pollution
- To recommend some possible measures to reduce noise pollution

MATERIALS AND METHODS

Eight major intersections in Sylhet city were selected to assess the noise level. The major intersections were Madina Market, Subidibazar, Amberkhana, Chowhatta, Zindabazar, Niorpool, Bondor and Rikabibazar. Noise levels were measured during the period of 8:00 am to 8:00 pm of the workdays. The four time intervals were:

- 8:00 am to 11:00 am
- 11:00 am to 2:00 pm
- 2:00 pm to 5:00 pm
- 5:00 pm to 8:00 pm

Before the measurement being started, calibration was performed. The NL-04/NL-14 simultaneously calculates the L10, L1, Lmax, and L1. After processing, the display was switched to show any of the above values.

Noise levels were measured at the road side as well as at distances (near hospital building) away from the road side. The sound level meter was switched to fast response position. During each hourly interval, sound levels were measured for 10 minutes for a couple of times. The average values of these measurements were recorded as the sound level for the corresponding location and time interval.

Traffic Noise Index (TNI) and Noise Climate (NC):

TNI and NC were computed by using the following equations; TNI and NC measured as dBA:

\[ TNI = L_{10} + 4(L_{10} - L_{0}) + 30 \]

\[ NC = (L_{10} - L_{0}) \]

RESULTS AND DISCUSSION

Public opinion says, noise irritates them mostly, they can’t sleep and it also disturbs their concentration at work. According to field survey it was found that most of the people feel noise as a hazard but very few of them know about its impact on health.

![Fig. 1. Health hazards of noise pollution in major areas of Sylhet. A: Madina market, B: Subidibazar, C: Amberkhana, D: Chowhatta, E: Zindabazar, F: Bondor, G: Niorpool, H: Rikabibazar](image-url)
The study also observed that the noise levels at four time intervals are almost same. The following table shows the different parameters of noise level at various intersections.

Table 1. Equivalent Noise Levels (dBA) at Various Locations

<table>
<thead>
<tr>
<th>Time interval</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 am - 11:00 am</td>
<td>Madina Market 70.56 68.00 71.00 69.00 70.50 68.67 67.00</td>
</tr>
<tr>
<td>11:00 am - 2:00 pm</td>
<td>Subidbazar 72.88 70.00 77.90 71.00 72.00 70.50 69.80</td>
</tr>
<tr>
<td>2:00 pm - 5:00 pm</td>
<td>Amberkhana 68.96 69.40 75.00 70.70 71.00 71.00 71.70</td>
</tr>
<tr>
<td>5:00 pm - 8:00 pm</td>
<td>Chowhatta 74.00 70.00 78.00 72.00 73.80 72.00 72.60</td>
</tr>
</tbody>
</table>

Table 2. Values of NC and TNI at various locations

<table>
<thead>
<tr>
<th>Location</th>
<th>NC (dBA)</th>
<th>TNI (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modina market</td>
<td>8.90</td>
<td>56.90</td>
</tr>
<tr>
<td>Subidbazar</td>
<td>13.90</td>
<td>77.70</td>
</tr>
<tr>
<td>Amberkhana</td>
<td>5.60</td>
<td>60.30</td>
</tr>
<tr>
<td>Chowhatta</td>
<td>7.70</td>
<td>58.20</td>
</tr>
<tr>
<td>Zindabazar</td>
<td>8.50</td>
<td>52.00</td>
</tr>
<tr>
<td>Bondor</td>
<td>4.90</td>
<td>65.70</td>
</tr>
<tr>
<td>Niorpool</td>
<td>8.40</td>
<td>55.90</td>
</tr>
</tbody>
</table>

CONCLUSION

The study says, Madina market, Chowhatta and Niorpool are the most vulnerable intersections for hearing loss, concentration loss, mental loss and irritation (Fig. 1). At various time intervals equivalent Noise Levels are the highest in 5:00 pm - 8:00 pm (Table 1). In Amberkhana intersection equivalent Noise Level is the highest 78.00 dBA. Table 2 also shows the highest noise prone area is Subidbazar (NC and TNI are 13.90 dBA and 77.70 dBA respectively).

From the analysis of data it was observed that average noise level in the road side is about 74 dBA which exceeds the acceptable limit of 45 dBA set by the Department of Environment (DOE). The following measures can be adopted to control noise pollution:

- Tree plantation can be encouraged. They act as a barrier. They absorb the sound energy and reduce noise level.
- Control of noise sources can be adopted; drivers can be trained with proper vehicular maintenance. Traffic can be controlled, geometric and structural design of the roads can be controlled.
- Noise path can be controlled by using appropriate barriers that can reflect and diffuse noise.
- Buffer zones can be created between roads and the house holds to provide a distance over which noise can be attenuated.
- Awareness programs can be carried out to make the people known about the hazards of noise. It can be helped to control noise pollution at the receptor site.

REFERENCE

Assessment of Spatial Variation of Water Quality of Tunggak River Adjacent to Gebeng Industrial Estate, Malaysia

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ABSTRACT
Anthropogenic impact on the Tunggak River is as a result of rapid industrialization in the study area. The study was conducted with the objective to explore the spatial variation of the water quality of the river due to anthropogenic activities. Water samples were collected monthly from selected sites and analyzed applying APHA & HACH standard methods. Trace elements were determined using Inductively Coupled Plasma Mass Spectrophotometer (ICP-MS). SPSS statistical software was used for data analysis. The study revealed that point sources especially industrial wastes contributing the major pollutants. Less amount of dissolved oxygen (DO) and higher concentration of chemical oxygen demand (COD) & ammoniacal nitrogen and trace elements made the water unusable. Based on Department of Environment-Water Quality Index (DOE-WQI) Malaysia, maximum stations except lower and uppermost were categorized as class IV (highly polluted). Pollution was higher in the middle stations due to addition of most of the industrial effluents to those sites.

INTRODUCTION
Water is the most delicate part of the environment which is essential for human and industrial development. Due to increasing population and rapid growth of industrialization the demand of fresh water rises tremendously in the last few decades [1]. The rate of fresh water deterioration by anthropogenic activities is coupled with the ever-growing demands of water resources [2]. Malaysia is subsidized with a bounty of natural water resources which is contributing significantly to the socio-economic development of the country [3]. But the situation is changing day by day with population growth, urbanization, and industrialization. According to the Environmental Quality Report 2009, 46% river water of Malaysia is polluted which is higher than previous couple of years [4]. The Tunggak is one of the important rivers in Pahang which is adjacent to Gebeng the main industrial area in Kuantan, Pahang, Malaysia. The town Gebeng is located near Kuantan Port; where industrial development is growing rapidly. These industrial activities are generating effluents which contain high concentrations of conventional and non-conventional pollutants that deteriorating the water quality of the river. In the study area, non-point source associated with runoff from construction sites of newly developing industrial areas and the point source contributing the maximum pollutants especially industrial wastes. Industries like, petrochemical, medicinal, wooden and mining are discharging their effluents in the river through various drain/channels. As a result the water of the river contains high amount of ammoniacal nitrogen (NH3-N), less DO and many other components that deteriorate the water quality. The industrial waste water of the study area contain nickel (Ni), mercury (Hg), cadmium (Cd), zinc (Zn), chromium (Cr), lead (Pb) and copper (Cu) [5]. So, the river water quality becomes more polluted. Therefore, the study was done with a view to identify the behavior of the water quality parameters and to disclose the spatial variation of the pollution status of the surface water.

MATERIALS AND METHODS
A. Study Area and Selection of Station
The Tunggak River is situated in between 3°56′06″ to 3°59′ 44″ N and 103°22′42″ to 103°24′47″ E adjacent to the Gebeng industrial town holding several types of industries (Fig. 1). Station selection was done considering the land use-pattern, point-sources of pollution, vegetation and river network. Starting from lower stream 10 stations was selected for sampling.

B. Sampling, Data Collection and Analysis
Water samples were collected monthly from pre-selected 10 stations. Three (3) samples were collected from identical 3 positions in every station for replication. Data regarding the position of the station was collected using GPS. BOD samples were carried using separate BOD bottle. APHA & HACH standard procedure was followed during sampling and samples preservation [6-7]. Using YSI in-situ data of pH, Temperature, DO, Turbidity, Salinity, Electrical conductivity (EC), and total dissolved solids (TDS) were also collected during the sampling. For chemical parameters HACH spectrophotometer was used. BOD was calculated with the initial reading collected just after sampling and the final reading after 5 days incubating at 20°C temperature. TSS analyzed by using gravimetric method and heavy metals were determined by ICP-MS. All parameters were analyzed within 7 days of sample collection.

RESULTS AND DISCUSSION
C. Data Analysis
The main aim of environmental research is to identify for underlying factors which are not observable directly in database, for this factor analysis technique is suitable [8]. For the factor analysis SPSS statistical software was used to analyze the data. For this study data were analyzed for mean, standard deviation (SD), range, correlation and Analysis of Variance (ANOVA).

A. In-situ Parameters
River water temperature in Malaysia usually ranges from 24°C to 31.3°C [9] and Malaysian normal water temperature is 27-31°C [10]. Water temperature of the Tunggak river varied

Fig. 1. Map of the study area indicating Tunggak River
It was due to station 1 & 2 are located near the sea and station 7 is adjacent with some industries which discharge sulphur reach effluents into the river. The amount of NH\textsubscript{3}-N varies from 0.25 mg/L at station 9 to 3.47 mg/L at 3 (Fig. 3). The values were beyond the permissible limit of INWQS of Malaysia [11]. NO\textsubscript{x}-N level was within the safe level (<0.4) [9] except station 5-7 (Fig. 3); these three stations received most of the effluents from the industries including polymer, chemical, metal, gas & power and wooden industries in Gebeng. From the analysis PO\textsubscript{3}-3 recorded highest 6.3 mg/L at station 10 (Fig. 3) while the other stations contain relatively low PO\textsubscript{4}-3-. Meanwhile PO\textsubscript{3}- amount was in permissible level at station 7-9 [11].

