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ENVIRONMENTAL POLLUTION AND ITS CONTROL IN DHAKA, BANGLADESH : IMPLICATIONS OF URBANIZATION

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Abstract

Environmental pollution regarding urbanization is a great concern in the urban centers of many developing countries all over the world. Dhaka, the capital of Bangladesh, is growing very fast due to high influx of people from rural areas. The rapid expansion of Dhaka's population has brought tremendous pressures on its infrastructure as well as on the existing provisions for sound management of the environment, resulting in severe environmental pollution. The current urbanization trend of Dhaka would trigger the opportunities leading to further growth and development. The projected urban development of Dhaka resulting in increased influx of people, growth of infrastructural organization and investments would be accompanied by problems with magnitude and dimensions leading to expansion of environmental risks and hazards. This article evaluates the situation of environmental pollution in Dhaka associated with urbanization and finds severe environmental degradation in Dhaka. Some potential measures to control the arising environmental pollution are recommended. The Government's regulatory/legislative policy and framework regarding environmental protection is also evaluated and suggestions have been made in this regard. Finally, the article argues that time is running out for tackling Dhaka's environmental problems and call for urgent action.

KEYWORDS: *Developing country, Dhaka, Urbanization, Environmental pollution, Pollution control.*

1. Introduction

Environmental problems have become a common concern for all mankind, spanning those close to daily life to those of global proportions with a time frame that extends from the present to future generations. The roots of these problems mainly lie in the economic activities and lifestyle patterns of human community.

Economic development is essential for a developing country like Bangladesh. Therefore, the development plans and programmes should pursue sustainable growth to alleviate wide spread poverty in the country. Unfortunately, economic activities are closely linked with the various types of damages to the environment. Environmental damage threats not only the development process but also the safety of human beings and other living things. Bangladesh

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has experienced unimpeded growth of population and economy in the last couple of decades. Too often in the past, development strategies and programmes (including a wide range of donor-funded projects) have pursued economic growth without fully appreciating or acknowledging the costs to the environment. As a result, like many developing nations, the country is suffering from growing environmental problem (UNDP, 1995).

Today, more than forty percent of the world's population live in urban areas and this figure is estimated to reach sixty percent by the year 2025. Urban areas throughout the world, especially in developing countries, are facing various environmental problems such as grave air and water pollution. Thus sustainable development, which leads to construct of healthy and safe urban environment without excess loading to global environment, of these urban centers will be very important issue. A milestone was achieved at the Rio Earth Summit when cities were successful in broadening the environmental debate to focus attention on urban priorities. There was broad-based agreement that the developing world's growing urban populations and environmental problems need attention. Dhaka, the capital of Bangladesh, having a population of about 9 million, about 20,000 persons per sq.km, is one of the biggest cities of the developing countries. The rapid expansion of Dhaka's population has brought severe pressures on its infrastructure as well as on the existing provisions for sound management of the environment, resulting severe air pollution, water pollution, poor sanitation and unhygienic waste management.

There exist a limited number of studies on the environmental problems in Dhaka, but those studies were only concentrated on the very specific issue of the environmental pollution and did not analyzed from urbanization point of view such as Azad and Kitada (1996), Kitada and Azad (1997) studied the SO_2 and NO_2 pollution in Dhaka, Rahman (1993) studied the waste management in Dhaka. This article examines the nature and magnitude of environmental pollution associated with urbanization in Dhaka. The potential actions needed to tackle the arising environmental pollution are suggested. The Government's regulatory/legislative policy and framework is also analyzed and discussed. This study would be helpful to understand the overall environmental situation in Dhaka and to take necessary steps to save Dhaka from severe environmental degradation.

2. Urbanization and its Effects on the Environment of Dhaka

Dhaka (latitude $23°43'$ N and longitude $90°24'$ E), is in the middle of Bangladesh (latitude $20°34'$ to $26°38'$ N, longitude $88°01'$ to $92°41'$ E), a country which lies in the eastern part of south Asia. Dhaka, located in flat plain with no mountain, is surrounded by rivers at all sides and is the center of commerce and industry in Bangladesh. Dhaka enjoys generally a sub-tropical monsoon climate.

Dhaka has a long history as a regional capital due to its strategic and commercial position at the head of the Bay of Bengal at a point on the river Buriganga. As a "Muslin Village" about 400 years ago in the pre-Mughal period Dhaka was restricted to an area of 1.5 km^2 at the junction of the river Buriganga and the Dholai khal (river). Dhaka became the capital of the Mughal viceroys at the beginning of the 17th century, and a center for their expansion of overland and maritime trade. With the decline of Mughal power in the 18th century began the period of the British Raj (1764 - 1947). Dhaka became the capital of the East Bengal and Assam Province in 1905. After the partition of India in 1947 Dhaka became the capital

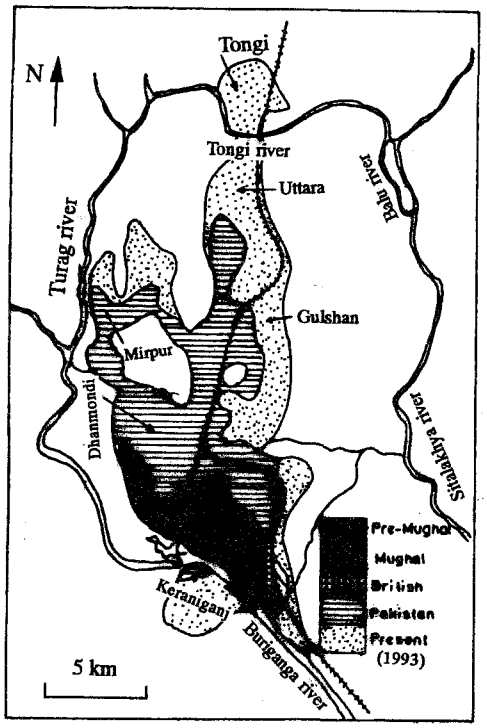


Figure 1. Dhaka city : Expansion over time (Source: Mamoon, 1993).

of East Pakistan and expanded to cover an area of 40 km^2. The independence of Bangladesh in 1971 stimulated the growth of Dhaka. At that time the city population was less than 2 million. The expansion and population growth in Dhaka with time is shown in Figures 1 and 2, respectively. Dhaka has experienced a rapid growth of population since 1961s (see Figure 2). Massive migration from the rural areas is found to be the dominant cause of this growth. The current rate of population growth in Dhaka is about 7.5% per annum (Ahmed et al., 1995) whereas the annual average growth rate in Bangladesh is about 2.1%. According to the United Nations, Dhaka was the 31st largest city in the world in 1985 and is expected to be the 15th largest by the year 2000 (UN, 1987), when the total population of the city will be about 10 million. Another study shows that the population of Dhaka will be about 17.5 million in 2010 (Bartone, 1995), and will rank as a "Mega City". By the year 2025 Dhaka will be a megalopolis with a population of about 20-30 million and with an areal extent as shown in Figure 3 (Ahmed, 1991). At that time the physical expansion will cover most of the low lying areas and the present urban center will merge together gradually. This process will produce a single ecological system. Under such condition the city service facilities and environment will be heavily burden.

