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# Impact of Municipal Waste Dumping on Soil and Water Around a Dump Site in Rajshahi City

Khan, Mohammad Zakir Hossain

University of Rajshahi

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# IMPACT OF MUNICIPAL WASTE DUMPING ON SOIL AND WATER AROUND A DUMP SITE IN RAJSHAHI CITY

A Thesis
Submitted to Institute of Environmental Science (IES) at the
University of Rajshahi in Partial Fulfillment of the Requirements
for the Degree of
MASTER OF PHILOSOPHY
IN
ENVIRONMENTAL SCIENCE

By
**MOHAMMAD ZAKIR HOSSAIN KHAN**

INSTITUTE OF ENVIRONMENTAL SCIENCE
UNIVERSITY OF RAJSHAHI
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BANGLADESH

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| Principal Supervisor | Co Supervisor |
|---|---|
| Dr. Md. Golam Mostafa<br>Professor<br>Institute of Environmental Science<br>University of Rajshahi<br>Rajshahi<br>Bangladesh | Dr. Ananda Kumar Saha<br>Professor<br>Department of Zoology<br>University of Rajshahi<br>Rajshahi<br>Bangladesh |

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# DECLARATION

I declare that the thesis entitled “Impact of Municipal Waste Dumping on Soil and Water Around a Dump Site in Rajshahi City” submitted for the degree for Master of Philosophy in the Institute of Environmental Science, University of Rajshahi, Bangladesh is the record of work carried out by me during the period from 2010 to 2014 under the guidance of Dr. M. G. Mostafa and Dr. Ananda Kumar Saha and that this did not form the basis for the award of any degree for this University or any other university or any other similar institution of higher learning or prize.

(Mohammad Zakir Hossain Khan)

Researcher

# CERTIFICATE

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This is to certify that Mohammad Zakir Hossain Khan is the sole author of the dissertation entitled “Impact of Municipal Waste Dumping on Soil and Water Around a Dump Site in Rajshahi City”. This dissertation or part thereof has not been the basis for the award of any degree, diploma or associated with any other similar title.

We are forwarding this dissertation to be examined for the degree of Master of Philosophy in the Institute of Environmental Science, University of Rajshahi. The data presented in the thesis are genuine and original. Mohammad Zakir Hossain Khan has fulfilled all the requirements according to rules of the University for submission of a dissertation for the Master of Philosophy degree and made distinct contribution to the field of environmental science.

Principal Supervisor

Dr. Md. Golam. Mostafa
Professor
Institute of Environmental Science
University of Rajshahi
Rajshahi
Bangladesh

Co Supervisor

Dr. Ananda Kumar Saha
Professor
Department of Zoology
University of Rajshahi
Rajshahi
Bangladesh

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***Mohammad Zakir Hossain Khan***

# ABSTRACT

This study was directed toward the fundamental understanding of the impact on surface water, ground water and soil with time due to the open dumping of solid waste at a site in Rajshahi, Bangladesh. Surface water samples were collected from two surface locations (small ponds) S1 and S2 near the dump site and ground water samples were collected from one tubewell near the dump site at two months interval from August, 2010 to July, 2012. Also soil samples were collected from three locations near the dump site. Samples were taken from the top soil, a half meter depth, and a one meter depth from each of the locations. Details laboratory analyses were performed to determine the status of surface water, groundwater and soil of the study area.

The major cations of $Na^+$ and $Zn^{2+}$ were found in the surface water at location S1 at the end of the study in concentrations of 310 mg/l and 0.1 mg/l. Among anions, $HCO_3^-$ and $Cl^-$ were found at concentrations of 446 mg/l and 570 mg/l. The results of the analysis showed that the mean concentration of cations were from highest to lowest, $Na^+ > Mg^{2+} > K^+ > Ca^{2+} > Fe^{3+} > Mn^{2+} > Cu^{2+} > Zn^{2+}$. At the same time, the concentration of $K^+$ and $Zn^{2+}$ were found in the surface water at location S2 at the end of the study in concentrations of 1130 mg/l and 0.1 mg/l. Among anions, $HCO_3^-$ and $Cl^-$ were found to be 684 mg/l and 390 mg/l. The results of the analysis showed that the mean concentration of cations were from highest to lowest $K^+ > Na^+ > Mg^{2+} > Ca^{2+} > Fe^{3+} > Mn^{2+} > Cu^{2+} > Zn^{2+}$.

The analytical results of the hydro-chemical composition of the shallow tube well water in the study area showed that $BOD_5$ and COD of the groundwater were higher than the standards of DoE (Department of the Environment), Bangladesh. $Mg^{2+}$ was the dominant ionic species among the cations of the shallow tube well water samples, and at the end of the study it was found at a concentration of 230 mg/l while the other cations were $K^+$ (6 mg/l), $Ca^{2+}$ (112 mg/l), $Na^+$ (114 mg/l), $Cu^{2+}$ (0.24 mg/l), $Fe^{3+}$ (0.55 mg/l), $Mn^{2+}$ (3.44 mg/l) and $Zn^{2+}$ (0.2 mg/l). Among the anions, $HCO_3^-$ and $Cl^-$ were found at a concentration of 210 mg/l and 14 mg/l at the end of the study. At the end of the study, the major anions of the shallow tube well water were from highest to lowest $Mg^{2+} > Na^+ > Ca^{2+} > K^+ > Mn^{2+} >$

$Fe^{3+} > Cu^{2+} > Zn^{2+}$. It was also found that, $Ca^{2+}$, $Mg^{2+}$ and $Mn^{2+}$ exceeded the limits of DoE, Bangladesh. No Arsenic was present in the ground water.

The concentrations of $Fe^{3+}$ and $K^{+}$ were found in the soil in the highest and lowest quantities among cations, respectively at location A and at the end of the study the amount were 165.7 μg/g and 3.12 μg/g respectively at top soil and among anions, S and P were found at concentrations of 255 μg/g and 188 μg/g at the end of the study. The results of the analysis showed that the mean concentration of cations were from highest to lowest, $Fe^{3+} > Mn^{2+} > Zn^{2+} > Cu^{2+} > Mg^{2+} > Ca^{2+} > K^{+}$. The concentrations of $Fe^{3+}$ and $Zn^{2+}$ were found in the soil in highest and lowest quantities among cations, respectively at location B at the end of the study and the concentrations were 29.8 μg/g and 1.28 μg/g respectively on top soil and among anions, S and P were found at concentrations of 34.05 μg/g and 26.7 μg/g at the end of the study. The results of the analysis showed that the mean concentration of cations were from highest to lowest, $Fe^{3+} > Mn^{2+} > Ca^{2+} > Mg^{2+} > Cu^{2+} > K^{+ >} Zn^{2+}$. The concentrations of $Fe^{3+}$ and $Zn^{2+}$ were found in the soil in highest and lowest quantities among cations, respectively at location C and at the end of the study the concentrations were 51.8 μg/g and 0.52 μg/g respectively at on top soil and among anions, S and P were found 10.5 μg/g and 7.8 μg/g at the end of the study. The results of the analysis showed that the mean concentration of cations were from highest to lowest, $Fe^{3+} > Mn^{2+} > Ca^{2+} > Mg^{2+} > Cu^{2+} > K^{+ >} Zn^{2+}$. Inside the study area all parameters increased with time, which has a direct relationship with the surface and ground waters of that place, and which also increased with time. Low concentration of analyzed parameters in the soil were found at a far distance from the site.