Biochemical parameters BOD and COD were analyzed and the result revealed that BOD was the highest 32.88 mg/L at station 7 and the lowest was 4.23 mg/L at 9 (Fig. 4). The BOD values at all stations were beyond the permissible limit [11] and it was due to the discharge of industrial wastes in the river flow. In the same way COD value recorded higher at station 7 and lesser at station 9 (Fig. 4). However, COD level recorded safe at station 9 & 10 [11]. Due to the addition of industrial effluents with the river water the quality of water deteriorated and based on the types of industry pollution level of the river differ from station to station.

Heavy metals were determined by ICP-MS and demonstrated in Fig. 5. Result showed that water of the river bearing especially the middle stations containing Co, Cd, Cu, Pb and Cr beyond the permissible level [11]. Adjacent to the river the major industries are chemical, polymer, metal, petrochemical and gas & energy; those effluents bear the toxic heavy metal as a result polluting the surface water of the river.

from 26.16°C to 35.24°C among the stations. In most of the stations temperature was within the normal limit of Malaysian standard but the temperature of station 6 to 8 were beyond the standard limit [11] (Table 2). Regarding pH values, it was varied from station to station. The highest pH value 9.12 was recorded in station 6 followed by station 7 and station 7. These three stations received most of the effluents of the industrial estate consist of polymer, chemical, metal, gas & power industries. On the contrary, the lowest value 4.16 was recorded in station 8 followed by station 9 and 10. It was might be because of the industrial effluents at the area of station 8 and 10 contained acidic substances and due to submerge condition at station 9 pH was also low (Table 2). Only the value of pH in station 1 was within the permissible range [11]; perhaps it was due to the tidal interference from South China Sea (Table 1).

### Table 1. Physico-chemical parameters of different sampling sites and classification based on INWQS of Malaysia

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Station no. (total station)</th>
<th>Value/ amount</th>
<th>Water Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>1 (1)</td>
<td>6.0 – 9.0</td>
<td>Class II</td>
</tr>
<tr>
<td></td>
<td>2 – 7 (6)</td>
<td>6.5 – 8.5</td>
<td>Class I</td>
</tr>
<tr>
<td></td>
<td>8 – 10 (3)</td>
<td>5.0 – 9.0</td>
<td>Class III</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>1.5,7.8 (4)</td>
<td>3.12 – 3.38</td>
<td>Class III</td>
</tr>
<tr>
<td></td>
<td>2-4.6 &amp; 9-10 (6)</td>
<td>1.58 – 2.71</td>
<td>Class IV</td>
</tr>
<tr>
<td>EC (μS/cm)</td>
<td>1 – 2 (2)</td>
<td>10880-18013</td>
<td>Class IV</td>
</tr>
<tr>
<td></td>
<td>3 – 7 (5)</td>
<td>1068 – 1585</td>
<td>Class II</td>
</tr>
<tr>
<td></td>
<td>8 – 10 (3)</td>
<td>24 – 750</td>
<td>Class I</td>
</tr>
<tr>
<td>Salinity (%)</td>
<td>1 – 2 (2)</td>
<td>5.685 – 9.38</td>
<td>Class IV</td>
</tr>
<tr>
<td></td>
<td>3 – 6 (4)</td>
<td>0.52 – 0.715</td>
<td>Class II</td>
</tr>
<tr>
<td></td>
<td>7 – 10 (4)</td>
<td>0.01 – 0.34</td>
<td>Class I</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>1 – 8 &amp; 10 (9)</td>
<td>6.59 – 23.44</td>
<td>Class II</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>3.87</td>
<td>Class I</td>
</tr>
<tr>
<td>TDS (mg/L)</td>
<td>1 – 2 (2)</td>
<td>6250-16137</td>
<td>Class IV</td>
</tr>
<tr>
<td></td>
<td>3 – 6 (4)</td>
<td>613-767</td>
<td>Class II</td>
</tr>
<tr>
<td></td>
<td>7 – 10 (4)</td>
<td>8.15 – 365</td>
<td>Class I</td>
</tr>
</tbody>
</table>

EC readings of the stations were mostly within the normal limit except the 1, 2 & 3 (Table 2). This was because of entering the saline water in these stations during tide from the South China Sea. Concentration of DO recorded very low in all of the stations varies from 1.1 mg/L at station 2 to 4.4 mg/L at station 1 (Table 2). According to INWQS, Malaysia the stations were categorized as class III and IV based on DO concentration (Table 1).

TDS concentration was higher in the lower stream stations compare to the uppermost. Station 1 and 2 contained the highest amount of TDS due to tidal disturbance, forested area and there were some agricultural activities adjacent to the station 2. Meanwhile, TDS of station 7-10 were in permissible limits 500 mg/L [11] (Table 2). Turbidity level varies from 2.1 NTU at station 7 to 34.5 NTU at station 5 (Table 2); only station 9 was in normal level whether rest of all contained higher value of turbidity according to the INWQS, Malaysia.

### R. Ex-situ Parameters

Collecting samples from sampling sites were analysed in laboratory for determining the amount of Sulphate (SO\textsubscript{4}), NH\textsubscript{3}-N, Nitrate-nitrogen (NO\textsubscript{x}-N), Phosphate-phosphorus (PO\textsubscript{4}-3-), BOD, COD and TSS. Results showed that the amount of sulphate was highest in station 1 followed by 2 and 7 (Fig. 2).
C. Water Quality Index

DOE-WQI was calculated to classify the water quality of Tunggak river. The computed values categorized the river water of Tunggak as Class IV (highly polluted) except the lower stream station 1 and upper stream stations 9 & 10. Regarding those three stations, they were categorized as polluted and slightly polluted respectively. That was perhaps at station 1 there was tidal interference and forested areas; and at station 9 & 10 there was less industrial activities generating comparatively lesser effluents. However, according to the Interim National Water Quality Standards of Malaysia, water of the river was found to be unusable without irrigation [11].

![Fig. 4. Status of organic parameters COD and BOD among the stations](Image 61x144 to 258x266)

![Fig. 5. Status of trace element Concentration among the Stations](Image 270x143 to 475x269)
CONCLUSION

This study revealed that the pollution level was comparatively higher in the middle stream stations because of maximum wastes discharged to those stations from the industries. On the other hand due to tidal interference at lower stream and less industrial activities at the upper stream caused less pollution in lower and upper stream stations. Considering the analytical results and data analysis it is clear that the major source of pollutant was the industrial activities. To reduce the water pollution level close monitoring of industrial activities should be ensured and emphasis should also be given on recycling of industrial wastes of their own before discharging to the river flow.

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REFERENCE

Characterization and Filtration Performance of Pressed Non-woven Fabric Membrane

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ABSTRACT

Low cost membranes for water treatment using non-woven fabric membrane are proposed. The non-woven fabric membranes are applied in the novel separation technologies that are the pore diffusion separation and the flow fractional separation. The compression ratio, surface roughness and pore size of the membrane were evaluated in the correlation of their filtration performance. It was able to reduce the membrane thickness, the surface roughness and the average pore size of the non-woven fabric membrane by pressing in wet state. It was confirmed the particles with more than 10 μm could be removed completely and it was maintained almost stable between two days (3000 minutes) and almost no clogging was observed.

INTRODUCTION

Due to the increase in the world population and the economic development, the water shortage has become a serious problem. To solve the water shortage, many technologies of water treatment have been developed. The water treatment required for developing countries must be small size, easy to handle and low cost, since it is not easy to build large-scale infrastructure. A problem of a centralized city is also needed to concern. Due to old facilities of domestic infrastructure, it will be good chance to convert them to such small-scale equipment.

In the case of installing small devices, the operation system must be simple, because the local people have to operate them. A membrane separation may be the most effective. The membrane separation device currently on the market is very expensive. The reason of the price increases is the high production cost of the membrane.

In this paper, one of the low cost membranes for water treatment is proposed. The membrane using non-woven fabric is manufactured by mass production. The authors think the non-woven fabric membrane can be applied for water treatment and it is possible to develop a novel separation membrane having a micron pore size.

The pore diffusion, defined as the diffusion of a substance in a pore of a membrane, is the technique to separate the large particles and water [1]. Water molecule passes through the inside of the membrane with a multilayer structure by diffusion and also is filtered through a bulk flow. The particles shift their position to the place where shows the higher flow rate. The particles cannot be entered to the internal pores of the membrane, and then, is separated from water. One of the features of the pore diffusion is high level of particle removal ability. On the other hand, slow filtration rate is a disadvantage. Non-woven fabric membrane can be satisfied for the demand of low cost in membrane technology.

The flow fractionation separation has been proposed for the porous membrane [2]. The separation mechanism is based on the flow fractionation effect (or the collection axis effect) that occurs by quickened flow rate [3] (Fig. 1). The flow fractionation effect is observed in blood flow within the human body [4]. By the use of this effect we may maintain a stable long-term filtration performance. For example, red blood cells move to the center of the blood vessel by the effect resulting the stable filtration [5, 6]. When we use this effect in the filtration process of aqueous solution, it is possible to separate particles and water by low pressure filtration. The flow fractionation effect is observed only in the case of the shear stress to the particles exceed over the critical value that originates the rotational motion of the particles in a flow stream. This indicates that the flow stream of a given aqueous solution must be the laminar flow and the flow should give the shear rate to the particles. The shear rate, τ, is given by the following equation (1).

\[ \tau = \frac{V}{t} \]  

Where, \( V \) is the flow rate (mm/s), \( t \) is the width of the flow path (mm). When the particles size is a sub-micron, more than 20 sec\(^{-1}\) shear rate works effectively on the rotational motion of the particles.

Even in the case of the non-woven fabric membrane, the flow fractionation is available and also the pore diffusion is applicable. We can expect the development of the novel low cost and small scale equipment for water treatment.

In this paper, we will prepare a prototype non-woven fabric membrane by pressing a commercial available non-woven fabric. The pressed non-woven fabric may be evaluated compression ratio, surface roughness and an average pore size. The wastewater containing particles of a certain particle size may be employed and the separation performances including particle removal ability and filtration speed may be evaluated. We intend to evaluate the potential application for the novel separation technology.