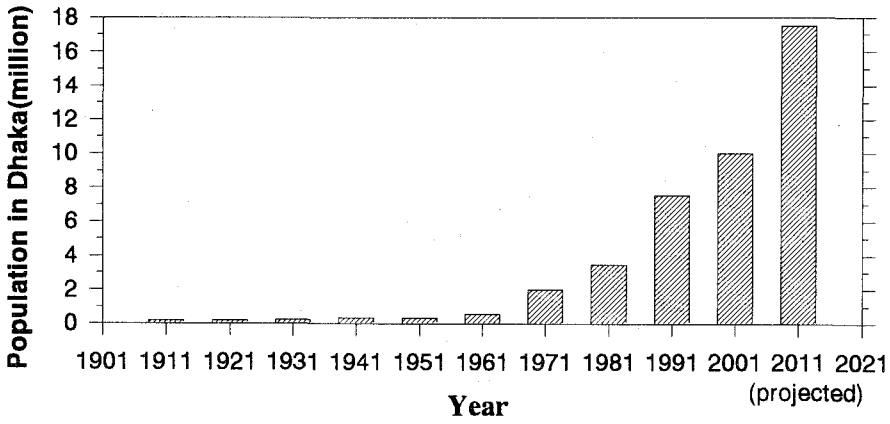


Figure 2. Population growth in Dhaka city, 1911-2011 (Based on Mahbub and Islam, 1990).

In developing countries, urbanization and industrialization are still at an early stage, and, for this reason, the potential for pollution and other forms of environmental degradation is arguably much greater than that in developed countries. The level of urbanization in Bangladesh is low (about 20% in 1991), but the rate of urbanization is high (over 70% annually, during the last four decades) which has already caused severe environmental pollution (MOEF, 1994). This rapid rate of urbanization in Bangladesh may likely to continue in the future and thereby environmental degradation also.

Dhaka is the main center with about 9 million people, about 30% of the total metropolitan population in Bangladesh. A tenfold increase in Dhaka's population, mostly due to migration of rural-poor, in last two decades has drastically over-stretched services, such as sewerage, water and air. In particular, the urban sanitation system has been overwhelmed in the collection and disposal of solid waste and sewage. In many areas people lack safe drinking water. The two problems above coupled with untreated disposal of industrial wastes (e.g., toxics from tannery and textile activities) have polluted surface as well as ground water in Dhaka. Water sources in close proximity to the city (e.g. rivers, canals, lakes and ponds) are generally used for disposal of almost all types of wastes. Another set of environmental problems in Dhaka is air pollution caused by uncontrolled emissions from motor vehicles, brick fields, industries, domestic and commercial activities. Extensive physical changes to the land surface have also been resulted, principally by filling and covering the natural drainage channels that once characterized the area. These implications of urbanization on the living environment of Dhaka are described in the subsequent sections. However, rapid urbanization and industrialization may not create serious environmental problems, provided there is an adequate understanding of the environmental implications of such processes and the timely creation of an institutional framework to address the problems.

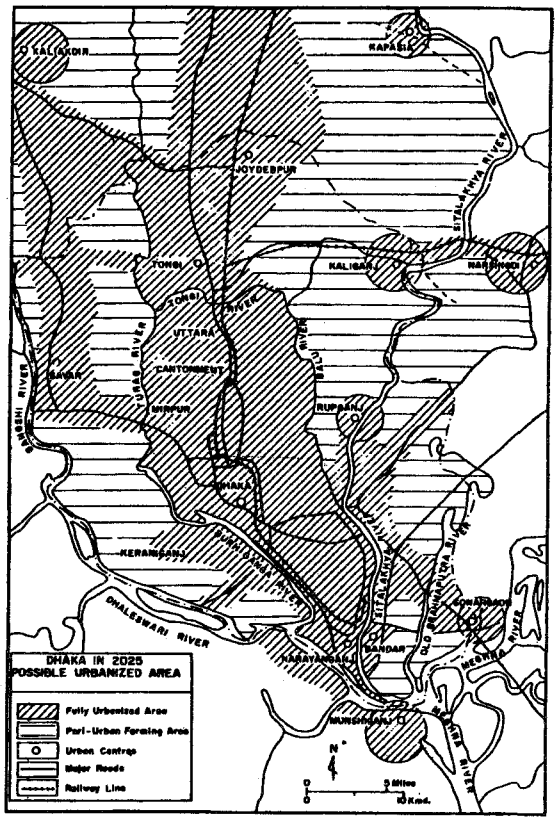


Figure 3. Possible urbanized area of Dhaka in 2025 (Source: Ahmed, 1991).

3. Atmospheric Environment Issue

More than one-and-a-half billion people in the world live in urban areas with dangerous levels of air pollution and the situation is getting worse as cities grow and more and more vehicles, industries, homes and power stations contribute to the pollution load. Some of the highest air pollution levels are in the urban centers of the developing countries such as Dhaka. The World Health Organization (WHO) has set the maximum acceptable limit of suspended particulate matter (SPM) at 200 $\mu g\ m^{-3}$ of air. In central Dhaka (Hatkhola road), the SPM was found as high as 1900 $\mu g\ m^{-3}$ in January 1995 (DOE, 1995). Motor vehicles are considered to be mainly responsible for this hazard. In Bangladesh, the total number of trucks, buses, cars, autorickshaws are 462,000 and Dhaka alone has 142,000 vehicles. Although the figure is very low in comparison to many developed countries of the world, but the pollution level is much higher than those countries depicting an alarming picture of urban air quality in Dhaka. This is due to poor fuel quality (lubricant oil is usually mixed with fuel to cut fuel cost), use of

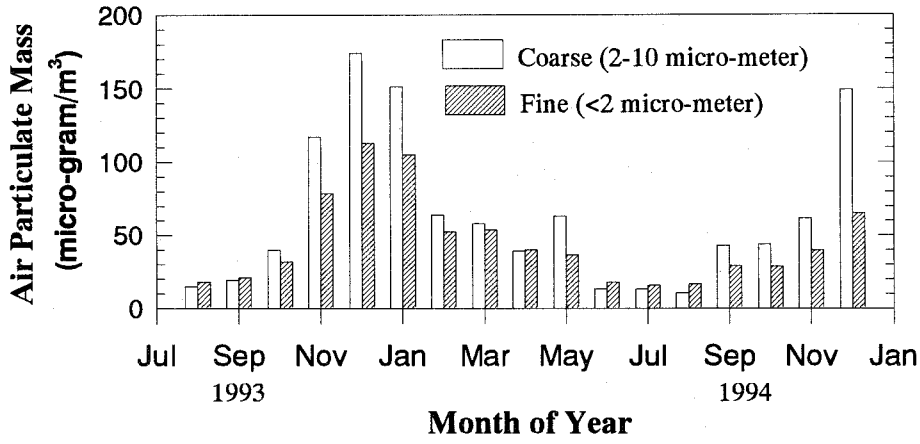


Figure 4. Monthly variation of air particulate mass at an urban site (23.4° N, 90.22° E) in Dhaka, 1993-94 (Source: Khaliquzzaman et al., 1995).