The study shows that, most of the analyzed physical, anaionic and cationic parameters of surface and groundwater increased with time. During the study period, flora and fauna around study area were also collected in a short survey. Most of the aquatic flora and fauna that one would expect to be there, but were absent in the surface water body of the study area. The study observes that there was an adverse effect from the solid waste on the surface water, ground water and soil. Although, the experimental results of this study indicate impacts of solid waste leachate on soil and, surface and groundwater, it is recommended for further research with larger in the field site and onsite leaching studies would be conducted to explore the long-term impacts of solid waste.

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# ABBREVIATIONS

| | |
|---|---|
| AAS | Atomic Absorption Spectrophotometer |
| BC | Before Christmas |
| BOD | Biochemical Oxygen Demand |
| COD | Chemical Oxygen Demand |
| DO | Dissolved Oxygen |
| DoE | Department Of Environment |
| EC | Electrical Conductivity |
| EPA | Environmental Protection Act |
| FS | Feasibility Study |
| GHGs | Greenhouse Gases |
| LDCs | Least Developed Countries |
| MSW | Municipal Solid Waste |
| NYS | Not Yet Selected |
| PPE | Personal Protective Equipment |
| PVC | Poly (Vinyl Chloride) |
| RCC | Rajshahi City Corporation |
| RDA | Rajshahi Development Authority |
| TA | Total Alkalinity |
| UNEPA | Union of Europe Professional Patent Representatives |
| US | United State |
| UV | Ultra Violet |

# CHAPTER 1

# INTRODUCTION

# INTRODUCTION

## 1.1 Background

The developing world is experiencing rapid population growth and a massive shift towards urban population. In fact, in 1998 the world's population grew by over 78 million people with 97% of this growth occurring in the poorest countries stated in The Population Institute, 1999. Urban centers of the developing world are experiencing the brunt of this growth and most are ill equipped to handle these added stresses. Mark et al. (2000) stated that, health and environment get jeopardized when urban infrastructure is unable to cope with increasing demands. The management of solid waste is an area of universal concern for both the developed and developing world. It is imperative that efficient, technically sound, and cost effective solid waste management solutions are developed in the near term for the benefit of the burgeoning populations in the world's cities and the natural environments that must sustain them.

Solid waste means any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations. Solid waste is generally termed as "unwanted or undesired" material. Though the term is universal, it has different concern depending upon the location and living standard of people.

Solid waste consisting of everyday items we consume and discard. It predominantly includes food wastes, yard wastes, containers and product packaging, and other miscellaneous organic and inorganic wastes from residential, commercial, institutional, and industrial sources. Examples of wastes are appliances, soft drinks cane, glass, tin, newspapers, clothing, food scrapes, boxes, disposable tableware, office and classroom paper, furniture, wood pallets, rubber tires, and cafeteria wastes. Sehker and Beukering (1998) stated that the generators of municipal solid waste are broadly classified as residential, industrial, commercial, institutional, construction, demolition, municipal and agricultural types. Municipal solid waste is also generated by human and animal activities that are discarded as useless or unwanted waste. Economic development, urbanization and improving living standard in cities of developing countries have lead to increase in the quantity and complex composition of municipal solid waste. Glawe et al. (2005) and Erdogan et al. (2008) stated that management of municipal solid waste resulting from rapid urbanization has become a serious concern for government departments, pollution control agencies, regulatory bodies and public in most of the developing countries. Several other factors like education standard and infrastructure of the country have significant effect on municipal solid waste generation. Kansal (2002) stated that the quantity of municipal solid waste in developing countries has been consistently rising over the years. Visvanathan and Trankler (2003) stated that the municipal solid waste composition varies from place to place and also bears a rather consistent correlation with the average standard of living. Inefficient management and disposal of municipal solid waste is an obvious cause for degradation of environment in the developing countries. Khajuria et al. (2008) stated that ecological impacts such as land degradation, water and air pollution are related with improper management of municipal solid waste. The collection is performed by the municipality within a given area. They are in either solid or semisolid form. The term residual waste relates to waste left from household sources containing materials that have not been separated out or sent for reprocessing.

Solid waste can be classified into different types depending on their source: a) Household waste is generally classified as municipal waste, b) Industrial waste as hazardous waste, and c) Biomedical waste or hospital waste as infectious waste. Municipal Solid Waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. Industrial and hospital waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous. Hazardous wastes could be highly toxic to humans, animals, and plants; are corrosive, highly inflammable, or explosive; and react when exposed to certain things e.g. gases. Hospital waste is generated during the diagnosis, treatment, or immunization of human beings or animals or in research activities in these fields or in the production or testing of biological. It may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc. These are in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner.

Disposal means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste, hazardous wastes, or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters, from community activities. Historical accounts on waste management suggest that waste disposal methods such as open dumping, burning, burying a rudimentary form of land filling, and composting were practiced from as early as 2000 BC by both the Chinese and the Greeks stated in Environmentalists, Every Day, 2011.

Rushbrook (1999) stated that three types of landfills are an integral part of most solid waste systems. These are the open dump, the semi-controlled landfill, and the sanitary landfill. Generally open dumping site is a land disposal site at which solid wastes are disposed of in a manner that does not protect the environment, is susceptible to open burning, and is exposed to the elements, disease vectors and scavengers. These unplanned heaps of uncovered wastes, often burning and surrounded by pools of stagnated polluted water, rat and fly infestations with domestic animals roaming freely and families of scavengers picking through the wastes is not only an eyesore but a great environmental hazard. It is determined at the stage where the collected waste is unloaded on dumping site to its final stage- disposal. To dispose waste in efficient way technology knowledge, trained Manpower, appropriate infrastructure and availability of land is required. For disposal of solid waste commonly used methods are open dumps, landfills, sanitary landfills, and incineration plants. Selection of proper disposal method is necessary and primarily it depends on the 'quantity of solid waste generated and type of waste to be disposed'. There is, however, no single technique which is suitable in all situations. Johannessen and Boyer (1999) stated that open dumping of municipal solid wastes has been practiced as a default strategy in most of the developing countries with limited control measures, including those related to the environmental impacts. This approach is the primitive stage of landfill development and still remains the predominant waste disposal option in developing countries owing to their low initial costs and lack of expertise and equipments. Komilis et al. (1999) stated that landfill is considered to be a reliable and cost effective method of solid waste disposal in the developing countries where adequate land is available. Land filling has been the most common method of solid waste disposal generated by different communities for many years. The majority of urban centers in the developing world use open dumping as their principal disposal method.