METHODS

A. Non-woven fabric membrane

Regenerated cellulose filament non-woven fabric (The non-woven fabric membrane) was prepared by copper ammonium process (100g / m\(^2\) basis weight, 390 μm thickness, \( R_{\text{a}}=21.1 \) μm surface roughness), and roller pressed or hot pressed in a wet condition. Hot press was operated by hand with a heated iron. Roller press machine was used for the roller press. The average pore size of the original regenerated cellulose filament non-woven fabric was about 100 μm including support mesh pore size.

Fig. 1. The flow fractionation effect diagram
B. Compression Ratio

The compression ratio was calculated with the thickness of the membrane before and after pressing. Compression ratio is given by the following eq. (2).

\[
\text{Compression ratio} = \frac{(T_1-T_2)}{T_1} \times 100
\]

Where T1 is the thickness of non-woven fabric membrane before pressing, T2 is the thickness after pressing.

C. Surface Roughness

The surface roughness of the pressed non-woven fabric by the roller press was measured. The surface roughness is represented by the average roughness Ra. When the highly of the surface of the fabric is expressed in \( y = f(x) \), in micrometers (\( \mu \text{m} \)), Ra value was determined by the equation shown in the Fig. 2, the roughness curve.

\[
\text{Ra} = \frac{1}{L} \int_0^L \! y(x) \, dx
\]

D. Average Pore size

Average pore size of the membrane, more than 50% compression ratio, was measured by the filtration rate of distilled water by the following formula (3).

\[
2\pi r^2 = \frac{J \times \Delta \rho \times \eta}{\Delta P \times k \times \rho \times \eta}
\]

Where J is the flow rate (mL / min), \( d \) is the thickness (\( \mu \text{m} \)), \( \Delta P \) is pressure difference (mmHg), A is the membrane area (m\(^2\)). These are using the measured values. Prp is "1 - (cellulose density / membrane density)". \( \eta \) is the viscosity.

E. Evaluation of filtration performance

The separation performance was evaluated by filtering waste water through the non-woven fabric membrane. The waste water includes the large particle of toxic flocculated materials by using floculating agent (nucleating agent). The floculated materials, about 20 \( \mu \text{m} \) particle size (measured by DLS, Dynamic light scattering) (Fig. 3), were stirred by a pump of the flow fractionation separation unit and crushed by shear force to smaller particles about 10\( \mu \text{m} \) to be around. The particles were filtered through the pressed non-woven fabric membrane.

RESULTS AND DISCUSSION

A. Non-woven fabric membrane

Regenerated cellulose filament non-woven fabric by copper ammonium process was pressed by roller press machine at 30°C in wet condition.

The cross-section of the pressed non-woven fabric membrane was observed with a microscope. Distribution of fiber was measured as a function of the distance from the surface of non-woven fabric and total fiber number per cross-sectional area unit. The number of fiber cross-section present in the layer of 500 \( \mu \text{m} \) length and 50 \( \mu \text{m} \) depth of the cross-sectional view was more than 10 in any layer. Pulsation of the number had been within 2 times of the number and the average number of 0 and those values are the number of fiber cross-section present in the layer at 500 \( \mu \text{m} \) length 10 \( \mu \text{m} \) depth cross-sectional direction also. The pulsation indicates that non-woven fabric membrane has a laminated multilayered structure. This multilayered structure is one of the most important factors for the separation by the use of a membrane. Thus this prototype non-woven fabric membrane can be expected having a certain separation performance.

B. Compression ratio

Compression ratio of the pressed non-woven fabric membrane was measured. The observed compression rate of the hot pressed membrane was 11.8%. The edge of the Roller Pressed membrane was 52.6% and at the center of it was 43.2%.

C. Surface roughness

Surface roughness was measured before and after the press of the non-woven fabric membrane. The original non-woven fabric was Ra (\( \mu \text{m} \)) = 21.1, the hot Pressed membrane was Ra (\( \mu \text{m} \)) = 13.9, roller pressed (center) Ra (\( \mu \text{m} \)) = 17.1, (edge) Ra (\( \mu \text{m} \)) = 7.7. For water treatment, it might be necessary to make the surface roughness small as like less than Ra = 10 to realize laminar flow. It is necessary to clarify the condition of the edge of the roller pressed non-woven fabric membrane in order to get the reproducible manufacturing. Fig. 6 represents the value of Ra for four membranes.

D. Average pore size

Pressed non-woven fabric membranes were prepared in industrial scale under the conditions of 52.6% compression
rate. The average pore size of the membrane was measured through the water filtration rate method. The average pore size was about 8 μm degree, as shown Fig. 6.


Fig. 7. Change in pore size with thickness of membrane; prepared by compression rate 52.6 %

E. Evaluation of filtration performance

By using the non-woven fabric membrane prepared in industrial scale, a wastewater was filtered and its separation performance was evaluated. After filtration, large particles with more than 10 μm in the waste water were almost cleared by visual inspection.

The filtration rate in this filtration experiment could maintain at a stable filtration rate about two days (3,000 minutes) and almost no clogging was observed.

Fig. 8. Filtration performance

CONCLUSION

It was possible to compress and reduce the thickness of the non-woven fabric membrane in the wet state. It was able to reduce the surface roughness and the average pore size of the non-woven fabric membrane by pressing. It was confirmed the particle removal performance for 10 μm particle size. The performance maintained almost stable between two days (3000 minutes) and almost no clogging was observed under the flow fractionation and the pore diffusion.

REFERENCE

A Case Study on Fire Hazard in Rajshahi City, Bangladesh

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ABSTRACT
Rajshahi city, which is one of the important metropolitan cities in Bangladesh, has been developed with the wheel of civilization known as one of the most environment friendly, livable and hazardless cities in this country. Moreover, in the recent past, several developments in the commercial sector have been occurred. Furthermore, with the commercial and industrial development several human induced hazards have also been introduced here. Fire hazard is one of them which have become one of the biggest causes for the headache of the city. The state of environment of the city has noticeably changed for the issue, which is into a burning oven, since last decade. Recent history of fire occurrence of fire hazard, in consequence lost property and amount of rescued property has been reviewed as well. A specific zone which seems to me most vulnerable to the hazard occurred by fire has been taken for the subject matter of the study and the probable occurrence of the hazard and their cause has been analyzed in this study. Mainly, most of the fire is occurred from short circuit and blast as well as burning of flammable things such as wood, gas cylinder etc. Moreover, the hazard due to this occurrence is not only due to these accidents only, it is also induced due to the inaccessibility of fire fighters in time. For a sustainable solution of these hazards, some preventive measures have been proposed that includes the immediate improvement of the infrastructure of the city and enhancement of the public facilities which is the instant need of this city.

INTRODUCTION
Since the first step of human being in this globe, hazard has become part and parcel of them. Hazard is always unwanted but hazard has been facing this unwanted thing repeatedly. The hazards can be primarily classified into two categories i.e. natural hazard and man-made or man induced hazard. Natural hazard is of such type which can hardly be avoided but the other one i.e. man induced hazard is predictable and also manageable. Fire hazard can be classified as some sort of semi natural and semi man made hazard. In presence of air (oxygen), combustion of combustible materials (fuels) results fire. In order to start a fire there should be initially sufficient heat (just equal or above the ignition temperature) to ignite a fuel and also the combustion reaction should also produce enough heat to maintain the combustion temperature above its ignition temperature for the sustenance of the fire. A fire develops itself in three stages such as namely -Incipient stage, Smoldering stage & Flame stage. In a nutshell, for a fire to break out, the three essential components are Fuel, Oxygen and Heat [1].

Public attitudes toward fire have changed significantly over the past two decades and that educating the public about fire and its management has become a matter to be concerned about [2]. Large numbers of people are killed or injured every year in Bangladesh in industrial accidents, fires and building collapses. The limited building and safety regulations are rarely enforced and routinely flouted. Fires due to short-circuits, substandard wiring and electrical faults are common, essentially due to building contractors and landlords seeking maximum demand value of those things. The possible temporary and permanent solutions has been tried to propose based on the study of the fire service authority which is done after any occurrence of fire hazard by estimating the amount of the each type of property and valuable things damaged as well as rescued. Finally the total amount is calculated in terms of the present market and demand value of those things. The possible temporary and permanent solutions has been tried to propose based on the study on the several considered conditions of different zones.

RESULTS
A. Recent History of Fire Occurrence and Their Cause
Fire has occurred frequently in the city since last years. The main causes of those fire occurrences are short circuit, blast of gas cylinder, from flammable materials, from wooden fuel ovens etc. Fig. 1 shows the recent history of fire occurrence since last ten years. It has been noticed that, appreciable amount of loss of property has been occurred and the rescued amount is also noticeable as shown in Fig. 2 and Fig. 3 which has been collected from the database of the Fire service authority, Rajshahi. More or less, it has been noticed that the amount of fire hazard occurrence has not been decreased or changed its pattern much. So, it can be said that the cause problem of the fire occurrence is more or less all the similar. Atrociously, it has been seen that in the year 2011, 2003 and 2002, the fire hazard has occurred the record amount of damage of the public property. Eventually, the amount of property rescued is more in the year 2011 as well as in 2002. The last biggest fire occurrence was at Rahman Jute Mills, Paba, Rajshahi in January 22, 2011 which showed its devastating feature. Seven units of fire fighters worked relentlessly for 16 hours to manage that fire. Lots of property damaged and hence the mill has been closed in consequence.
B. Fire Service at Rajshahi City

The infrastructure of Rajshahi fire service is not very good because there are lots of technical problems and lack of modern instruments. The fire service authority have a map of Rajshahi City which shows the water source and warden posts located in different areas of the city. But recently the source of water supplies have reduced and the map shown in Fig. 4 has become less efficient and unauthentic.