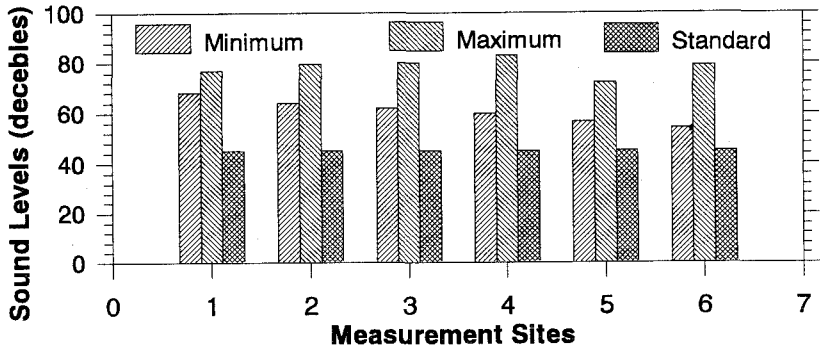
reconditioned aged cars, inadequate maintenance of vehicles, engine types such as two-stroke engine, uncontrolled emissions and the absence of a proper traffic planning. The particulate matter pollution in Dhaka, as could be seen in Figure 4, is highest during winter months (November-January) since there is hardly any rainfall at all in winter, and lowest during rainy months, i.e. June to August (Khaliquzzaman et al., 1995).

The level of sound pollution in Dhaka, may be, the worst, and motor vehicles are mostly responsible for this. Usually the motor vehicles overtake each other at high speed with loud honks. There is no application of the regulations related to sound pollution in Dhaka at all. The level of sound pollution in and around major hospitals in Dhaka is shown in Figure 5 (DOE, 1997), which shows the exceedence of standard value at every hospital.

Vehicles in Bangladesh use leaded fuel as the country's lone refinery is not technically able to produce lead-free fuel. Lead pollution in Dhaka's air is probably the highest among polluted cities, especially during low-rain months. Bangladesh Atomic Energy Commission (BAEC) has detected, in a study conducted during the period August 1993 to December 1994, as much as 463 ng m^{-3} lead in fine particulate samples (< 2 μm size) collected in Dhaka - compared to Mexico city's 383 and Bombay's 360 ng m^{-3} (see Table 1) (Khaliquzzaman et al., 1995). The CO concentration was as high as 18 ppm in January 1992 (Azad et al., 1992).

The three-wheeled autorickshaws with two-stroke engines, a popular public transport whose numbers appear to grow as prolifically as those of Dhaka's residents, are thought to be mainly responsible for this severe lead pollution.

The average levels of SO_2 and NO_2 pollution in Dhaka in January 1990 were 312 and 55 μg m^{-3} (NEMAP, 1996). Approximately 5,142,555 people in Dhaka in 1992 were exposed to air pollution level (only for three air pollutants, SPM(PM10), SO_2 and NO_2) exceeding "safe" health standard of Bangladesh which were considered as 400, 100 and 100 μg m^{-3} for SPM(PM10), SO_2 and NO_2, respectively (NEMAP, 1996). Emissions from traffic vehicles are about 55% responsible for this severe SO_2 and NO_2 pollution in Dhaka. The major industrial source, brick field, is responsible for about 30% of SO_2 and 17% of NO_2 pollution (Azad and Kitada, 1996; Kitada and Azad, 1997; Azad and Kitada, 1998).



1 - Sir Salimullah Medical College Hospital
2 - Dhaka Medical College Hospital
3 - Bangladesh Inst. of Research in Diabetes, Endocrine & Metabolic Disorders
4 - Institute of Post-Graduate Medicine & Research
5 - Dhaka Shishu Hospital
6 - Shaheed Suhrawardy Hospital

Figure 5. Typical level of sound pollution in and around major hospitals in Dhaka (Source: DOE, 1997).

Many people in Dhaka, from school children and office workers to bus drivers, sometimes use masks when they leave their homes. The highly elevated pollutant concentrations have already threaten public health, vegetation, and invaluable ancient monuments. According to UN (1987) the population of Dhaka has a high incidence of bronchitis and other respiratory diseases. About 4,905 premature deaths, and 8,299,656 hospital admissions and sicknesses requiring medical treatment incidences were occurred in urban Dhaka in 1992 due to air pollution hazards (NEMAP, 1996). The effects of air pollution are more severe in Dhaka due to expose to other infectious agents.

In the context of high atmospheric pollution, we measured 10-day-average concentrations of SO_2 and NO_2 at 64 sites in Dhaka using molecular diffusion tubes during the period mid-December 1995 to mid-January 1996 (see Kitada and Azad, 1997; Azad and Kitada, 1996), and simulated their spatial distribution and temporal variation together with control strategy

Table 1. Concentration of Pb and Br in different cities in fine particulate (< 2 μm) (ng m^{-3})

City		Pb	Br	Br/Pb
Dhaka	LRF	463	116	0.25
	MRF	253	30	0.12
	HRF	160	15	0.09
Mexico City		383	67	0.17
Bombay (March)		360	31	0.09
Sydney		333	115	0.34
Los Angeles		70	39	0.56
Kyoto		40	10	0.25

LRF - Low rainfall, MRF - Medium rainfall, HRF - High rainfall.
Source: Khaliquzzaman et al. (1995)

Table 2. SO_2 and NO_2 concentration levels in some urban areas

City	SO_2 Concentration (ppb)		NO_2 Concentration (ppb)	
	Maximum	Mean	Maximum	Mean
Sapporo (Japan)	21	7.4	45	27.4
Nagoya(Japan)	7	6	34	31
Agra (India)	8.4	5.6	8.9	7.5
Varanasi (India)	29.3	20.5	37.2	28.2
Dhaka	104	17	35	20.75

Source: Kitada and Azad (1997)

using an Eulerian transport/chemistry/deposition model (Kitada et al., 1984; Carmichael et al., 1986; Kitada et al., 1993; Kitada and Azad, 1997; Kitada and Azad, 1998). The measurements show that the present pollution level in Dhaka in winter (especially SO_2) is severe. The highest 10-day-average SO_2 was about 100 ppb, which is about 13 times larger than that at the polluted site in Nagoya, Japan in the same season, in the south-east suburban of Dhaka where many brick fields and other industries are located and is on the downwind of downtown Dhaka. The polluted zone, in which the average SO_2 was over 40 ppb, extended along the major road running from north-west to south-east, and also parallel to the river Buriganga in Dhaka area. Use of high sulfur containing fuel in traffic vehicles is the main reason of high SO_2 along the major roads. The highest NO_2 concentration was 35 ppb, and higher concentration appeared in the city center and along main roads in Dhaka.

The 10-day-average SO_2 exceeded 40 ppb at seven sites; the value of 40 ppb is the Japanese environmental standard, under which daily average of hourly values has to be kept. The WHO guideline for SO_2, about 66 ppb, which was estimated by logarithmic extrapolation for 10-day-average, was exceeded at 2 sites in the south-east industrial and brick field zone. The situation of SO_2 and NO_2 pollution in Dhaka with respect to other urban areas could be understood from Table 2.