Open dumping is not a scientific way of waste disposal. Open dumps refer an uncovered site used for disposal of waste without environmental controls. The waste is untreated, uncovered, and not segregated. In spite of its simplicity in execution, the financial involvement for this traditional method of waste management has been quite high particularly for the big metropolis. Uncontrolled, open dumps are not a sound practice. Open dumps are exposed to flies and rodents. It also generates foul smell and unsightly appearance. Loose waste is dispersed by the action of wind. Drainage from dumps contributes to pollution of surface and ground water and also the rainwater run-off from these dumps contaminates nearby land and water thereby spreading disease.

As a default strategy for municipal solid waste management, open dumps involve indiscriminate disposal of waste and limited measures to control operations, including those related to the environmental impacts of landfills. Johannessen and Boyer (1999) stated that the open dump approach is the primitive stage of landfill development and remains the predominant waste disposal option in most of the developing countries owing to their low initial costs and lack of expertise and equipment. They pose significant risks to human health and the environment, especially as solid waste become more complex in industrializing countries. In addition, the cost of remediating these sites can easily exceed their total lifetime capital and operating costs. Contaminated groundwater may never be returned to usable condition and other environmental impacts may take many decades to ameliorate. Open dumps attract numerous birds that feed on the wastes, which can make them more serious disease vectors than flies or rodents.

The major part of solid waste management was direct open dumping. It is unfortunately observed that developing countries where the waste is dump directly in unscientific and uncontrolled manners can be detrimental to the urban environment. Solid waste leachate contains variety of chemicals like detergents, inorganic chemicals and complex organic chemicals and metal. These components are themselves very much toxic elements which were not present in a free reactive form in the waste. During infiltration of water by rainfall, water already present in the waste, or water generated by biodegradation cause the leachate to leave the dumping ground laterally or vertically and find its way into the ground water or nearby surface water thereby causing contamination. In recent times, the impact of leachate on groundwater and other water resources has attracted a lot of attention because of its overwhelming environmental significance. Leachate migration from wastes site or landfills and the release of pollutants from sediments (under certain condition) pose a high risk to groundwater resources if not adequately managed. Suman Mor(2005) stated that dumped solid wastes release its initial interstitial water gradually and some of its decomposition by- products gets into water moving through the waste deposit. That liquid containing innumerable organic and inorganic compound called ‘leachate’. This leachate accumulates at the bottom of the landfill and percolates through the soil. Reinhart (1993) and Brown and Donnelly (1998) stated that pollutants found in leachate include organic contaminants which are soluble refuse components of decomposition products of biodegradable fractions of municipal solid waste and a variety of heavy metals. The existing waste disposal practice has threatened.

Khoury R. and El-Fadel, et al. (2000) stated that Geographical location has a significant impact in the process of leaching from the dump and geographical conditions in the same place they belongs to the nature of the climatic zone in the study illustrating the impact near the site of solid waste from the sea, shows the temporal variation of leachate quality in seawater saturated fills. Generation of leachate from solid waste landfill in arid regions has long been neglected on the assumption that minimal leachate could be formed in the absence of precipitation. Rewat Watananugulkit (2003) stated that the water quality of ground water in the dry season is better than in the rainy season.

Landfill temperature, a largely uncontrollable factor influencing leachate quality, has been shown to fluctuate with seasonal ambient temperature variations. Temperature affects bacterial growth and chemical reactions within the landfill. Khoury R. and El-Fadel, et al. (2000) stated that each microorganism possesses an optimum growth temperature, and any deviation from that temperature will decrease growth due to enzyme deactivation and cell wall rupture. Solubility of many salts NaCl increases with temperature.

Leaching occurs when soluble components are dissolved (leached) out of a solid material by percolating water. Leachate may also carry insoluble liquids (such as oils) and small particles in the form of suspended solids. Depending on the waste types further contaminants may be introduced as a result of biodegradation of wastes. Almost any material will produce leachate if water is allowed to percolate through it. The quality of leachate is determined primarily by the composition and solubility of the waste constituents. Suman Mor (2005) stated that if the waste changes in composition due to weathering or biodegradation, then leachate quality will change with time. This is generally the case in landfills containing municipal waste. The stages in the generation of leachate set out below are representative of landfills that have received non-hazardous municipal waste.

Whichever way one chooses to look at it, the 21st century is already promising to be the age of global urban communities. The United Nations predicts that by early in the 21st century, approximately half of the world's six billion people will live in cities. Cities themselves will mushroom in size; and the number of million-plus cities -already at about 316, out of which 200 are in developing countries, will continue to grow. Even in comparatively less urbanized or in regions higher to perceived as predominantly rural regions, like Sub Saharan Africa or Bangladesh, many cities have been doubling their populations. By the end of this century most of the countries in the world will have one or more densely populated (million-plus) cities. Thus, cities will play important and even decisive roles in the future of the world; and world issues will be urban issues. The 21st century will indeed be the "Urban Century". As cities continue to absorb half of the increasing proportion of the population in many developing countries, their environmental deterioration is becoming more and more apparent. Inadequate pollution control and waste management policies and practices result in urban areas being inundated in their own waste and choked by their own omissions. Pollution from urban waste has become the most formidable threat to health. The increasing quantity of solid waste, and its collection and disposal, has emerged as a serious problem all over the world. The indiscriminate dumping of hazardous waste which gets mixed with other municipal waste is a growing threat. The problem is compounded by numerous small scale enterprises which proliferate in the city. While the contribution of small scale enterprises to the variety and vitality of the city's economy is considerable, they are an increasing source of solid and liquid wastes. The problem of the urban environment and the apparent failure of city management to address it effectively so far have pitted the city as the antithesis of expansion. To address the environmental problem, the city is perceived as a net consumer of resources. Seizing this opportunity of addressing waste issues is a major challenge for municipal management.

Rapid increase in population and change in life style in Bangladesh have resulted in a dramatic increase in the generation of solid waste. It includes as well as commercial waste that accounts for a relatively small part of the total solid waste stream in developed countries. Accumulation of a large amount of waste may create several problems to inhabiting populations. Population growth has been contributing to increase the quality and variety of waste. Collection, transportation and handling of the waste must also be properly dealt with, if not, the waste creates a number of problems, many of which are related to human health and environment.

Iftekhar Enayetullah et al. (2005) stated that Bangladesh, being a developing country, is predominantly a rural country. In 1951, the percentage of urban population was only 4.33% of the total population. Since then the rising trend has continued reaching around 24% by the year 2001. Growth of urban population due to large influx of rural-urban migration is triggered by the migrants’ poverty at home. The deplorable condition of poor migrants and acute shortage of adequate housing have led to mushroom growth of slums and squatter settlements in urban areas, especially in secondary towns of Bangladesh.