C. Possible vulnerable zones

Based on the collected information from the authority of fire service of Rajshahi City and field survey, the area Shaheb Bazaar has been indicated as possibly the most vulnerable to fire hazard. Surprisingly because of the absence of enough water bodies and other source of water needed for fire-fighting, Shaheb Bazaar is the main commercial area of Rajshahi City where billions of BDT transactions is done every day and thousands of people’s daily income is dependent on this area. That is why the Shaheb Bazaar and its surrounding area have been selected for the concern of this study. The map shown in Fig. 6 shows the selected area for this study.

D. Cause of Vulnerability

Determining the fire source is one of the most important parts of performing a fire hazard analysis [6]. The prime cause of vulnerability of fire has been pointed out as the lack of source of water instantly after occurrence of any fire. This has
been the most problematic thing which has been a headache of the authority and others who are thinking about the fire occurrence at that zone. Form the questioner survey among the peoples of that zone and the fire service authority it has been indicated as the prime cause of fire hazard. Another thing is that, the improper access of fire service vehicles due to unmanaged road network and inadequate road width has also been taken into account as the probable cause of fire hazard. Whereas, it is found that minimum 18 ft width of road is needed for the access of fire-fighting vehicles. Moreover, there is provision of fire-fighting in elevated places by ladders only up to three stories which is extremely inadequate for some situations when it is needed to climb more than that. On the consequence of the mentioned causes the management of fire occurrence has been very much time consuming and less effective.

E. Possible Solution

Following the fire fighting system of the developed countries as a role model, the possible solution to overcome the problem of inadequate source of water may be the use of fire hydrant as shown in Fig. 7. There should be adequate amount of fire hydrant in specially that zone in suitable interval. The installation of adequate amount of fire hydrants might be very costly but the necessary steps should be taken by the authority by using the optimum amount of fire hydrants for the safety of that zone. As temporary basis, some other steps may be taken personally by the consumers by arranging some temporary firefighting measures. Another thing is that, authority should strictly enforce rule about the building by law and should also take some necessary steps for increasing the accessibility of the area by the fire service vehicles.

Fig. 7. Fire hydrant

DISCUSSIONS

From the above study of accessing the vulnerability of fire hazard, it has been noticed that there are some zones where there is even no accessibility of small firefighting vehicles whereas there should be minimum 10 feet wide road for entering a firefighting vehicle. So the reserved water from the vehicles could not be used for firefighting. That is why it is really urgent to take step for the vulnerability mitigation by introducing modern technologies. Since the whole infrastructure of that zone is not ready for defending fire, adequate amount of fire hydrant is necessary for the firefighting. Furthermore, the authority should take necessary steps for increasing the accessibility of vehicles. Moreover, the occurrence of such type of event may cause endless sufferings, damage of public property and even death.

CONCLUSION

Present state of the fire safety condition of Shaheb bazaar zone has been discussed in the study and it is strongly recommended that authority should take the necessary steps against this burning issue.

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REFERENCE

Baseline Assessment of Short-lived Climate Pollutants in Bangladesh
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ABSTRACT
Bangladesh has local urban air quality problems affecting the health of the countries inhabitants, in addition to being a top greenhouse gas (GHG) emitter. The Short-Lived Pollutants (SLCPs) of methane, black carbon (BC), and tropospheric ozone are seen as a new indicator of pollutants which are forcers impacting the climate at a much greater/faster rate than the traditional GHGs. Global emissions databases, inventories, and models were used as sources to compile SLCP emissions for Bangladesh for the most recent years available, in addition to limited historic and future emissions analysis. This baseline assessment of SLCPs for Bangladesh shows that emissions of methane, BC, and ozone pre-cursor gasses have been increasing over the last decades, where the particular source sectors for each component are identified.

INTRODUCTION
Dhaka can be considered the mega-city with the world’s worst urban air quality [1]. A combination of numerous local emission sources in addition to special local and regional winter meteorological conditions gives the city exceedingly high air pollution concentrations throughout the year, and especially during the winter season [2, 3]. The exposure of the city’s estimated 15 million residents to this alarmingly poor air quality poses the greatest health risk of the top mega-cities in the world and demands attention [4], including immediate research and corresponding mitigation [2, 3]. The World Health Organization (WHO) estimates that up to 10,000 pre-mature deaths are associated with outdoor air pollution annually in Bangladesh [5].

While urban air quality is a major health issue at the local level in Bangladesh, there are also particular issues regarding local emissions impacting the global climate - Bangladesh is noted as one of the top 25% worst greenhouse gas (GHG) polluting countries in the world [6]. Recently, the Climate and Clean Air Coalition To Reduce Short-Lived Climate Pollutants initiative [7] was established between the U.S., Canada, Sweden, Mexico, Bangladesh, and Ghana to address the Short-lived climate pollutants (SLCP’s) which are impacting the global climate at the highest rate, and are now seen as more threatening forcers in the short term than just GHGs in general, or CO₂ alone [7, 8]. SLCPs include the main pollutants of methane (CH₄), Black Carbon (BC) and tropospheric ozone (O₃); in addition, hydrofluorocarbons (HFCs) can also be included as an SLCP threat [8].

The Malé Declaration compiled the first baseline emissions inventory specifically for Bangladesh with data up to 1998 [9]. Since this initial inventory, a comprehensive assessment or inventory of country-wide emissions for the suite of criteria pollutants is lacking, and no assessments have been made specifically for the new pollutant grouping of SLCPs and their corresponding emissions at the national level in Bangladesh. This paper will present an initial assessment and compilation of SLCPs, examining the sectors, sub-sectors, and activities making up these current and projected future atmospheric emissions for Bangladesh. The assessment for these emissions will be based on top-down regional and/or global emissions database sources, where multiple sources are necessary to cover the range of pollutants making up SLCPs.

MATERIALS AND METHODS
Various emissions database/inventory sources were utilized to compile the different pollutants examined in this assessment for Bangladesh: Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) [10, 11], Emissions Database for Global Atmospheric Research (EDGAR) [12, 13], Transport and Chemical Evolution over the Pacific (TRACE-P) [14], Intercontinental Chemical Transport Experiment B (INTEX-B) [15], Regional Emission Inventory in Asia (REAS) [16, 17], and Multi-Sensor Re-analysis of total ozone (MSR) [18, 19].

The GAINS South Asia model (Final Report, Baseline08 scenario) was utilized to compile methane emissions for the years 1990-2030 for Bangladesh, in addition to identifying the sectors and activities making up these emissions. EDGAR database (v4.0-4.2) was utilized to investigate and compile methane emissions for 1970-2008, and ozone pre-cursor emissions for 2008 in Bangladesh. TRACE-P/INTEX-B databases were utilized to investigate BC emissions in Bangladesh for 2000 and 2006 respectively. REAS inventory (v1.11) was utilized to compare methane, BC, and ozone pre-cursor emissions for Bangladesh and the region in 2000. MSR was used to investigate ozone data from 1978-2008 over Bangladesh and region.

RESULTS AND DISCUSSION
The primary components making up SLCPs (methane, BC, and ozone) will be examined for Bangladesh for the most recent data. Where possible, the activities making up these emissions will be identified, and projections up to 2030 estimated. Global methane emissions for 2008 (Fig. 1) show that Bangladesh is located in a region of relatively high emissions exceeding 500 tons per year per 0.1 degree grid cell shown. REAS shows similar distribution patterns as EDGAR for the Asian region.

Fig. 1. Global methane emissions for 2008 (Source: EDGAR v4.2)

The EDGAR database also reveals that methane emissions for Bangladesh have been variable each year from 1970-1990 (between 4.0-4.4 Mt CH₄/year), while from 1992-2008 emissions have steadily increased 15% during this period to over 4.6 Mt CH₄ in 2008. GAINS also shows a similar increase of approximately 15% for methane emissions for the similar overlapping period of 1990-2010, and also projects this increase to remain steady through 2030 with emissions of 5.0 Mt CH₄/year. The agricultural sector consistently makes up the vast majority (between 75-80%) of the increasing methane emissions from 1990-2030 in Bangladesh (Fig. 2). Emissions from the industrial sector are also increasing over time but at a rate which is consistently about 2.5 million tons/year less than the agricultural sector. Methane emissions from the other sectors of residential and traffic are very low in comparison as expected.

GAINS calculates that the sole activities of rice cultivation (1.8 Mt CH₄/year) and cattle (1.4 Mt CH₄/year) make up the agricultural sector emissions of methane for 2010 in Bangladesh,
in which this is 42% and 33% of the total methane emissions respectively for that year. EDGAR also shows rice cultivation as the greatest contributor to methane emissions in Bangladesh, which has decreased from approximately 3.2 Mt CH\textsubscript{4}/year in 1970 to 2.2 Mt CH\textsubscript{4}/year in 2008 for this single activity. EDGAR on the other hand shows that the next greatest contributing activities to methane emissions of cattle (enteric fermentation) and wastewater treatment are greatly increasing for the period 1970-2008 at approximately 30% and 130% respectively, with 2008 emissions for methane from cattle at 0.9 Mt CH\textsubscript{4}/year and for wastewater treatment at 0.7 Mt CH\textsubscript{4}/year. REAS data is not presented or compared to other data sets for methane because the values are up to a factor 1000 greater than the EDGAR and GAINS data presented, which possibly suggests data errors in REAS.

Asian BC emissions for 2006 (Fig. 3) shows Bangladesh is in a specific region with high BC emissions of 750 – over 1000 tons per year per 0.1 degree grid cell shown. This spatial representation from INTEX-B presents a similar distribution as other global BC distribution map found [20, 21] which shows that Bangladesh and the surrounding region has some of the highest BC emissions in the world. In addition, REAS Asian BC maps also show Bangladesh in a hot-spot region for Asia in 2000.

Fig. 3. Asian BC Emissions for 2006 (Source INTEX-B, 2007).