Simulation based on projected emission scenario in 2010 was performed which shows that SO_2 and NO_2 concentration at the city center of Dhaka in 2010 would be increased by 88 and 60%, respectively. The simulation with projected emission scenario also shows that SO_2 value at all places of the downtown Dhaka would exceed 40 ppb in 2010 (see Kitada and Azad, 1998).

A series of control strategy simulations were conducted to find out a method to reduce pollutant concentrations in Dhaka (Kitada and Azad, 1998). In this regard the three major simulations were :

(i) Changing sulfur-content of diesel oil for vehicles from current 1.44% in weight to 0.5%. In this case ambient SO_2 concentrations would be reduced by around $40 \sim 55\%$ in the city center.

(ii) Substituting gasoline for current diesel oil for vehicles. This can reduce ambient SO_2 concentrations as much as $50 \sim 80\%$ in the city center.

However, ambient NO_2 concentrations rather increase by $5 \sim 7\%$ over large area in central Dhaka. Thus an appropriate method to remove NO_x from exhausted gas must be applied at the same time in this case, such as catalytic decomposition of NO_x.

(iii) Substituting natural gas for current diesel oil for vehicles. This can reduce ambient SO_2 concentrations by $50 \sim 90\%$ and NO_2 by $20 \sim 45\%$ in the city center. Furthermore, high

SO_2 concentrations in the south-eastern industrial area can be decreased to their 60% values.

Judging from the results of these three cases, the best way for air pollution control in Dhaka would be to use natural gas as fuel for traffic. Furthermore, it would also be necessary to cut the industrial emissions by 50% to keep the SO_2 concentration in the south-east suburban below the Japanese standard value. Although this comparison does not explicitly include cost point of view, Bangladesh can produce natural gas from her domestic mines, and thus it would be potentially competitive to other types of fuel.

Other general policies for abatement of air pollution in Dhaka would be :

(i) To raise fuel efficiency of motor vehicles ; for example, to replace two-stroke engine cars, which are widely used in Dhaka, with more fuel-efficient cars, and to maintain cars in their good conditions.

(ii) Each car must have equipment for removal of NO_x and heavy metals from exhaust gas.

(iii) To have appropriate road system to avoid traffic jam, such as separation of walk way and road for cars, and properly planned road network.

(iv) To set emission standards for industries and cars.

The brick fields, which are mainly developed in the north-west and south-east side of Dhaka, mostly create air pollution. The imposed ban on the use of fuelwood in brick fields, to protect the forest resource, has forced to use coal which is creating severe air pollution in Dhaka (see Figure 6); the brick fields are responsible for about 30% SO_2 pollution in Dhaka (Azad and Kitada, 1996; Kitada and Azad, 1997). Research and testing have clearly indicated that natural gas is the preferred fuel for brick burning; it is more efficient, economical, and produces a better quality product (USAID, 1990). A policy change to promote the use of natural gas as a source of energy for brick-burning may significantly reduce the demand for fuelwood, and avoid the increase in air pollution associated with the increased use of coal in brick fields.

In addition to pollution control, it is necessary to adopt preventive measures through stipulating the requirements in the Planning Standards and Guidelines for Dhaka. The air quality impacts of various development initiatives should be modeled. If the predicted air quality is not acceptable, the adoption of certain pollution prevention measures or alternative siting should be recommended.

However, the emission reduction is normally an expensive work. It is seen, for example, from the study of Foell et al. (1995) that the 'bat' (best available control technology) control strategy for Asia would cost 42 billion US$ per year in 2000. Similarly, the estimated cost for Mexico city to reduce air pollution in four years was 3.3 billion US$ (Martinez and Sterner, 1994). From these two estimates the cost regarding air pollution abatement strategy in Dhaka could be understood. Therefore, careful cost-benefit analysis should be done prior to adapting the control measures.

4. Surface Water Issue

Polluted surface water causes direct health threats when they are used as drinking water sources (official or unofficial), for bathing or washing, for irrigation of edible crops, or for food processing. As well as the biological contamination from untreated human waste, industrial discharges and agricultural runoff add toxic chemicals, pesticides and fertilizers, exposing water users to acute and chronic health risks.

Rivers, canals, lakes and ponds are the major source of surface water in Dhaka. The

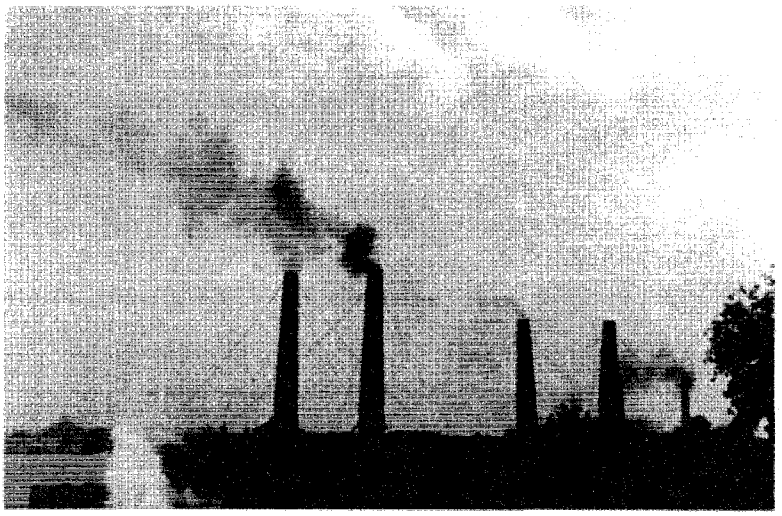


Figure 6. A brick field in the south-east side of Dhaka (March, 1996). The brick fields operate only in dry season (November - April) due to meteorological condition.

main water pollutants include : (1) oxygen demanding wastes, (2) pathogens, (3) inorganic chemicals, (4) acids and bases, (5) disease-causing agents, and (6) synthetic organic compounds.

There are many ponds scatterly distributed in Dhaka which are important surface water source in the city. Every day thousands of people use these ponds for washing, bathing, swimming, cooking and other purposes. Islam et al. (1994) investigated the faecal pollution, a potential source of diarrhoeal diseases, of major five ponds in Dhaka for one year which shows the ponds are highly contaminated by faecal matter; the faecal coliform count varied from 1.63×10^4 to 6.48×10^5 cfu/100 ml.

The river Buriganga, which flows by the south-western periphery of Dhaka city, is the biggest river around Dhaka. Industries and commercial centers are situated beside this river. The river receives directly or indirectly a large fraction of organic wastes generated in the city through various drains and discharged outfalls.

"Wastes from 170 tanneries at Hazaribagh, at the rate of 2,500 gallons of liquid waste per day on average, are polluting the water of the river Buriganga. Following examination by the Directorate of Environment, it has been found that a liter of water from the Buriganga contains 24 mg of T-alkali. The same amount of water contains 2.6 mg of chromium. Chemical oxygen demand (COD) in a liter of water is 12 thousand mg. Two hundred coliform bacteria were found in every one hundred milliliters of Buriganga water at the WASA (Water Supply and Sewerage Authority) discharge point". (Source: The Financial Express, Dhaka, 6 March 1995).