Most of the developing countries like Bangladesh are facing a serious environmental threat due to huge amount of solid waste generation and its mismanagement. The generation rate is very close in each major city. Overall, the per capita generation varies from house to house depending on the economic status, food habit, age and gender of household members and seasons. Alamgir et al. (2005) stated that the generation of solid waste in six major cities of Bangladesh as recorded in the year of 2005. Solid waste was generated at a rate of 0.325 to 0.485 kg/cap/day obtained from different sources as 75 to 85% residential, 11-22% commercial, 1 to 1.5% institutional, 0.5 to 1.25% municipal services and 0.4 to 2.5% others. The compositions are 68 to 81% food and vegetables, 7 to 11% paper and paper products, 3 to 5% polythene and plastics and 9 to 16% others.

There is an insignificant variation of composition in solid waste at six major cities of Bangladesh. The rapidly biodegradable portion is normally very high compared to other portions, essentially due to the use of fresh vegetables and in absence of food processing industries.

Rajshahi Municipality, which was one of the oldest municipalities in Bangladesh, was established in 1876. Rajshahi Municipality was renamed as Rajshahi Pourashabha, and finally, Rajshahi Pourshava was declared Rajshahi City Corporation in 1991. Besides the City Corporation, a governing body named Rajshahi Unnayan Kortripokhkho (Rajshahi Development Authority-RDA) is there to plan the development of the city and to coordinate all the development related work.

At present, the city generates approximately 350 MT of solid waste every day while the amount increases to 400 MT during summer. Of the total, only 230 MT are collected and dumped into the open dumping ground at Nawdapara. The remaining 120 MT of waste are used for composting. This data was taken from RCC authority during field survey. The officially designated dumping ground at Nawdapara remains open to pollute the air and water while liquid wastes collected from drains are often kept on streets to dry up as Rajshahi City Corporation (RCC) lacks proper waste management logistics, said experts and sources in the RCC.

An article of The Daily Star June 27, 2009 of Nazrul Islam et al. stated that 40% of the total population belongs to low-income, 50% in the middle income group, while 10% in the high-income group considering that, the weighted average domestic solid waste generation rate in Rajshahi City Corporation area has been calculated daily 0.203 kg. The per capita domestic waste generation rate was derived from sample household survey and then by calculating the weighted average of waste generation rate of the low, middle and high income families. Hence, total domestic waste is derived through multiplying the per capita domestic waste generation rate by the population of RCC. On the other hand, market waste has been estimated through considering the waste collected from different markets of the city. Overall waste generation rate in RCC is 0.289 at high growth rate of population; while it is 0.245 at medium growth and is further higher (0.341) at low growth rate of population in the city. Considering the present waste generation rate of 0.245 kg/capita/day and medium growth rate of population, the projected waste generation in Rajshahi City Corporation would be 327 tons in 2020, 453 tons in 2025, 627 tons in 2030 and 714 tons in 2032.

Bangladesh Municipal Development Fund’s Field Survey Report on March 2012 stated that physical composition analysis of waste was done by collecting samples from households, markets and on trucks arriving at landfill sites. It is seen that major portion (79% to 85%) of solid waste in residential areas as well as market areas of Rajshahi City Corporation is compostable. The average percentage of compostable waste in residential areas is 82.47%, non-compostable waste is 13.93% and ash content is 3.60%. On the other hand, similar compositions for market waste area 84.77%, 7.02% and 8.21% respectively. The large quantity of degradable organic contents present in the waste composition of Rajshahi City Corporation indicates the necessity for frequent collection and removal. This also indicates the potential of recycling of organic waste for resource recovery.

Over 40 percent solid wastes of Rajshahi city are dumped into drains, open spaces and water bodies, causing environmental pollution and health hazards. Even the officially designated dumping ground remains open to pollute the air and water while liquid wastes collected from drains are often kept on streets to dry up as Rajshahi City Corporation (RCC) lacks proper waste management logistics, said experts and sources in the RCC. The matter came to light recently as the RCC started implementing projects to clean the city's major drains. The officials found the drains filled up and clogged due to rampant dumping of solid wastes over years.

A WHO Expert Committee (1967) condemned dumping as “a most unsanitary method that creates public health hazards, a nuisance, and severe pollution of the environment. Dumping should be outlawed and replaced by sound procedures”.

Michel Pugh (1999) stated that municipal Solid waste Management services in most of the cities comes a poor third in municipal priorities, after water supply and sanitation. However they are under pressure from their own legislation to move away from the current disposal practices of open dumping to sanitary land filling. Such a change is unlikely to occur in the nearest future due to limitations on finance, shortage of technical resources and lack of institutional arrangements. It is advisable to have small incremental improvements in landfill design and operation rather than an attempt to make a single large technological leap. This approach should also match the affordability and sustainability considerations. A good solid waste disposal site management is an important part of environmental hygiene and needs to be integrated into total environment planning. Unsanitary disposal of waste provides harborage for disease vectors, causes odour nuisance, defaces cities and may be a source of pollution of waste sources. Strausses (1991) particulates emitted during burning have deleterious effect on materials, paint-work, glasses and fibre material. Other impacts of such gaseous emissions include deterioration of clothing materials, curtains and wood and the corrosion of metals migration of gases from dumps sites through the soil to the nearby locality posses a principal risk to health. Current demand for land use has increased the pressure for urban regeneration and re-development of former derelict. Land property adjacent to land fill waste sites are increasingly being used for industrial, commercial and residential purposes.

Agunwamba (1998) stated that the dump sites are usually haphazardly located without careful consideration of environmental and public health. These sites are usually open, subjected to frequent burning, cause depreciation of property value nearby and sometimes obstruct communications.

Bangladesh categorized one of the Least Developed Countries (LDCs) by World Bank in terms of the following criteria: low-income, human resource weakness, and economic vulnerability. At present, 50 countries are designated as LDCs, out of which 8 countries are from Asia - Afghanistan, Bangladesh, Bhutan, Cambodia, Laos PDR, Maldives, Myanmar and Nepal. Ulrich Glawe et al. stated in Solid Waste Management in Least Developed Asian Countries that these countries have a number of priority issues pertaining to the country’s development. Among those, management of municipal solid waste is one of the priority urban issues. Although cities of LDACs have a lower rate of waste generation compared to the cities of the developing countries, their quantum of waste is high owing to their higher levels of population density. The tropical climates with a high degree of rainfall and humidity aggravate the problem of solid waste disposal. As cities are becoming more urbanized, their waste composition also changes. The substantial increase in the use of paper and packaging is probably the most obvious change. Other significant changes are due to the higher proportion of plastics and consumer products and their related packaging material in the solid waste. The negative side of greater affluence is that it brings greater volume of wastes, making it more expensive for management.

An Impact Assessment is generally carried out as an integral part of the Feasibility Study (FS) or together with it. If so than the findings of the Impact Assessment could be incorporated in the study area design, overall planning and budget and that the study area could be implemented accordingly. When an Impact Assessment is conducted separately as just an add-on, often it does not get due importance in the overall implementation of the study area, which undermines the role of the Impact Assessment and can contribute to environmental damages. In the case of solid waste dumping site of RCC, the study area is existing. The management of solid waste is an area of universal concern for both the developed and developing world. It is imperative that efficient, technically sound, and cost effective solid waste management solutions are developed in the near term for the benefit of the burgeoning populations in the world’s cities and the natural environments that must sustain them. This paper focuses on the Land disposal of solid waste and how current practice of open dumping could be improved to sustainable landfills in a phased manner.