INTEX-B registers Bangladesh with 43.1 kt/year total BC emissions for 2006, increasing at approximately 10% from 39.1 kt/year for 2000 as found in TRACE-P. The sector distributions of the BC emissions for these two years (Fig. 4) show emissions from the industrial sector are surprisingly low (0.1 kt/year for 2000 and 2006). There are 3000+ brick kilns as BC sources which operate in the country, so it is assumed that these industrial sector emissions in INTEX-B are severely underestimated; doubts have been raised regarding the emission factors used for brick kilns in the INTEX-B database [22], which can explain part of this underestimation. REAS presents BC for Bangladesh at 67.1 kt/year for 2000, which is almost double the value presented in TRACE-P for the same year.

Fig. 4. BC Emissions for Bangladesh divided by Sector for 2000 and 2006; compiled using INTEX-B for 2006 data and Trace-P for 2000 data.

Global mean ozone values using monthly averages for 1978-2008 taken from MSR show that Bangladesh is located in an area of lesser ozone (as per indicated Dobson Units) than other areas around the globe (Fig. 5a). In addition, the anomaly map presented for the year 2008 (Fig. 5b) shows that Bangladesh experienced lesser ozone for this year (as indicated by approximately -5 Dobson Units) than the mean value of the previous 30 years. When looking closer in at Bangladesh in the South Asian region (Fig. 5c), it is apparent that the 30 year mean for ozone is slightly greater (at a range of approximately 5 Dobson Units) in the northern areas of the country closer to the Himalayas. During the year 2008, the anomaly map (Fig. 5d) shows ozone is slightly less overall for the country (at a range of approximately -2 to -4 Dobson Units) for this year in comparison to the mean value of the previous 30 years.

Global mean ozone values using monthly averages for 1978-2008 based on monthly mean values; compiled using EDGAR v4.2.

The primary pre-cursor gasses to ozone include carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), nitrogen oxides (NO\textsubscript{x}), and methane – these individual pollutants can be assessed as an indicator for possible ozone formation. To understand how Bangladesh is contributing to ozone levels, it can be valuable to examine the pre-cursor gas emissions as an indicator for the Bangladesh ozone contribution (Fig. 6). EDGAR indicates that all of these
gases have been increasing during the period 1970-2008, somewhat contradicting the MSR data that 2008 ozone values were lower than the mean of the data from 1978-2008. During this 30 year period, methane has increased approximately 10% where as previously indicated the primary contributor to these emissions are from the agricultural sector (rice and cattle); CO has increase 40% where a majority of these emissions are coming from the residential sector; NMVOCs have increased 70%, also coming from the residential sector; and NOx increased 200%, coming from transport and residential (including electricity production) sectors.

Table 1. Summary of SLCP emissions for Bangladesh.

<table>
<thead>
<tr>
<th>Component</th>
<th>Emissions</th>
<th>Contributing Sector</th>
<th>Global</th>
<th>Hot Spot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>Increasing</td>
<td>Agriculture</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>Increasing</td>
<td>Residential/Industrial</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Ozone</td>
<td>Increasing</td>
<td>Agriculture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methane</td>
<td>Increasing</td>
<td>Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>Increasing</td>
<td>NMVOCs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOX</td>
<td>Increasing</td>
<td>Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transport/Residential</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION

This paper presents an overview of the current SLCP emissions in Bangladesh, including historic value comparisons, and future emissions projections for select components. Bangladesh is in one of the most polluted regions (hot-spot) of the world for SLCPs of methane and BC in which each are increasing at the national level, in addition to the increase of ozone formation pre-cursor gasses, while Bangladesh is not necessarily located in a hot-spot for this pollutant (Table 1). Methane emissions have increased 15% from 1990-2010, and are expected to continue at this rate through 2030. A majority of these emissions are coming from the agricultural sector, primarily rice cultivation and cattle. BC emissions are increasing 10% between 2000 to 2006, in which sources used indicate the majority of these emissions are originating from the residential sector; dodt has been expressed regarding this sector distribution, in which the industrial sectors must contribute more than is being indicated. Emissions of ozone pre-cursor gasses have increased between 10-200% from 1970-2008, where the bulk of these emissions are originating in the residential and agricultural sectors.

ACKNOWLEDGMENT

The author would like to recognize Philipp Schneider (Research Scientist, NILU) for compiling the Ozone data from MSR, as well as Vo Thanh Dam (Engineer, NILU) for assistance with the INTEX-B/TRACE-P database. Appreciation is also given to Bjarnar Sivertsen (Associate Research Director, NILU) for support, and Cristina Guerreiro (Senior Research Scientist, NILU) for guidance and quality control. In addition the author would like to thank Dr. Md. Nasiruddin (Joint Secretary, Ministry of Environment and Forests in Bangladesh) for identifying the need for the assessment presented in this paper, and encouraging its completion.

REFERENCE

Valuing the Cost of Environmental Pollution: 
Case of Hazaribagh Area, Dhaka, Bangladesh

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ABSTRACT
When people choose to live in a place, many determinants act as influencing features. The environmental quality is one of those determinants that determine the quality of life. The fact that people are found living in a polluted area indicates that they avail other benefits. This flow of logic is used for the hedonic pricing method to calculate the environment quality. The Hazaribagh area is one of the worst polluted areas of the world. Rayer Bazar area, another area with almost equal socio-economic conditions considered as the control area for this research. In this research, among all the possible costs and benefits, differentials between the medical expenditure as a cost and the household expenditure as a benefit are evaluated. This research investigates the relationship between the environmental condition, the household expenditure and health related expenditures of the people living in these areas.

INTRODUCTION
Environment provides us all the life supporting elements and services in our everyday life. But this environment is being polluted in many ways. Among them, manmade pollution is a significant one. This pollution has emerged since 18th century’s industrial revolution.

While industrial growth is inevitable for the development of a country, a pollution free environment is also inevitable for a typical human life. In this regard, there must be a balance in between industrialization and clean environment for the overall development and a typical living standard of its inhabitants. But the failure to maintain this balance in Hazaribagh area, which is located in the capital city Dhaka in Bangladesh has placed it in the “World’s Worst Polluted Places” in 2006, ranked by Blacksmith Institute [1].

As a result of the extreme pollution, it has become very grim to live here. Even though, people live in Hazaribagh to avail some facilities like lower house rents and other living expenditures. But living in such a polluted area is cursed with different diseases in both short and long run. While trying to save living expenditures, people are being subjected to other health related expenditures. So, this research traces the rationale of living in Hazaribagh.

The economy and environment are highly interlinked. There are many links between these two systems. First, the environment provides the economic system with inputs of raw materials and energy resources, including minerals, metals, food and many others. Most of the time, these inputs are transformed into outputs by the economic system which consumers demand. Second, the economy uses the environment as a waste sink in the production system. Waste may also be produced from the consumption activities. Basic types of these wastes are: solid, air and water borne. But the environment has a limited capacity to absorb and transform into harmless substances. Third, the environment provides households with a direct source of amenity. Finally, the environment provides the basic life supporting services to the economic system [2].

In the context of Hazaribagh, the tannery industries using inputs from the nature to fulfill consumers demand by producing finished leather. While processing the raw leather, tanneries create many negative externalities including air and water pollution. These hazardous wastes have exceeded the nature’s assimilative capacity in Hazaribagh. As a result of this pollution environment has failed to provide any amenity values to its residents, rather it provides disturbances or sufferings. These sufferings come with expenditures.

Knowing all these sufferings and costs, people still prefer to live in such a polluted area, but why? For several decades this has been a burning question regarding Hazaribagh. Needless to say about hundreds of reports that have failed to clarify the reason and identify the impacts of living in this region.

This research tries to find out whether living in this area really generates any benefit for the dwellers or not. In other words, the main objective of this research is to find out the net gain or profit/benefit people achieve living in this area, if there is any. In this study, the living costs and benefits were compared with costs and benefits of living in another area which is free from tannery pollution and consists of other general characters of the targeted area Hazaribagh.

The study aims at addressing the following objectives: a) To evaluate the benefits that people achieve living in this area, b) To evaluate the costs they bear living in this area, and c) Finally, a comparative analysis of living in this area.

MATERIALS AND METHODS
A. Field Work and Research Methods
The research is quantitative in nature. Primary and secondary data were collected for supporting the analysis of the research.

a) Research area
Research areas are located in Hazaribagh thana1 and Rayer Bazar thana. These areas were preferred based on their environmental, socio-economic and security conditions. The pattern of the housing or infrastructural development was not unnoticed too. Number of tanneries located in Hazaribagh area made this the first choice as one of our fields of research. Selection of the second area or the control area, Rayer Bazar was based on the prevailing socio-economic condition that we found matches with Hazaribagh most and the environmental condition that differs from the prevailing scenario of Hazaribagh.

b) Primary data
For primary data, 50 households were selected from each area of interest. Based on the structure of the buildings interviewed households can be categorized in 4 categories. These categories are Kacha, Semi Pucca, Pucca2, Multi Storied. Respondents were interviewed with a semi-structured questionnaire so that they can add their comments if necessary.
c) Secondary data

Information from newspaper articles, books, journals, periodicals, project reports, NGO reports and government reports including census reports were used as the source of secondary data for the analysis of this study.

B. Methodology

After collecting primary and secondary data from fields and different sources, data were rigorously analyzed and interpreted. This research, being quantitative in nature demanded use of several statistical tools and methods for achieving the result and to be able to come to a conclusion and predict for further policy purposes.

C. Methods to Evaluate Environmental Pollution

There are several scientific ways to estimate or evaluate prevailing standards in an area. The techniques available for valuing the environmental goods and services can be categorized into revealed preference and stated preference approaches. Revealed preference techniques rely on observations of actual market behaviors of the actors for evaluating them. This approach observes the behavioral changes with the change of the environmental condition as they assume the fact that some marketed goods are bundles of characteristics [3]. These techniques are chosen when peoples’ acts reflect the condition of the environment. The most practised revealed preference techniques are travel cost method (TCM) and the hedonic pricing method (HPM).

For the analysis of the acquired data, different statistical tools (mean, standard deviation, t-test) were used. For the house rent and health cost comparisons, mean of the collected data were used. Then the rent and health cost differentials were obtained and further compared to revile the benefit or costs appear to the residents of Hazaribagh.