The river's share of pollution load is increasing rapidly with the growth of the city. The assimilative capacity of the river in the dry season (winter) decreases due to adverse hydrological changes with time. The general pattern of presence of dissolved oxygen (DO) along Buriganga river during lean period (March-May) is depicted in Figure 7 (DOE, 1997), which shows DO level in most part of Buriganga river (Chandnighat to Pagla) is below 4 mg

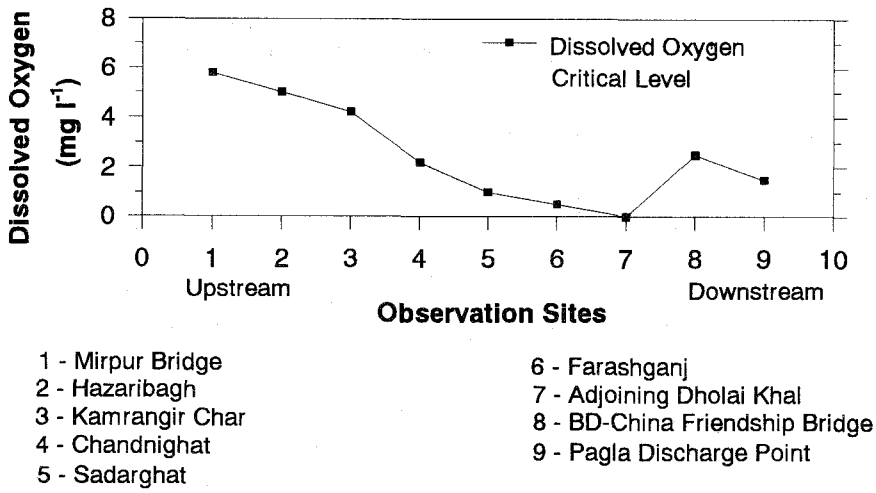


Figure 7. General pattern of presence of dissolved oxygen (DO) along Buriganga river during lean period (March-May) (Source: DOE, 1997).

l^{-1} (critical level for fish living). Balu river across Tongi (north side of Dhaka) is also extremely polluted during dry season. BOD ranges from 20 to 110 mg l^{-1} during May-July (DOE, 1996). Sitalakhya river (east side of Dhaka) gets adversely affected by the discharge of thermal power plant in certain reaches as well as by the Jute and Textile mills along Narshingdi which has caused for rise of the level of BOD and ammonium concentration in this river.

Azad (1994) evaluated various potential control measures to improve the water quality of the Buriganga river using a 2-dimensional analytical model (Gowda, 1984; Rahman and Azad, 1996). Three control strategy simulations were performed which are described below :

(i) Shifting of Tanneries from Hazaribagh Area

If tanneries are removed from Hazaribagh area, the simulation results suggest that average CBOD (Carbonaceous Biochemical Oxygen Demand) value of the water of the river Buriganga will decrease by about 7% and average DO will increase by about 1%.

(ii) Shifting of Tanneries from Hazaribagh and Setting up a Treatment Plant at Dholai Khal Outfall

If the tanneries are removed from Hazaribagh area and a treatment plant is set up at Dholai khal, the water quality of the Buriganga river will improve. The model results indicate that CBOD concentration of water of the Buriganga river would decrease by about 10.5% and DO would increase by about 1.5% averagely in this case.

(iii) Treated Effluent of Rayer Bazar, Hazaribagh and Dholai Khal Outfalls

If a treatment plant is set up at Hazaribagh area to treat the wastewater from tanneries, and another plant is established at Dholai khal to treat wastewater from this outfall, the average CBOD value would decrease by about 9% and average DO would increase by about 1.2% in water of the Buriganga river as simulation results suggest.

In the above three simulations 25 mg l^{-1} CBOD and 5 mg l^{-1} NBOD (Nitrogenous Biochemical Oxygen Demand) value as the effluent quality from the proposed treatment plant is considered.

From the above three simulations it seems that shifting the tanneries from Hazaribagh and setting up a treatment plant at Dholai khal would be the best method to improve the water

quality of the Buriganga river. The shifting of tanneries would not only improve the water quality of the Buriganga river but also save the people of the adjacent Dhanmondi residential area from bad odour, eye nuisance and other types of unhygienic environment.

5. Sub-surface Water Issue

In Dhaka, urban development and the sustainability of groundwater resources are in conflict. About 90% of the public water supply in Dhaka is currently provided from boreholes, meeting only 50% of the current demand. 205 public supply boreholes, up to 180 m deep, are distributed across the city and managed by the Dhaka Water and Sewerage Authority (DWASA). Water demand is increasing and groundwater abstraction is rising at up to 20% per year. Dhaka WASA is trying to overcome the water shortage problem by installing more and more wells.

Recharge to the aquifer is by vertical leakage from ponds, and by leakage from the surrounding polluted rivers and urban sources. Approximately 20% of the recharge to the aquifer comes as induced leakage from the river Buriganga. Despite reduction of natural recharge by up to 80% on account of urbanization, over 30% of the abstraction is derived from urban recharge. The remainder comes by vertical flow through the Madhupur Clay aquitard and from beyond the city boundaries (Ahmed et al., 1995). As recharge is insufficient to satisfy the heavy abstraction, storage is being depleted. The piezometric decline in the aquifer is on average 0.75 m per year (Ahmed et al., 1995). The abandonment of wells are common occurrence due to water level decline at a higher rate. The cost of tubewell sinking is also increasing gradually. Sustainability of the aquifer is seriously threatened.

Groundwater quality is also threatened by over-exploitation, and gradually deteriorating, as monitored at two borehole (Mothijheel and Mohammadpur) by the BWDB (Bangladesh Water Development Board) since 1976. Concern is centered on contaminants from the chemical and tanning industries, and the extensive municipal landfills within the city, which lie within the large piezometric depression caused by excessive abstraction. Both the river Buriganga and the urban recharge sources are known to be heavily polluted. At the Mothijheel borehole chloride concentration increased from 2 mg l^{-1} in 1974 to 44 mg l^{-1} in 1988. Nitrate, initially absent, increased to 5 mg l^{-1} over the same period (Ahmed et al., 1995). Both are general indicators of contamination; detailed data on specific contaminants of concern regarding health are not available.

Heavy exploitation of the aquifer beneath Dhaka has led to continuing water level decline and modification of the recharge regime, which is in turn having a detrimental effect on the groundwater quality. In the long term the sustainability of the aquifer resources is limited. If Dhaka city continues to expand, the aquifer will be unable to meet the rising demand for water. Yet the aquifer has the capacity to supply groundwater of reliably good quality within a sustainable limit if protected properly.

Figure 8. A waste disposal bin on the road side in central Dhaka (September, 1997) which is typical in this city.

Figure 9. Typical solid waste collection system in Dhaka city (September, 1997) (the spot of the picture is a busy place, Sahabagh, in downtown Dhaka).