Zurbrugg (2002) stated that the uncontrolled manner in which solid waste is disposed of at most open dumpsites may create serious health problems to humans, animals, and environmental degradation. Inadequate waste disposal translates into economic and other welfare losses. The environment is degraded in a number of ways. Soil is contaminated by being in contact with solid waste and leachate.

According to Marshal (1995), open dumpsites are a major problem to the environment, especially on the air that the people inhale. Dumpsites emit obnoxious odour and smoke that cause illness to people living in, around, or closer to them. According to Wrensh (1990) dumpsites maybe a source of airborne chemical contamination via off site migration of gases and the particles and chemicals adhering to dust, especially during the period of active operation of the site. The UNEPA (2006) stated that wastes that are not properly managed, especially excreta and other liquids and solid wastes from households and the community, are a serious health hazard and could lead to the spreading of diseases. The report further states that unattended wastes lying around attract flies, rats, and other creatures that, in turn, spread diseases. Normally, it is the wet waste that decomposes and releases a bad odor. The bad odor affects the people settled next to the dumpsite, which clearly shows that the dumpsites have serious effects to people settled around or next to them.

Contamination of surface and groundwater may occur when leachate from the dump, via flow paths (on or under the surface), reaches groundwater or surface water. Waste sometimes deposited directly into water at dumpsites resulting in the direct chemical and physical contamination of surface water. Many contaminants (especially heavy metals) are trapped in the soils beneath dumpsites, resulting in risk of further long term environmental contamination and restricting the potential after use of the site. Land filled organic waste may contribute to the greenhouse effect via emissions of methane. Other types of gas emissions may contribute to the degrading of the ozone layer and/or may be toxic to humans (especially scavengers or any local populations). Uncontrolled burning of solid waste (particularly certain types of plastics) releases smoke and gaseous contaminants into the air. The smoke commonly contains particulates, carbon monoxide and other contaminant gases including low levels of dioxins, all of which can be hazardous to health. In some cases odour and direct hazard may occur from the generation of hydrogen sulphide due to disposal of certain types of waste, or the development of reducing, anaerobic conditions in the waste mass.

Fauna in and around dumpsites may be impacted either by direct consumption of the solid waste, or by consumption of contaminated plants and/or animals, or as a result of leachate effects on groundwater and surface water. Plants near open dumpsites can be impacted directly by the waste, dust or smoke from burning. Dumps tend to affect the type and number of plants in the surrounding area and the presence of dead vegetation are often associated with the zone of direct impact around dumpsites. Dead vegetation is normally a result of trampling by foot, vehicle or animals, but may also be the result of direct contamination by waste or leachate, the migration of landfill gas, or as a result of burning or smoke effects.

One of the primary health risks of dumps is the spreading of diseases (diarrhoea, hepatitis etc.). The ways such infection can be spread are numerous, but are often related to direct contact with the waste (e.g., clinical waste, faecal matter) by scavengers and other unauthorized persons being on the site. The other main pathway is by vectors such as foraging animals, rats, birds, flies and mosquitoes etc). EPA905-97-001 stated that the health risks associated with illegal dumping are significant. Areas used for illegal dumping may be easily accessible to people, especially children, who are vulnerable to the physical (protruding nails or sharp edges) and chemical (harmful fluids or dust) hazards posed by wastes. Hileman, B. (1998) stated that another US EPA study indicates that dioxin emissions from open burning of garbage in one day by four families could equal the emissions from a municipal solid waste incinerator burning 200 tons per day. Seedcorn (1998) stated that Dioxins are known to suppress the immune system, disrupt hormonal balances and promote carcinogenisis.

Due to lack of management, site accidents may occur at dumpsites, mostly involving scavengers and staff. The greatest risk relates to cuts and wounds (and subsequent infection), but other types of accidents involve fires, explosions, plant and equipment and landslides within the waste mass.

The approach to waste management around the globe also has a significant impact on global warming and climate change. This is because a number of waste disposal methods are themselves significant producers of greenhouse gases (GHGs) which have been identified as the cause of global warming. While contemporary thinking on global warming focuses on carbon dioxide ($CO_2$) as the main offender, other GHGs such as methane ($CH_4$), water vapour ($H_2O$), and nitrous oxide ($N_2O$) are certainly more important drivers of global warming from a waste management point of view. Porter (2002) stated that Methane is produced in considerable quantities from the decomposition of organic waste in municipal landfills, and is deemed to have around 21 times the global warming potential of $CO_2$. Furthermore, other waste reduction and disposal methods, such as composting, incineration, and even open dumping, also generate GHGs such as nitrous oxide and water vapour, in addition to carbon dioxide. Williams (2009) noted that global waste production was predicted to double over the next 20 years, driven by increased urbanization and greater waste generation per capita in emerging economies.

This overall increase in the generation of municipal solid waste globally, along with evolving waste management strategies, particularly in developing countries, holds the potential to exacerbate the climate change challenge which confronts humanity over the medium to long term.

Due to solid waste disposed off on land in open dumps or in improperly designed landfills, it may cause the following impact on the environment. Ground water contamination by the leachate generated by the waste dump. Leachate is produced when water filters downward through a landfill, picking up dissolved materials from the decomposing wastes. Surface water contamination by the run-off of leachate from the waste dump and also acidity to surrounding soil. Leachate may contain undesirable or toxic chemicals. A high concentration of contaminants in leachate may make groundwater pollution more likely. Bad odour, pests, rodents and wind-blown litter in and around the waste dump. Solid waste may generate inflammable gas (e.g. methane) within the waste dump and Release of green house gas. Gaseous emissions from land filling are environmentally significant on a global scale today and will acquire more importance in the future. Gaseous emissions are also important for the working environment and for people living near landfills. Bird menace above the waste dump may affects flight of aircraft. There has also possibility of Fires within the improper open dumping. There might have Erosion and stability problems relating to slopes of the waste dump. Epidemics through stray animals are an important issue.

The study on “Impact of Municipal Waste Dumping on Soil and Water Around a Dump Site in Rajshahi City” is going to study first in Rajshahi. Most of the study was done on solid waste management in Bangladesh especially in Dhaka. There has a Cow Haat near the dumping site. During study that Haat shifted to dumping site and RCC started dumping at old cow hut site.

This study focuses on the Land disposal of solid waste and how current practice of open dumping could be improved to sustainable landfills in a phased manner.

## 1.2 Goals and Objectives

The main goal of this study is to carry out a comprehensive baseline assessment of solid waste dumping impact scenario on soil and water around an open dump site in the Rajshahi City. The objectives of research are-

- To assess physico-chemical characteristics of soil in and around the dumpsite
- To assess physico-chemical characteristics of surface and groundwater in and around the dumpsite
- To evaluate the impact of waste dumping on soil in and around the dumpsite
- To evaluate the impact of solid waste dumping on surface and groundwater around the dumpsite
- To assess the impact of solid waste on flora and fauna near the dump site

# CHAPTER 2

# MATERIALS AND METHODS

# MATERIALS AND METHODS

The physico-chemical parameters of collected soil, surface water and groundwater samples were analysed to understand the quality of soil and water in the study area. The analyses were done using several methods such as gravimetric, electrochemical, colorimetric and optical. Detailed analytical techniques of soil, surface water and groundwater and the data analysis in this study are discussed in this chapter.