The framework for the analysis is

![Fig. 2. Economic Valuation Methods](image)

The framework for valuing the cost of Environmental pollution in hazaribagh.

Here “X” is assumed as the control area. Rayer Bazar is the control area in this study.

RESULTS AND DISCUSSION

A. Choice of Living

It is coherent that only occupational preference cannot explain people’s choice of living. There are other factors influencing the choice of housing for the individuals. The most viable reasons influencing people’s choice of the area of living are observed by the authors. Most of the time their behavior is subjective to the distance of the workplace, schools of their children, low housing cost and low living cost. Another major influencing agent is the paternal property location.

To the utmost surprise, we found that only about 2% people chose Hazaribagh as they believed to have low living cost, 10% for availing low housing cost while 24% and 8% people live in Rayer Bazar to avail the low living scopes and low housing opportunities respectively. 32% of the surveyed inhabitants of Hazaribagh inherited their property and only 20 inhabitants of Rayer Bazar are found living on inherited property. But, almost half of the people (46%) living at surveyed area Gozmahal, Hazaribagh prefers to avail minimum distance to their workplace and choose to live there. In contrast to this situation, 32% people living in Rayer Bazar prefer to aim for their nearer workplaces.

Data collected by the researchers also represents the rationale of the responses by the interviewees. Respondents inherited their property started living in Hazaribagh since the early years of independence of Bangladesh, in contrast to the case of Rayer Bazar where people inherit property since the middle of 1980s.

A visible degradation of environmental condition in Hazaribagh is represented by the two charts above. 10% of the respondents believe the housing price prevailing in Hazaribagh

![Fig. 4. Rational for choosing specific region for living](image)

![Fig. 5. Choice and years of living in an area](image)
is low and the second chart shows that this portion of inhabitants living in Hazaribagh for not more than 1 year. And this decreasing housing cost represents high degradation of environment in Hazaribagh within last few years.

The argument above is clearly proved in the following chart.

![Years of living by causes of living](image)

**B. Infrastructure and the Rent causal Relationship**

![Age of Building by Structure](image)

The Table 2 shows the group statistics of the 100 household surveyed on ground. The information it comprises is very much vital for understanding the research. The variables REN_YR represents rent per square feet for each of the households per year, and MED_EXP represents medical expenditures of each household in the last year. The statistics represents that, only 38 households live in rental houses in Hazaribagh, and rests are the permanent residents. While, in Rayer Bazar, 44 households live in rental basis. The mean rent per square feet per household in 235.59 ± 19.55 taka in Hazaribagh and 298.64 ± 19.70 taka in Rayer Bazar.

<table>
<thead>
<tr>
<th>THANA</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>REN_YR_Hazaribagh</td>
<td>38</td>
<td>235.58</td>
<td>120.50</td>
<td>19.54</td>
<td></td>
</tr>
<tr>
<td>REN_YR_Rayer Bazar</td>
<td>44</td>
<td>298.63</td>
<td>130.68</td>
<td>19.70</td>
<td></td>
</tr>
<tr>
<td>MED_EXP_Hazaribagh</td>
<td>42</td>
<td>14911.19</td>
<td>27377.89</td>
<td>4224.50</td>
<td></td>
</tr>
<tr>
<td>MED_EXP_Rayer Bazar</td>
<td>33</td>
<td>12536.36</td>
<td>17998.58</td>
<td>3133.15</td>
<td></td>
</tr>
</tbody>
</table>

In terms of sick reports, 42 households in Hazaribagh reported at least one of their members being sick, and 33 households responded from Rayer Bazar in this context. Mean medical expenditure per year per household in Hazaribagh is 14911.20 ± 4224.5 taka and in Rayer Bazar 12536.36 ± 3133.1 taka.

This research found that the prevalence of different diseases in Hazaribagh is considerably higher in contrast to Rayer Bazar. In Hazaribagh, more than 52% households suffered from diseases more than 1, while in Rayer Bazar only 22% household had diseases more than 1 last year.

<table>
<thead>
<tr>
<th>Area</th>
<th>% of households suffering more than 1 disease last year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazaribagh</td>
<td>56%</td>
</tr>
<tr>
<td>Rayer Bazar</td>
<td>22%</td>
</tr>
</tbody>
</table>

These are the observations and findings the authors found from the research fields.

While there is environmental pollution caused by the tanneries, these are also providing more income generating opportunities. This availability of income generating activities pull in people from different regions and areas. Thus, the increased demand of living in this area creates higher demand for housing and the price of housing goes up. Even than the present cost of housing significantly differs from the housing cost of Rayer Bazar. But the expenditure of health cost does not differ significantly. Although the prevalence of diseases in Hazaribagh differs highly, it is seen as insignificant one, representing no relation between environmental pollution and health purpose expenditures. Due to a very high variance in the medical expenditure of the residents of these areas may be a reason behind this representation.

**CONCLUSION**

Housing property valuation is the most used and relied method for valuing the environmental pollution. In our country, housing market structure is not like other countries. So, instead of using housing price, we used the rent of houses based on their area. Rent of these houses highly depend on the structure and most importantly in Hazaribagh, the rent of houses highly decline over time. This represents high damage of building structure by the tannery pollutants.

In terms of health, people living in Hazaribagh are having many different health related problems. Some of the
inhabitants lost their limbs permanently like kidney, eye etc. Some of them are suffering from chronic diseases. Most of the people have a regular headache, fever and other dermatological diseases. 15% of the respondent of Hazaribagh found suffered from yellow fever last year. But in Rayer Bazar, these diseases are less severe and less people are affected from those diseases.

At the beginning of the research, from the literature reviews and understanding the rational human behavior it seemed that peoples’ choice of living is mostly influenced by the lower cost of living or lower cost of housing. While researching, it has come to the our attention that motivation behind living in such a polluted area is not the low living cost or lower housing cost, rather the availability of income generation activities, inheritance is the major factor motivating to live people here. Living in this area also allows them to pay more attention to their occupation minimizing their transportation cost and travelling time. This phenomenon is also supported and found viable in this research. As a result of paying more attention to works regarding tanneries, people are more exposed to the pollutants and wastes. Life is becoming a threat for them silently. Finally a noticeable verse from a newspaper article should be noted: “It is their (tannery industries) living which is causing our death; we need foreign currency from exports of tannery items alright, but by no way should it be at the cost of lives and the environment.”

ACKNOWLEDGMENT

For the successful completion of this research we must show our gratitude to Professor Mahbub Ullah. We are very lucky to have the chance to work under his close supervision. We must address our heartiest gratitude to Hasina Begum for supporting us in all the ways possible for successful completion of this research. We must mention our gratitude to Dr. Mahfuzul Haque, Sharif Abdul Wahab, Ruhun Wasata, Tasfi Salsabil, Abdul Hamid, Shahriar Tonmoy, Jubayer Ahmed, Sayeed Islam who helped us whole heartedly in collecting data from the research fields. We are grateful to Motia Israt Janah, A.B.M. Abul Hasnat Mollah and finally Touhida Khan Khushbu, for valuable comments and recommendations regarding the research work.

REFERENCE


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1 Thana is a unit of police administration. In 1792 by the government of the Bengal Presidency, the district magistrates were asked to divide their respective districts into police jurisdictions called ‘thana’. Initially, a thana was purely a police jurisdiction. After 1982, each thana was upgraded into a upazila (sub-district). The upazila system has since 1999 been revived. There are now 496 thanas in the country including those in metropolitan police jurisdictions. With the creation of circle system, particularly after 1961, thana became the main centre of development activities with most of the development departments of the provincial government having their own functionaries at that level.

2 Kacha house refers to houses constructed with bamboo, wood, tin and other vulnerable partitions, Semi pacca house refers to the houses constructed with concrete partitions and walls but roof made of vulnerable or weak materials and finally Pacca house refers to single storied houses that consists of concrete partitions, walls and roof too.

3 Last year represents a year (September 2010 to September 2011) before the research was conducted.
Factors Affecting Adoption of Compressed Natural Gas (CNG) Vehicle in Bangladesh - An Application of Bass Model

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ABSTRACT

Environment friendly products have been widely accepted by the people not only in developed countries but also in developing countries. There are certain reasons for adoptions. In this paper diffusion model used to see the factors affecting in CNG conversion vehicle in Bangladesh. The study finds out both imitation and innovation effect has evident in adoption of CNG vehicle. From economic to social reasons are influenced people to adopt CNG conversion vehicle. High imitation effect with high impact of word of mouth clearly increased this adoption rate. Environment friendliness, ease of use, price competitiveness and adaptive with lifestyle are some of the major reasons behind the adoption as well.

INTRODUCTION

Adoption studies not only highlight the past phenomena rather many cases it shows the future direction. This paper mainly used data from Bangladesh to check the adoption of CNG vehicle and influencing factors as a general. But more specifically some influencing factors of CNG adoption can relate to the relevant other industry in a more dynamic fashion by which we can give some policy recommendations for these area. In this regard, this paper used basic view point of Diffusion of Innovation (DOI) model given by [1]. Later the paper will discuss about the findings from application context.

Bangladesh has natural gas resources and the country start using it as alternative vehicular fuel called Compressed Natural Gas (CNG). Earlier people got a wrong idea or myth about CNG about its safety issues and the storage cylinder is occupying the space etc. In fact the cylinder using in CNG as storage is looks like ammunition and general people got the wrong idea by seeing a cylinder. Later, by the awareness program of government and private organization people perception changed and adoption boomed. Now people find a cylinder as a friend sitting inside the vehicle saving his/her money and help the environment of the country.

Bangladesh has experiencing high rate of growth in CNG. At this stage total numbers of CNG vehicle users are 175499 in the year 2012 which reflect more than 30 % of the total vehicle. From 2000 and onwards market was open for various competitors and within a short time, it reached to a high rate of adoption. This adoption phenomenon inspired us to investigate the reasons behind it.