6. Waste Management Issue

6.1 Municipal Waste Management

Municipal wastes can be classified into two types; solid wastes and waste water. Solid waste is one of the major problems in Dhaka, and its management is currently both inadequate and inefficient, and lacks proper scientific and technical approaches. People dispose of domestic waste indiscriminately in an uncontrolled and unsanitary manner, and scavengers further scatter it (see Figure 8). Dhaka City Corporation (DCC) collects, using unhygienic open trucks (see Figure 9), about 1016 - 1524 Mg solid wastes per day, which is about 50% of total wastes generated (Rahman, 1993) and dump them openly near the water courses to seal and reclaim unwanted ponds, canals or low lying areas without any pre-treatment (see Figure 10). On completion the landfills are given a thin covering of soil and become areas designated for construction. This practice has serious health implications for urban residents. Firstly, such dumping sites become breeding grounds for rats and flies, with attendant disease vectors. Secondly, garbage dumped in this way often blocks drainage systems, which consequently overflow during the rainy season, creating further health hazards. Thirdly, no effort is made to separate domestic, industrial and medical garbage (which can be hazardous biological, chemical and radioactive wastes), so that harmful chemical contaminants from the latter two are present in some dump sites. Toxic and biomedical wastes significantly increase the life-threatening risks since they can transmit dangerous diseases like AIDS and Hepatitis B, particularly for the many urban poor whose means of survival is scavenging of the festering dumps.

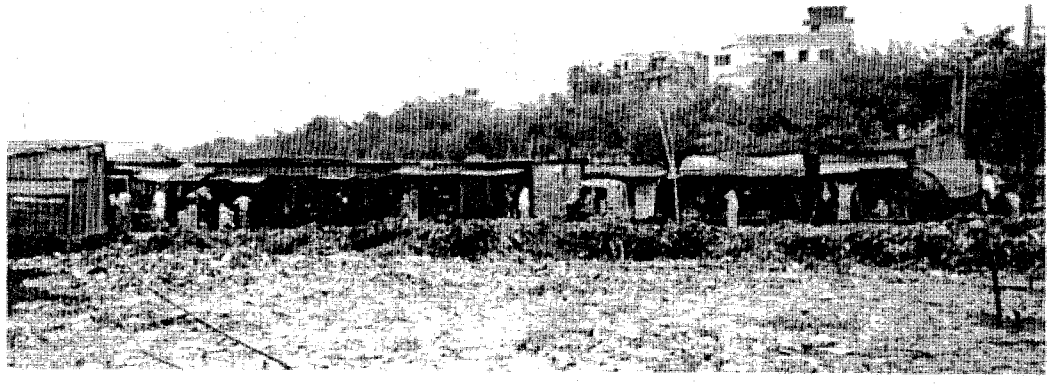


Figure 10. A pond is being filled by dumping solid waste in eastern Dhaka (September, 1997) which is very common in this city.

Table 3. Typical components of solid wastes in Dhaka.

Constituents	% By Dry Weight	
	Residential Area	Commercial Area
Food wastes	84.37	79.49
Paper	5.68	7.22
Plastics	1.74	1.48
Cloths	1.83	1.59
Glass, ceramic, metal, grass, other construction materials	6.38	10.22

Note: moisture content = 80-95%

Source: Rahman (1993)

Table 4. Characteristics of leachate of solid wastes in Dhaka.

Component	Range	Typical Value
PH	4.5 - 6.0	4.75
Suspended solids (mg l^{-1})	3000 - 14000	10000
Chloride (mg l^{-1})	1300 - 5000	1400
Nitrate (mg l^{-1})	0 - 200	50
Phosphate (mg l^{-1})	0 - 15	5
COD (mg l^{-1})	5000 - 17000	14000
BOD_5 (mg l^{-1})	5000 - 15000	9000

Source: Rahman (1993)

The physical characteristics of solid wastes from residential and commercial areas in Dhaka are shown in Table 3. The characteristics of leachate from solid wastes, which has an extremely high pollution potential, are shown in Table 4. Table 3 indicates that the major component of solid wastes is organic food wastes with high moisture content. There is an overflow of leachate of high organic loads (BOD_5 = 5,000-15,000 mg l^{-1} and SS = 3,000-14,000 mg l^{-1}) (see Table 4) during the rainy season which ultimately causes surface and shallow ground water pollution (Ahmed, 1995). Therefore, the development of a strategy for solid waste management in Dhaka is urgently needed to reduce the water pollution problem. The characteristics of solid wastes presented in Table 3 indicate that the low-cost technology for their safe disposal would be the production of bio-gas and compost (Rahman, 1993). Other general methods for solid waste disposal may be sanitary landfill or incineration. Demountable container system may be used for collection of solid waste which would be more hygienic than open truck. Industries, hospitals and health centers especially clinic which are mushrooming in Dhaka must be properly regulated, to ensure the safe disposal of hazardous wastes, to prevent contamination of water, food, air and soil and to reduce the health dangers from open landfill sites. The important principle of "reduce, reuse and recycle" has to permeate thinking of industry, commerce and individuals.

The industrial and domestic waste water of some part (15%) of Dhaka city are sent to Pagla treatment plant, only treatment facility in Dhaka, where they partially (may be namely) treated and discharged to the Buriganga river with high pollution load. Many pathogenic microorganisms are also present in waste water which are causative agents of different types of diseases to human beings. Therefore, the strength and capacity of the treatment plant should be increased.

As long as the city would continue to grow, the amount of waste generation would grow

proportionally. If proper waste management plans are not taken for Dhaka, it would cause further degradation of Dhaka's environment and pollution problems which will create various types of disease among the residents.

6.2 Industrial Waste Management

The industrial development in Dhaka is achieved so far without taking environmental consideration into account, i.e. without any effort to choose processes, technologies or equipment that will have less harmful effects upon the environment, without giving any thought for the life styles of neighbouring people and without giving due thought for rational use of natural resources. The industries have little, or almost no, regard for pollution control or for the occupational health of the work force. The Environment Pollution Control Act, 1977 and the Factories Act, 1965 have provisions for control of pollution emanating from industrial wastes. Unfortunately, satisfactory steps, in most cases, are yet to be seen. Satisfactory waste disposals/treatments are yet to be developed although such systems should have been built into the design of industrial set ups.