## 2.1 Study Area

Rajshahi City is located in the north-west of Bangladesh, which is the divisional headquarters as well as the administrative district. The study area covers approximately 7,40,000 sft and lies in latitudes 24˚24'N and longitudes 88˚35'E. The City Corporation has an area of 96.68 sq. km. The City Corporation consists of 4 upazillas, 35 wards and 170 mahallas. The city has a population of 646,716 (male 52.4%, female 47.6%) with a density of 6,689 persons per $km^2$ (Banglapedia, 2006). It is situated on the northern banks of the river Padma (the downstream of the Ganges River of India). The climate of the city is generally marked by monsoons, high temperature, considerable humidity and moderate rainfall. (BBS, 2005).

The climate of Rajshahi City, of which the study area is a part, is average tropical monsoon. The dominant southwest monsoon helds and sustains the rainy season. This usually starts in May and continues until August. The highest rainfall is observed during the months of monsoon. There are many fairly distinct seasons, the rainy and the dry seasons. These two seasons are coinciding with the “hot and humid” and winter seasons respectively. The dry season is November to April.

According to Statistical Pocket book 2008, Bangladesh Bureau of Statistics, the hot season commences early in March and continues till the middle of July. The maximum mean temperature observed is about 32 to 36 °C (90 to 97 °F) during the months of April, May, June and July and the minimum temperature recorded in January is about 7 to 16 °C (45 to 61 °F). The annual rainfall in Rajshahi district is about 1,448 millimetres. Average maximum humidity found to be 86% and minimum being 71% in July and February, respectively. At normal time, the maximum and minimum wind speed at Rajshahi, 11.5 km/hr and 4.9 km/hr, respectively and prevailing wind direction is southerly during monsoon and northwesterly during winter season. In 2001, maximum and minimum rainfall found as 411 mm in June and 00.00 both in January and December, respectively.

**Figure: 2.1 Location map of solid waste dump site**

The study area was near the Aaam Chattar at Nawdapara City By Pass highway in Rajshahi. The disposal site is located at a distance of about 8 km from the city center and it is 3 km away from the nearest community. The Divisional Head Quarters of Border Guard is located within 4 km and Rajshahi Airport is around 4 km from the disposal site. RCC is planning to use the land as vegetable market as post closure measure of the landfill site. The site is an open land in a relatively low elevated topography. Compared to the din and bustle of the city life, the study area site has a calm and serene atmosphere. The site has good road communication with heart of Rajshahi city; two high ways from city along north-south and east-west meet to the study area. Railway head quarter, Rajshahi city corporation, Bus stand etc are within 5 km. radius. Rajshahi airport is 7.0

km to north-east corner of study area. So the study area is well communicated from adjacent districts. Islami Bank Medical College & Hospitals and A Madrasha of dignitaries named “Mohanogor College & Madrasha” borders the eastern edge of the study area. City cow HAAT [weekly market]is adjacent to the study area. There are crop fields all around the study area. The location map of the study area is shown in Figure 2.1.

Everyday 350 MT solid waste generate in Rajshahi City Corporation (RCC). 230 MT of that amount are dumped at dumping site and 120 MT used for composting. Composting area is in 14 no ward, Terokhadia. Main solid waste dumping site is near at AAM CHATTAR, Nawdapara, City By Pass Road, Rajshahi. Total area of dump site is 50 bigha (7,40,000 sft). There are also 19 secondary waste dumping points. RCC use 12 nos. of truck / tractor for solid waste transportation. 33 nos. of rickshaw van used for transport on main road. 180 nos. of rickshaw van used for waste transport, ward wise. There are 60 nos. of wheel bar for waste transport on main road and 90 nos. of wheel bar for waste transport, ward wise. There are 34 permanent employee engaged in RCC for solid waste collecting and dumping operation and 1092 nos. of daily contractual employee engaged for solid waste collecting and dumping operation. The cheapest and the oldest easy method of solid waste disposal is 'open dumping' where the waste is dumped in low - laying areas on the city outskirts and leveled by bull - dozers from time to time.

A thorough laboratory investigation was carried out to determine the characteristics of decomposed waste of municipal solid waste dumping site of Rajshahi City Corporation. Samples are collected from various depths by driving PVC pipe in different locations of the dumping site.

Solid waste dumping affect the environment by air, water, soil pollution and also damage the property in the vicinity. The solid waste decomposed slowly and during decomposition, under the anaerobic conditions, the bio-degradable portion produces gases like hydrogen sulfide ($H_2S$), methane ($CH_4$) and mercaptan (CHSH). The general anaerobic transformation of solid waste with the help of microorganisms can be described by the following equations stated by Amiya Kumar Sahu (2007) in Present Scenario of Municipal Solid Waste (MSW) Dumping Grounds in India.

$$\text{Organic matter} + H_2O + \text{Bacteria} + \text{temperature}$$
$$\rightarrow \text{new cells} + \text{resistant organic matter} + CO_2 + CH_4 + NH_3 + H_2S \qquad (1)$$

Under the reducing condition, sulfate reduces to sulfide which subsequently combines with hydrogen to form $H_2S$.

$$2CH_3CHOHCOOH + SO_4^{2-} \rightarrow 2CH_3COOH + S^{2-} + 2H_2O + 2CO_2 \qquad (2)$$

Lactate Sulfate Acetate Sulfide Ion

$$4H_2 + SO_4^{2-} \rightarrow S^{2-} + 4H_2O \qquad (3)$$
$$S^{2-} + 2H+ \rightarrow H_2S \qquad (4)$$

Hydrogen sulfide

The biochemical reduction of an organic compound containing sulfur radical can lead to the formation of malodorous compound such as methyl mercaptans as shown in the schematic equation.

$$CH_3SCH_2CH_2CH\ (NH_2)\ COOH \rightarrow CH_3SH + CH_3CH_2CH_2\ (NH_2)\ COOH \qquad (5)$$

Methionine Methyl Mercaptans Aminobutyric acid

## 2.2 Sample Collection

### 2.2.1 Water Sampling

There were three water samples, one was from shallow tubewell and two others were from surface water collected in every second month covering two years to evaluate the seasonal variations, water quality, water type and geochemical process. Water samples were taken from three points namely S1, S2 and S3 and are shown in Figure 2.2. Location points S1 and S2 are the surface water bodies near the dump site. Location point S3 is ground water from 35m depth shallow tube well. The samples were collected in 1 L plastic bottles, which were pre-washed with dilute HCl and rinsed three to four times with distilled water. The groundwater samples were collected after 10 minutes pumping of shallow tubewells to remove groundwater stored in the well. The samples were not acidified for analyzing physical parameters and major anions. Samples were labeled, sealed and transported to the laboratory and stored in refrigerator at a temperature of about 4˚C until the analysis was done.