LITERATURE REVIEW

The product life cycle is always treated as an important aspect for understanding current state and future trend. In past literature concept of imitation has been revealed as a notion of imitating innovation effect, this paper Diffusion of Innovation (DOI) model used to see the factors affecting in CNG conversion vehicle in Bangladesh. The study finds out both imitation and innovation effect has evident in adoption of CNG vehicle. From economic to social reasons are influenced people to adopt CNG conversion vehicle. High imitation effect with high impact of word of mouth clearly increased this adoption rate. Environment friendliness, ease of use, price competitiveness and adaptive with lifestyle are some of the major reasons behind the adoption as well.

RESULTS AND DISCUSSION

The following result (Table 1 and Fig. 1) focuses the impact of innovation and imitation parameter which clearly shows high imitation effect exits in Bangladesh.

<table>
<thead>
<tr>
<th>Adopters in Bangladesh</th>
<th>Innovation Effect (p)</th>
<th>Imitation Effect (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNG (2003-2009)</td>
<td>0.001007***</td>
<td>0.607500***</td>
</tr>
</tbody>
</table>

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 1

Number of iterations to convergence: 11

A. Imitation Effect:

Usefulness: there are certain aspect first of all eco friendliness; Improvements have been seen in air quality in Dhaka city (capital of Bangladesh) through the increased use of CNG operated vehicles. The Department of Environment has measured decreases in the amount of particulate matter (PM10) following the implementation of the CNG project. Research had shown that CNG operated cars for instance emit around 10-20% less carbon dioxide up to 25% less nitrous oxide and 80% or less Carbon mono oxide, non-methane
hydrocarbons and other smog forming emissions in comparison gasoline car used in Bangladesh. Diesel contains Sulfur component and produces SO2 which cause acid rain, but the processed natural gas in Bangladesh is Sulfur free.

**Economic savings**: CNG and octane tariff are taka 30 /m3 and Taka 94/Litre respectively(1 litre octane equivalent 0.81 m3 of CNG).So a litre octane equivalent of CNG cost taka 24.3, that means 69.7 taka savings on per litre fuel consumption.

**Indirect benefits**: Since the fuel cost is cheap in CNG so the overall transportation cost is low. So it got an impact on the people to spend more money on their own necessities. Consumer and other goods prices has positive impact which has a direct relation with transportation cost.

**Ease of use**: CNG is a natural resource of Bangladesh, so as alternative fuel CNG is available within most of the major area of the country. There are 556 no of CNG filling station in Bangladesh to serve the 203,587CNG running vehicles. There are 180 CNG conversion workshop & servicing center in Bangladesh. A private car can run 50-60 km by one filling (considering a 60 ltr. cylinder and a 1500 cc car). These are indicating the reasons for adoption.

**Self efficacy**: People of Bangladesh also find CNG vehicle more worthy while examining it from the self efficacy context. Users have positive views regarding ecological aspect and economical aspect which helps to develop this positive view.

**B. Imitation Effect**:

**Subjective norm**: There are certain key role players who are acting as a catalyst for high rate of adoption. In Bangladesh taking decision by consulting others is quite a common practice and many cases people get the positive sides of CNG conversion.

**Word of Mouth**: There are 3 million people are directly related with CNG and enjoying its benefits (here we include vehicle user, people in CNG station, people in CNG conversion center, people in CNG related company both in govt. & private). These people are spreading the word CNG on their surroundings. The people who got its direct benefits they become the campaigner of CNG.

**CONCLUSION**

As developing country Bangladesh has enormous opportunities to capitalize the benefits of CNG. CNG has changed the everyday routine of people in Bangladesh. So, both Government and private relevant organizations should be focused on CNG and its regulatory issues. At this stage the industry facing almost growth stage so intensive competition is exists. So both innovation effect and imitation effect can be examined further to explore market nourishment and ensuring environment in a greater context.

**REFERENCE**

Polycyclic aromatic hydrocarbons in sediments of Love River, Taiwan
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ABSTRACT
The distribution, sources, and potential biological effects of 16 priority polycyclic aromatic hydrocarbons (PAHs) of the surfaces sediments, collected from ten sampling sites in Love River basin, Taiwan, were investigated by gas chromatography/mass spectrometry (GC/MS). The total concentrations of 16 priority PAHs ranged from 240 to 1,008 ng/g dry weight (dw) with a mean concentration of 633±312 ng/g dw. Base on the total concentrations of PAHs, sediments from Love River were moderately contaminated. Diagnostic ratios showed that the possible source of PAHs in the Love River could be a mixture of pyrolytic and petrogenic with a major pyrolytic predominance. The toxic equivalent concentrations (TEQcarc) of PAHs varied from 22 to 133 ng TEQ/g dw, with an average of 71±24 ng TEQ/g dw. As compared with the US Sediment Quality Guidelines (SQGs), the observed levels of PAHs at most studied sites in Love River should not exert adverse biological effects. Although at some sites the fluorene may exceed the effects range low (ERL), individual PAHs did not exceed the effects range medium (ERM). The results indicated that sediments in Love River should have potential biological impact, but should have no impairment. Because only one time was analyzed in this study, more work is needed to confirm the sources and toxicity of PAHs in Love River.

INTRODUCTION
Kaohsiung City is the largest industrial city in Taiwan with 2.2 million residents. Love River is 16 km long with watershed of 62 km² that covers about 40% of total Kaohsiung City. Originated near Tsa-Gong irrigation channel, Love River flows through the downtown area of Kaohsiung City and is finally discharged into Kaohsiung Harbor (Fig. 1). During earlier years, Kaohsiung City lack of sanitary sewer system causes un-treated raw wastewater to be discharged directed into adjacent water bodies that leads to serious deterioration of river water quality. Although in recent years, Kaohsiung City actively promotes the construction of wastewater collection and treatment systems, in 2009, the wastewater system only serves 56% of the city in 2009 [1]. Additionally, Kaohsiung City also actively involves in public projects on renovating rivers (e.g. Love River) by constructing river intercepting stations near the middle section of the river to divert the upstream polluted river water to a wastewater treatment for alleviating the downstream pollution problem. However, during the wet season, the river water intercepting gate is opened for by-passing the sudden surge of river flow brought over by storms that will discharge the upstream pollutants to downstream sections. Regions along Love River have dense population with prosperous business and industrial establishments. The major pollution source includes domestic wastewater discharges, industrial wastewater discharges (e.g. paint and dye, chemical production, metal processing, electronic and foundry), shipping, municipal surface runoff, and transportation pollution [2]. All the pollutants will eventually be accumulated in the bottom sediment.

MATERIALS AND METHODS
Surface sediment samples were collected at ten stations along the Love River (Fig. 1) in October, 2011 with Ekman Dredge Grab. Immediately after collection, the samples were scooped into glass bottles, which have been pre-washed with n-hexane and kept in an icebox, and then transported to the laboratory for analysis. In the laboratory, the samples were freeze-dried for 72 h, ground to pass through an 0.5 mm sieve and fully homogenized [5]. The dried sediments were placed at -20°C in pre-washed with n-hexane amber glass bottles covered with solvent-rinsed aluminum foil until further processing and analysis.

Particle size was determined with Coulter LS Particle Size Analyzer. Organic matter (OM) was analyzed according to Standard Methods 209F [6]. PAHs [e.g., naphthalene (NA), 2-methylnaphthalene (2-MP), acenaphthylene (ACE), acenaphthene (AC), fluorene (FL), phenanthrene (PH), anthracene (AN), fluoranthene (FLU), pyrene (PY), benzo[a]anthracene (BaA), chrysene (CH), benzo[b]fluoranthene (BbF), benzo[k]fluoranthene (BkF), benzo[a]pyrene (BaP), indeno[1,2,3-cd]pyrene (IP), dibenzo[a,h]anthracene (DBA), and benzo[g,h,i]perylene (BghiP)] were analyzed following the methods described in Chen and Chen [7].

RESULTS AND DISCUSSION
A. Concentrations of PAHs in Sediments
The grain size (sand, silt, and clay) distribution and OM content in sediment samples are shown in Table 1. Results from the grain size analysis indicate that the sediments were mainly sandy silts. The fine particle property of the sediments would cause the significant sorption effect on PAHs. Results from Table 1 indicate that higher OM (up to 23.5%) was
observed in sediment samples. The high organic contents of the sediment indicate that the accumulation of organics would cause the significant variations in sediment properties. The organic abundant characteristic of the sediment would cause the decrease in oxygen measurement in sediments, and thus, the sediments would be reduced to anaerobic conditions.

Table 1. Grain size and OM contents in surface sediments of Love River

<table>
<thead>
<tr>
<th>Station</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>OM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Hou-Gang Bridge</td>
<td>8.3</td>
<td>84.9</td>
<td>6.8</td>
<td>4.2</td>
</tr>
<tr>
<td>L2 Cai-Jin Bridge</td>
<td>78.3</td>
<td>20.2</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>L3 Ding-Sin Bridge</td>
<td>10.9</td>
<td>85.2</td>
<td>3.8</td>
<td>23.5</td>
</tr>
<tr>
<td>L4 Long-Hua Bridge</td>
<td>0.0</td>
<td>90.9</td>
<td>9.1</td>
<td>10.2</td>
</tr>
<tr>
<td>L5 Long-Xin Bridge</td>
<td>0.0</td>
<td>92.4</td>
<td>7.6</td>
<td>2.5</td>
</tr>
<tr>
<td>L6 Chi-Ping Bridge</td>
<td>0.0</td>
<td>87.6</td>
<td>12.4</td>
<td>8.8</td>
</tr>
<tr>
<td>L7 Zhong-Da Bridge</td>
<td>87.8</td>
<td>11.4</td>
<td>0.8</td>
<td>2.6</td>
</tr>
<tr>
<td>L8 Chien-Kuo Bridge</td>
<td>0.0</td>
<td>91.7</td>
<td>8.3</td>
<td>1.5</td>
</tr>
<tr>
<td>L9 Chi-Hsiea Bridge</td>
<td>0.0</td>
<td>86.5</td>
<td>13.5</td>
<td>6.6</td>
</tr>
<tr>
<td>L10 Kaolinsiu Bridge</td>
<td>0.0</td>
<td>92.4</td>
<td>7.6</td>
<td>10.3</td>
</tr>
</tbody>
</table>

The PAHs concentrations in sediments collected at different sites are given in Table 2. The total amount of PAHs (ΣPAHs) varied from 240 to 1,008 ng/g dw, with a mean concentration of 633±112 ng/g dw. The sediment in Stations L1, L2, L3, L4, and L7 have lower concentrations of ΣPAHs (290±59 ng/g dw) than other stations (862±125 ng/g dw). Based on the pollutant levels suggested by Baumard et al (1998): (a) low, 0 to 100 ng/g; (b) moderate, 100 to 1,000 ng/g; (c) high, 1,000 to 5,000 ng/g; and (d) very high, >5,000 ng/g, the PAHs levels in sediments may be classified as high for Stations L3 (Ding-Sin Bridge), moderate for the other stations.