Table 5: Different industries within Dhaka

Type of Industry	Number
Tannery	160
Textile	166
Pharmaceutical	106
Chemical	18
Pesticides/insecticides	4
Rubber and plastic	23
Iron or steel mills	30
Other	47

Source: Rahman (1993)

Table 6: Typical effluent quality of selected industries in Dhaka

Industry	PH	BOD_5 ($mg\ l^{-1}$)	Suspended Solids ($mg\ l^{-1}$)	Toxic Substance ($mg\ l^{-1}$)
Tanneries	8.6 - 10.4	660 – 2800	1300 - 11500	Chromium = 0.5 - 10.5 Ammonia = 100 - 135
Textile or Dyeing	6.8 - 11.8	180 – 1000	100 - 5000	Chromium = 9.6

Source: Rahman (1993)

"There are about 100 industrial plants in residential areas of the Dhaka city" - published in the daily newspaper 'Sangbad', 19 January 1995. Total about 554 different types of industry, as shown in Table 5, are situated within Greater Dhaka, along with about 350 brick fields surrounding it. Among these, 160 tannery industries are concentrated in a particular area (Hazaribagh) on the west-south-west bank of the river Buriganga, 166 textile industries with some other industries are concentrated in the central part of Dhaka (known as Tejgaon industrial area) and the rest of the industries are scattered in different areas of Dhaka especially in the south-east and north-west suburban. These industries generate solid, liquid

and, in some cases, gaseous wastes (e.g. odours from tannery, VOC from textile) with varying pollution burdens. The rapidly growing textile industry is now the most important industrial sector in Dhaka, accounting for about 80% of the value of industrial exports. A huge amount of untreated waste water from these industries with high pollution potential, as shown in Table 6, is discharged into open water courses such as river systems and low lying areas. These wastes are inorganic, organic and toxic in nature. In any developed country, the discharge into natural water sources of polluted effluent with these characteristics is prohibited. Hence, the treatment of industrial wastes is also one of the major concerns for the prevention of pollution. It was found that a nominal treatment of tannery wastes with a primary clarifier removes 89% suspended solids, 26% BOD and 95% chromium in a four-hour detention period and makes them suitable for discharge into the city sewer system for further treatment with domestic sewage (Rahman and Ahmed, 1990). Therefore, the different industries should find suitable low-cost treatment methods for the safe disposal of their wastes into natural water bodies.

A clearly defined standard for effluent/emission quality from industry also has to be established. Promotional strategies such as reduced rate of interest on loans for pollution control, higher rate of depreciation for pollution control devices and recognition to industry running best environmental protection by honouring with national award may also be helpful to reduce industrial pollution.

Table 7: Water quality status in Dhaka

Parameter	Deep Tubewell Water	WHO Guideline Value for Drinking Water
pH	7.5	6.5 - 8.5
EC (mohos cm^{-1})	4000	--
Chloride (mg l^{-1})	1130	250
TS (mg l^{-1})	1800	1000
DO (mg l^{-1})	3.10	--
BOD (mg l^{-1})	12	--
Iron (mg l^{-1})	0.30	0.30
E. Coli (no. per 100 ml)	0.00	0.00

Source: DOE (1996)

7. Drinking Water and Sanitation

Lack of a supply of safe water and adequate means of sanitation is blamed, at least in part, for as much as 80% of all disease in developing countries. Contaminated drinking water is prime cause of diarrhoeal disease - a major killer of infants and young children. The water crisis in Dhaka involves both the scarcity of water and its quality. "590 million liters of daily water deficit in the Dhaka city" - this news was published in the 'Daily Sangbad', 22 November 1994. Two main types of water resource exist in Dhaka, namely, ground water from 205 DWASA operated deep tube wells (pumping about 850 million liters water per day), the main source of water supply, which is thought to be fairly clean, and surface water from rivers, lakes and ponds which are the main sources of infection. The water quality status of deep tube wells in Dhaka

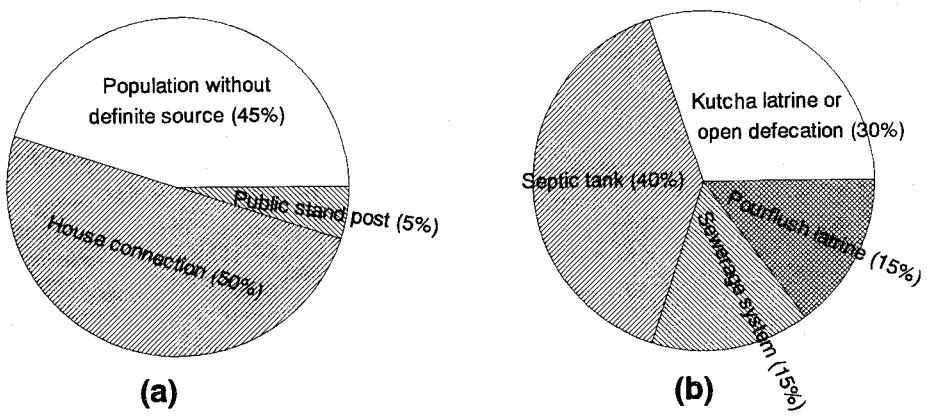


Figure 11. (a) Water supply and (b) Sanitation coverage in Dhaka city in 1990 (Source: DWASA report, 1991; Report of the Task Force on Water Supply and Sanitation Targets for the 4th Five-Year Plan, 1990).

is shown in Table 7 (DOE, 1996). The status of surface water quality in Dhaka is discussed in section 4 of this text. The service coverage of public water supply by the DWASA in 1990 is depicted in Figure 11(a), which shows that about 45% of the total population do not have definite sources of water for domestic uses. Water supply coverage further decreases in dry season due to lowering of the groundwater level. The major problem of water supply in Dhaka is the vast number of leak points in cracked pipes. These commonly lead to water contamination and related health problems, especially in the rainy season, when urban areas are often flooded.

To meet the daily requirement DWASA is planning to install 150 more deep tube wells in the next five years, without considering the adverse environmental impacts. Various studies have shown the falling of ground water level in Dhaka city, as the recharge of ground water is very low in and around the city. This is mainly because most of the urban areas have been paved or covered with impermeable layer and there is no artificial recharge wells either. This over exploitation of ground water should be stopped gradually by increasing the use of surface water, otherwise natural hazards such as land subsidence could stuck Dhaka.

Lack of hygienic sanitation affects nearly 82% of the population in Bangladesh, which in turn takes its toll on the environment, polluting land and water, and spreading disease (UNDP, 1995). The present status of sanitary practice in Dhaka is shown in Figure 11(b) which shows a small portion is served by sewerage system (15%), compared with the large portion served by septic tank system. Where sanitary facilities are not available, the septic tank effluent and sludge are being discharged into storm drains or open water bodies without regard to the effluent quality and their detrimental effects on the living environment. The only sewage treatment plant in Dhaka is not adequate for the treatment of sewage to a satisfactory level. As a result, effluent from the treatment plant with high organic load is discharged into the river system.

The fast rate of urban growth in Dhaka has resulted the shortage of housing, over crowding and lack of basic services such as water supply, sanitation, health care facilities and even proper roads in certain parts of the city. These are the areas commonly known as slum and quatter areas which have developed mostly as a result of urban migration of the rural poor. In

urban slums, just over half of the households use tubewell water for all their needs (UNICEF, 1993). The unhygienic conditions in the slums due to lack of sanitation make them unsafe and unhealthy for human habitation.

In Bangladesh, about 80% of all illnesses are related to water-borne disease (Erikshen et al., 1993). Raw sewage contamination in innumerable water systems in Bangladesh is the major factor for the transmission and spread of communicable water-borne disease including diarrhoea, cholera, typhoid, dysentery and shigellosis. Mosquito vectors are another major problem in Dhaka which help to spread malaria disease. There is free and unlimited access of the public to drugs. Their unrestricted use may create drug resistance. An example of such resistance is the case of Shigellosis disease (DANIDA, 1989).