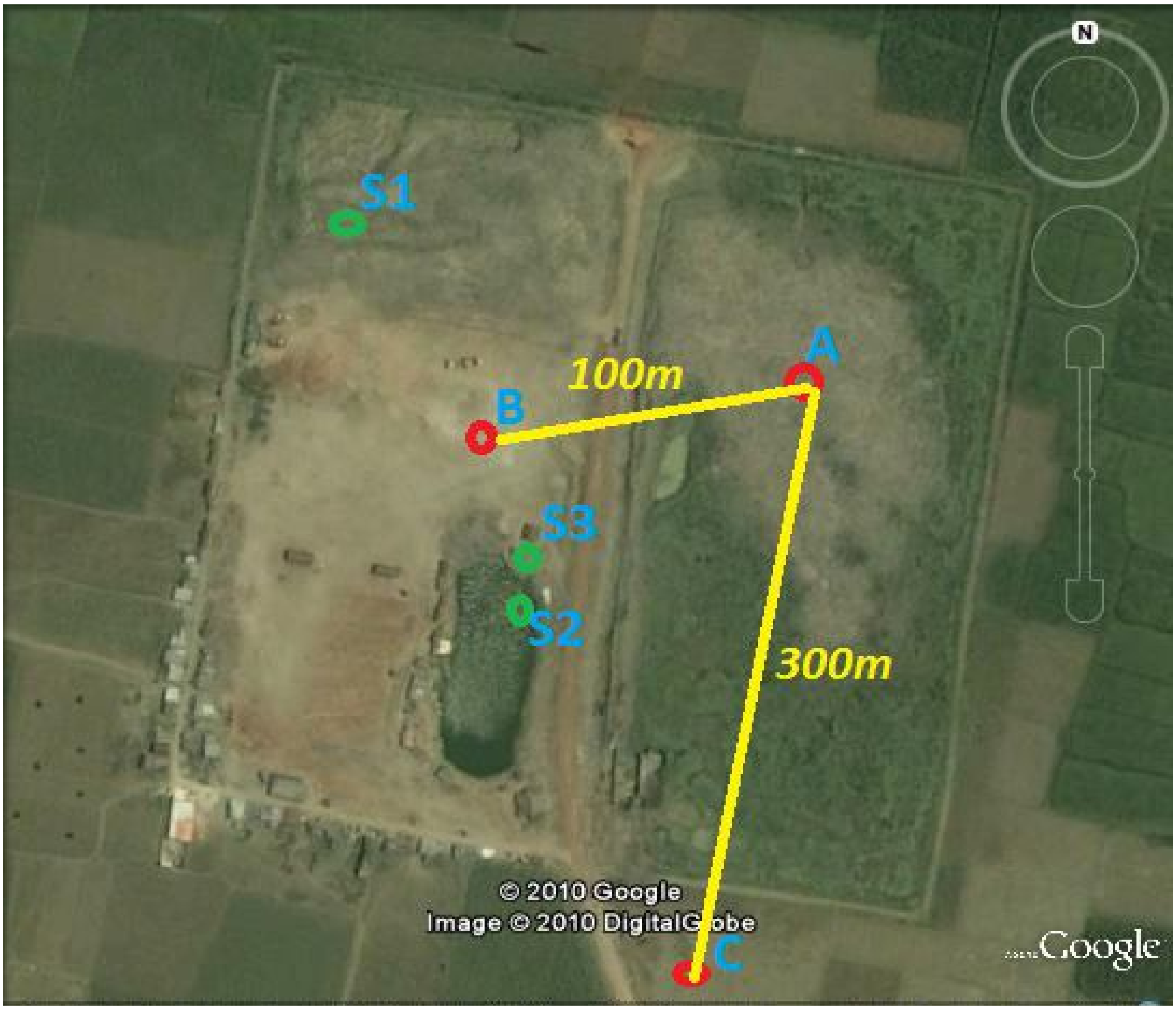

**Figure: 2.2 Soil and water sampling location (courtesy, Goole)**

### 2.2.2 Soil Sampling

Soil samples from the study area were collected using hand auger. Samples were taken from three location points of the dumping site namely A, B and C. Location point A was the the middle of the dump site, location point B was 100 m away from location A and Location point C was 300 m away from the location point A. The three sampling location points at the dumpsite are shown in figure 2.2. From each location point, three soil samples were collected, the first one was from the top soil, the 2nd one was from half meter (0.5 m) depth and the 3rd one was from one meter depth. Then collected samples were stored in plastic bags and transported to the laboratory for physical and chemical analysis using standard methods of analysis. pH, Potassium (K), Calcium (Ca), Phosphorus (P), Sulphur (S), Cupper (Cu), Iron (Fe), Manganese (Mn) and Zink (Zn) were measured in all soil samples. The soil sampling location points A, B and C are shown in figure 2.2.

## 2.3 Sample Preparation

### 2.3.1 Water Sample Preparation

200 ml water sample was digested with 5 ml of di-acid mixture ($HNO_3$:$HClO_4$:: 9:4 ratio) on a hot plate and evaporated to one-fifth of its volume, and then it was allowed to cool. It was then filtered through Whatman No. 42 filter paper and made up to a volume of 50 ml by double distilled water.

### 2.3.2 Soil Sample Preparation

#### 2.3.2.1 Extraction Method

The aquifer soil samples were air dried for 24 hour, followed by grinding and sieving. To estimate the concentration of Na, K, Mg, Ca, $HCO_3^-$, $Cl^-$ $NO_3^-$ and $SO_4^{2-}$, one part of air dried crushed soil was taken with 10 parts of neutral 1M ammonium acetate solution and shaken for 15 minutes. Then it was allowed to settle overnight. The supernatant was filtered and analyzed for various parameters by AAS (Atomic Absorption Spectrophotometer) and UV-Spectrophotometer. For Mn analysis one part air dried crushed soil was taken with 8 parts 0.5 M phosphoric acid extracting solution and shaken for 10 minutes. Then it was allowed to settle overnight. The supernatant was filtered prior to analysis by AAS.

#### 2.3.2.2 Digestion Method

Weight exactly 0.5g of dry soil sample was poured into a graduated test tube and mixed with 2 mL of aqua regia 1:3 (1 Conc. HCl: 3 Conc. $HNO_3$) for major heavy metal analyses such as Fe, Cu, Zn, As, Cd and Pd. The mixture was digested on a hot plate at 95°C for 1 hour and allowed to cool at room temperature. The sample was then diluted to 10 mL using double distilled water and allowed to settle overnight. The supernatant was filtered and analyzed using AAS as stated by Adams (1991).