In this study, Pearson correlations of the particle size, OM, and ΣPAHs concentration in sediment of Love River were examined. The results show that linear regression analyses show that the ΣPAHs is obviously a significant correlated to OM (r = 0.760; p<0.05), but not to particle size (p>0.05) for all sediment samples. The results suggest that organic matter played important roles in controlling the PAHs distribution in sediments [5].

B. Composition and Source of PAHs in Love River

According to the number of aromatic rings, the 16 PAHs were divided into three groups: (a) 2- & 3-ring, (b) 4-ring, and (c) 5- & 6-ring PAHs. The percentage compositions are 33.4 to 51.3% for 4-ring, 20.1 to 46.7% for 5- & 6-ring, and 15.0 to 35.5% for 2- & 3-ring. The 4-ring or 5- & 6-ring PAHs are the predominant PAHs congeners in the sediments collected from all locations. These results suggest that the PAH contamination in Love River comes essentially from an identical source and is indicative of a pyrolytic origin.

In general, characterized by predominance of parent compounds with four or more aromatic rings, pyrolytic PAHs are derived during combustion. In contrast, petrogenic PAHs (from petroleum and its products) contain only two or three aromatic ring compounds. Therefore, a ratio of low (2- & 3-ring) to high (4- to 6-ring) PAHs has been used to identify pyrogenic (<1) and petrogenic (>1) sources of PAHs in sediments [7–8]. In all Love River stations, the ratios of Σ2PAHs/Σ6PAHs were in the range of 0.18–0.55 (Table 3), indicating they originated from pyrogenic sources.

In addition, several PAHs isomeric ratios have been used to identify different sources that contribute PAHs to environmental samples [9–14]. The common ratios used to identify different sources of PAHs for sediment samples include AN/(PH + AN), FLU/(FLU + PY), BaA/(BaA+CH), and IP/(IP+BP) [7, 11–12, 15–17], as summarized in Table 3. The ratios of AN/(PH + AN) in the surface sediments form Love River were 0.54±0.09 (range 0.41–0.66), clearly suggest that a pyrogenic source could be possible source of PAHs. The ratios of FLU/(FLU + PY), BaA/(BaA+CH), and IP/(IP+BP), with values of 0.58±0.29 (range 0.29–0.94), 0.42±0.19 (range 0.13–0.76), and 0.54±0.18 (range 0.14–0.75), respectively, can be concluded that PAHs input to Love River mainly originated from domestic biomass burning and fossil fuel combustion. Some petrogenic characteristics were also found in the sediments. Results from the ratio calculations suggest that PAHs input to the Love River mainly came from domestic combustion-related activities.

C. Sediment Biological Effects Based on PAHs

A widely used sediment toxicity screening guideline of the US National Oceanic and Atmospheric Administration provides two target values to estimate potential biological effects: effects range low (ERL) and effect range median (ERM) [18]. The guideline was developed by comparing various sediment toxicity responses of marine organisms or communities with observed PAHs concentrations in sediments. These two values delineate three concentration ranges for each particular chemical. When the concentration is below the ERL, it indicates that the biological effect is rare. If concentration equals to or greater than the ERL but below the ERM, it indicates that a biological effect would occur occasionally. Concentrations at or above the ERM indicate that a negative biological effect would frequently occur.

Table 2 shows the measured concentrations of PAHs in comparison with the ERM and ERL values. Among the 10 sediment samples collected, the Σ2PAHs, Σ3PAHs, and Σ6PAHs were below the ERL. For an individual PAH, FL was above ERL but below ERM in stations L3, L4, L6, and L8–L10, which indicate that biological effects would occur occasionally. The results indicated that sediments in all sites should have potential biological impact, but should have no impairment.

Table 2. PAHs concentration (ng/g dw) in surface sediments of Love River

<table>
<thead>
<tr>
<th>Station</th>
<th>Σ2PAHs</th>
<th>Σ3PAHs</th>
<th>Σ6PAHs</th>
<th>Σ16PAHs</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Hou-Gang Bridge</td>
<td>13</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L2 Cai-Jin Bridge</td>
<td>14</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L3 Ding-Sin Bridge</td>
<td>15</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L4 Long-Hua Bridge</td>
<td>16</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L5 Long-Xin Bridge</td>
<td>17</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L6 Chi-Ping Bridge</td>
<td>18</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L7 Zhong-Da Bridge</td>
<td>19</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L8 Chien-Kuo Bridge</td>
<td>20</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L9 Chi-Hsiea Bridge</td>
<td>21</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>L10 Kaolinsiu Bridge</td>
<td>22</td>
<td>40</td>
<td>100</td>
<td>200</td>
</tr>
</tbody>
</table>

ERL* 160 44 16 19 240 85.3 600 665 261 384 430 63.4 525 1700 4022
ERM* 2100 640 500 1540 1100 5100 2600 1600 2800 1600 2600 3160 9600 44792

*ΣPAHs: sum of NA, ACE, AC, FL, PH, and AN; Σ2PAHs: sum of FLU, PY, BaA, CH, BbF, BkF, BaP, DA, IP, and BP; Σ6PAHs: sum of 16 PAHs; ERL and ERM refers to the effects range low and median [18].
D. Sediment Potential Toxicity Based on CPAHs

The assessment of sediment toxicity in this study was performed based on the total concentration of potentially carcinogenic PAHs (i.e., BaA, CH, BbF, BkF, BaP, IP, and DBA), ΣCPAHs [7, 17, 19–20]. The ΣCPAHs concentration varied from 72 to 510 ng/g dw, with a mean concentration of 267±165 ng/g dw. The ΣCPAHs accounted for 30 to 51% of ΣPAHs in sediments of Love River.

Table 3. Characteristic PAHs molecular diagnostic ratios

<table>
<thead>
<tr>
<th>PAHs</th>
<th>Petrogenic</th>
<th>Pyrogenic</th>
<th>Biomass combustion (grass, wood &amp; coal)</th>
<th>Fossil fuel combustion</th>
<th>Results from the present work</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΣLPAHs/ΣHPAHs</td>
<td>&gt;1</td>
<td>&lt;1</td>
<td>–</td>
<td>–</td>
<td>0.34±13 (0.18-0.55)</td>
</tr>
<tr>
<td>AN/(AN+PH)</td>
<td>&lt;0.1</td>
<td>&gt;0.1</td>
<td>–</td>
<td>–</td>
<td>0.54±0.09 (0.41-0.66)</td>
</tr>
<tr>
<td>FLU/(FLU+PY)</td>
<td>&gt;0.4</td>
<td>&lt;0.4</td>
<td>&gt;0.5</td>
<td>0.4-0.5</td>
<td>0.58±0.29 (0.28-0.94)</td>
</tr>
<tr>
<td>BaA/(BaA+CH)</td>
<td>&lt;0.2</td>
<td>&gt;0.2</td>
<td>0.2-0.35</td>
<td>&gt;0.35</td>
<td>0.42±0.19 (0.13-0.76)</td>
</tr>
</tbody>
</table>

The potential toxicity of sediment was evaluated using the total toxic BaP equivalent (TEQ*) [17, 19–20]. The TEQ* for all CPAHs was calculated using the following equation: 

\[ \text{TEQ}^* = \Sigma \text{CPAH} \times \text{TEQ}_{\text{BaP}} \]

where TEQ* is the toxic factor of carcinogenic PAHs relative to BaP. Among the most potentially carcinogenic PAHs, BaP is the only PAHs for which toxicological data are sufficient for derivation of a carcinogenic potency factor [21]. According to US EPA [3], TEF for BaA, CH, BbF, BkF, BaP, IP, and DBA are 0.1, 0.01, 0.1, 0.01, 1, 1, 0.1, and 1, respectively. In this study, the total TEQ* values of sediment samples varied from 22 to 133 ng TEQ/g dw, with the mean value of 71±42 ng TEQ/g dw. These values were similar to those of surface sediments from Huaihe River, China [22] but lower than other literature-reported sites, such as surface sediments of Kaohsiung Harbor, Taiwan [7], Naples harbor, Italy [23], and Meiliang Bay, China [17]. Among different CPAHs, contribution to the total TEQ* decreased in the following order: BaP (73.4%), BbF (7.5%), DA (6.5%), IP (6.5%), BaA (5.4%), BkF (0.39%), and CH (0.06%).

CONCLUSION

The 16 priority PAHs in the surface sediment samples collected from various locations in Love River, and their possible sources and potential toxicological significance have been identified. The ΣPAHs concentrations in sediments ranged from 240 to 1,008 ng/g dw with a mean concentration of 633±132 ng/g dw. Base on the total concentrations of PAHs, sediments from Love River were moderately contaminated. The possible source of PAHs in Love River could be biomass burning and fossil fuel combustion. From an ecotoxicological point of view, potential adverse biologic impact is probable for FL in the study sites. Because only one time was analyzed in this study, more work is needed to confirm the sources and toxicity of PAHs in Love River.

REFERENCE