8. Drainage and Water Logging

Due to rapid urbanization and unplanned and unregulated urban growth, many areas of Dhaka are affected by lack of drainage and stagnation of rain water. Relative low intensity rain causes serious water logging problems for certain areas of the city.

Waste and storm water is channelled by a large number of open drains throughout the city area towards the river Buriganga and to other surface water bodies such as Gulshan Lake, with no treatment. Drainage of surface water has been disrupted as the small natural channels (khals) and low lying areas have been infilled, often with municipal waste. Plastic bags used for shopping or carrying waste usually plug drains cause severe congestion and flooding during periods of rainfall. Construction of an encircling flood protection embankment in 1990 has further aggravated the situation resulting in blocking of the canals, and frequent water logging of the surface by contaminated water. During most of the monsoon period the water levels of the surrounding rivers remain higher than the water level inside the city area, which indicates that the city drainage is very dependent on the water levels of the peripheral river systems. Therefore standard draining by gravity may not always work.

Due to water logging certain parts of Dhaka are inundated for days, resulting in great traffic problems, thus increasing the risk of environmental hazards due to the presence of sanitary waste water. Therefore, it is urgently necessary to improve the drainage system in Dhaka. Extensive research is also needed in this regard.

9. Street Trading and Informal Markets

Street hawking and street food vendoring are popular occupations in Dhaka. The 'higgler' or 'huckster' sells a wide range of goods such as fruits, vegetables and fast foods on the Dhaka's major roads, footpath and business centers. It is interesting to note that vegetables, meat and fish are sold fresh in open markets without any packaging (see Figure 12). This type of trading of goods especially foods is unaesthetic, and causes diarrhoeal disease and sufficient environmental pollution and street congestion. When the working day is finished, vendors discharge litter such as perished fruit, paper and other rubbish on the street. Informal markets are a similar problem. They are common, and, because they are unlicensed, are not entitled to refuse disposal. Piles of waste attract vermin and add to the urban environmental degradation. The problem of unauthorized waste disposal often extends to river dumping, and encourages water-related disease in low-income slum people.

Figure 12. A typical open meat shop, which is unaesthetic, on the road side in central Dhaka (September, 1997).

Informal trading provides a livelihood for the urban poor and is increasing in Dhaka due to escalating unemployment. The environmental impacts of informality may persuade the authority to restrict its growth, but such actions may have social and economic repercussions for those involved. Rather than pursuing street clearing, Dhaka's administrative authority may assist vendors to dispose of their waste, and install services in markets and other public places.

10. Public's and Government's Environmental Concerns

The environmental pollution concern is poor among people in Bangladesh as it is related to the social-cultural matter. Bangladesh's media seems to be more aware of environmental pollution. Several newspapers and periodicals, including 'Daily Star', 'Bhorerkagoj', 'Inquilab' and 'Ittefaq', carry weekly reports on the plight of city dwellers including environmental pollution.

On a broader plane, Bangladesh's commitment to be part of the international environment conservation movement was reflected in its signing of a number of global conventions such as Rio de Janeiro Summit, Vienna Convention and Montreal Protocol. Bangladesh created the DOE (Department of Environment) in 1989 within a new Ministry of Environment and Forest (MOEF) to preserve the environment. In preparing the National Environmental Management Action Plan (NEMAP), the Government of Bangladesh has already taken an important lead to preserve the environment of the country. The use of environmental assessments in programme and project design is rapidly becoming the norm.

But with respect to the management of the environment and pollution control, the scenario in Dhaka is not good with inadequate and ineffective legislation. The law implementing

authorities are functionally and institutionally weak. There are lack of coordination among different government agencies, municipal authorities and the police on pollution control. Most of the organizations/ departments related to pollution control have not well trained and expert manpower. It is also needed to strengthen the capability of the agencies/organizations involved. Several national and international bodies have carried out studies, made evaluations and put forward recommendations to the Bangladesh government in this regard. These studies include the DANIDA report 'Environmental Profile : Bangladesh' (DANIDA, 1989), the CIDA report 'the Environment and Development in Bangladesh' (CIDA, 1989), SIDA report 'Environmental profile for Bangladesh' (SIDA, 1991).

To save the environment in Dhaka it is necessary to strike the conscience of the people about pollution and its subsequent effects. The authority can take the examples of Philippine where the month of September has been declared the month of environmental protection, or of Japan where Eco-Clubs are planned to be formed to make students of the primary and junior level conscious about the importance of environmental protection.

11. Final Remarks

Some environmental ramifications of urbanization in Dhaka are presented. Severe environmental pollution exists in Dhaka. It is primarily associated with air pollution, water pollution, solid waste management and blocked drainage systems. The pollution reflects underlying socio-economic and administrative problems that have confronted both municipal administrators and residents. In order to resolve such problems, several policy initiatives are required.

(1) The arising environmental problems in Dhaka should be resolved in the perspective of long-term policies that attempt to create Dhaka as new center of civilization. Short-term policy measures should be directed at establishing the minimum threshold of maintaining an affordable quality of life within the available resources in Dhaka.

(2) The Government needs to provide an enabling setting for tackling the Dhaka's severe environmental problems by providing the necessary policy and legislative framework, by moving forward on policy implementation, and by ensuring the enforcement of environmental laws. The existing environment-related laws need further strengthening. It also has a critical role to play in setting environmental standards, in ensuring the quality of environmental assessments, and in environmental monitoring, as well as in redirecting and promoting research and technologies that are much more responsible to the development needs of the people. However, the Government's actions and regulations on environmental issues could be very expensive. Therefore, before framing, implementing and enforcing such regulations, proper cost-benefit-risk analysis should be carried out.

(3) The residents of Dhaka also have to advance to save their environment. They have to start it from their personal level, family level to be aware of the environmental pollution, and change their life style and social-cultural system towards creating a pollution free environment. In view of the emerging environmental problems and urgent need for economic growth, the engineers should design and execute their projects in such a way that they pose "the least real environmental damage". Environmental issues have to incorporate in the development programmes and various plans. A balance between economic activities in the search for growth and development and environmental conservation have to be achieved. NGOs should be also advance for environmental conservation.

(4) To raise environmental awareness through media campaigns and education, national and

local print media can be stimulated and the Journalists should be trained on environment issues. Training programmes, briefing workshops, and information packages should be developed and widely disseminated at all levels. Educational institutions and universities need to improve their curricula to address environmental issues. There is also an urgent need to educate urban residents about the environmental issues such as sewage and garbage disposal and the associated health implications.

(5) If in the future, the increasing population pressure, increasing number of motor vehicles, increasing number industries and other activities become confined in only the major urban areas of Bangladesh, perhaps Dhaka would be the world's most polluted as well as disease prone city. Therefore, we argue that time is running out to control the severe environmental pollution in Dhaka and urge the responsible authority for taking urgent action.

However, environmental concern is relatively new thinking in Bangladesh and it may take time to expect a concerted action.

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