## 2.4 Analysis of Samples

### 2.4.1 Analysis of Water Samples

The collected groundwater samples were analyzed for the parameters including pH, electrical conductivity (EC), dissolved oxygen (DO), biochemical oxygen demand ($BOD_5$), chemical oxygen demand (COD), carbonate ion ($CO_3^{2-}$) and bicarbonate ion ($HCO_3^-$), chloride (Cl), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), cupper (Cu), iron (Fe), manganese (Mn), zink (Zn) and Arsenic (As). DO, EC and pH were determined immediately after collection of the samples to avoid further contamination. $BOD_5$, COD, Alkalinity, Chloride, K, Ca, Mg, Na, Cu, Fe, Mn, Zn and As were tested in Adroit Enviroment Consultants Ltd. laboratory in Dhaka. All experiments were conducted very carefully to ensure accuracy and precision. All reagents used in this study were analytical grade chemicals.

#### I. pH, EC and DO

pH of water sample was measured by pH meter of HANNA brand. EC of water sample was measured by EC meter of HANNA brand. DO of water sample was measured by DO meter, pen type for pocket carry of HANNA brand.

#### II. $BOD_5$

BOD measures the rate of oxygen uptake by micro-organisms in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark.

#### A. Procedure:

The $BOD_5$ in water samples was determined as follows:

- Prepared dilution water by aerating with compressed air for ½ hour into a 2000 ml flask.
- Added 2 ml each of phosphate Buffer, Magnesium Sulfate, Calcium Chloride, and ferric Chloride solution to 2000ml distilled water. Also added 2ml of raw sewage to the dilution water.
- Filled two BOD bottle containing the sample and two clean bottles to the top with seeded dilution water.
- Placed one bottle containing the diluted sample and one bottle containing the seeded dilution water in the incubator at $20^0$ C $\pm 1^0$C for 5 days.
- Performed Do test on the remaining two BOD bottle Cone Sample and the seed within 15 minutes after preparation.

- Performed DO test on the two incubated BOD bottles (One sample and one seed) after five days and record test result.

**B. Calculation:**

$BOD_5$ (mg/l) = $(D_1-D_2) - (B_1-B_2) \times$ dilution factor.

Where,

$D_1$ = DO of diluted sample after 15 mts.

$D_2$ = DO of diluted sample after 5 days.

$B_1$ = DO of dilution water after 15 mts.

$B_2$ = DO of dilution water after 5 days.

### III. COD

Chemical oxygen demand (COD) is a measure of the ability of chemical reactions to oxidize matter in an aqueous system.

**A. Reagents:**

1. Standard potassium dichromate (0.25N) Dissolve 12.26 gm of $K_2Cr_{20}Y$ dried at 103 $^oC$ in distilled water and dilute to 1000 ml.
2. Standard ferrous ammonium sulphate 0.1N Dissolve 39.2 gm in the distilled water add 20 ml Conc.$H_2SO_4$ and dilute to 1000 ml

**B. Procedure:**

Dilute 10 ml $K_2Cr_{20}Y$ to 100 ml, add 30 ml Conc. $H_2SO_4$ and cool. Titrate with ferrous Am. Sulphate using 3 drops of feroin indication. ml of $K_2Cr_{20}Y \times 0.25$

Take 20ml of waste water sample add 10 ml of 0.25 N $K_2Cr_{20}Y$ and then add 30.0ml Cone $H_2SO_4$ Mixed with silver sulphate and digest foe 2 hours in a Fredricks Condenser. Cool down and make the final volume 140 ml using distilled water titrate with ferrous ammonium sulphate using ferrous indicator. End pt:- bluish green to red.

**C. Calculation:**

COD = $(a-b) \times N \times 8000/20$

a= ml of ferrous ammonium sulphate for blank

b= ml of ferrous ammonium sulphate for Sample.

### IV. Carbonate ion ($CO_3^{2-}$) and Bicarbonate ion ($HCO_3^-$)

The carbonate ion ($CO_3^{2-}$) and bicarbonate ion ($HCO_3^-$) in groundwater samples was determined using titration method, which describes as follows:

The alkalinity in water samples is caused due to the presence of carbonate ion ($CO_3^{2-}$), bicarbonate ion ($HCO_3^-$) and Hydroxide ion ($OH^-$). In this study $CO_3^{2-}$ and $HCO_3^-$ were determined.

**A. Reagents:** Phenolphthalein indicator, methyl orange indicator and 0.1 N HCl.

**a) Preparation of phenolphthalein indicator:** Phenolphthalein indicator was prepared by exactly taking 0.5 g phenolphthalein in a 100 mL volumetric flask and added 50% ethanol slowly and shaken well and finally made up to the mark with 50% ethanol. Then it was shaken well and finally stored in a glass bottle.

**b) Preparation of methyl orange indicator:** Methyl orange indicator was prepared by exactly taking 0.5 g methyl orange in a 100 mL volumetric flask and added deionized water slowly and shaken well and finally made up to the mark with deionized water. Then it was shaken well and finally stored in a glass bottle.

**B. Procedure:**

Each of 100 mL of water sample was taken in two separate 250 mL conical flasks. 2 drops of phenolphthalein indicator was added to the first flask and no color was found indicated that phenolphthalein alkalinity (PA) was zero (0). So, $CO_3^{2-}$ ion was absent in water sample. Then, 2 drops of methyl orange indicator was added to the 2nd conical flask and shaken gradually and color was detected. The sample containing 2nd flask was titrated with 0.1 N HCl until the color changed to orange and it indicated the end point. It indicated that $HCO_3^-$ ion was present in water samples and noted the volume (mL) of acid from the burette used for the titration.

**C. Calculation:**

$$\text{Total alkalinity (TA, } CaCO_3 \text{ mg/L)} = \frac{A \times N \times 1000 \times 50}{V}$$

Where, A= mL of HCl used for titration with methyl orange indicator

N=Normality of HCl=0.1 N HCl

V=Volume of water sample taken=100 mL

### V. Chloride ion ($Cl^-$)

The Chloride ion ($Cl^-$) in water samples was determined using $AgNO_3$ titration method, which describes as follows:

**A. Reagents:** $K_2CrO_4$ indicator and 0.0141 N $AgNO_3$.

**a. Preparation of 5% $K_2CrO_4$ (indicator):** 5% $K_2CrO_4$ indicator was prepared by exactly taking 5 g $K_2Cr_2O_4$ in a 100 mL volumetric flask and it was dissolved by 50 mL distilled water. Then 0.0141 N $AgNO_3$ was dded drop wise in the $K_2Cr_2O_4$ containing volumetric flask until the first permanent red precipitate was produced. Filtered the solution and finally it diluted by distilled water slowly and finally made up to the mark with the distilled water.

**b. Preparation of 0.0141 N $AgNO_3$:** 2.397 g of AgNO3 was weighed out, transferred to a 1000 mL volumetric flask and made up to the mark with distilled water gradually. The resulting solution was 0.0141 N. The solution was standardized against NaCl. Reagent-grade NaCl was dried overnight and cooled at a room temperature. 0.25 g portions of NaCl were weighed into Erlenmeyer flasks and it was dissolved by distilled water. Finally it was diluate up to the mark of 100 mL by distilled water. In order to adjust the pH of the solutions, small quantities of NaHCO3 were added until effervescence ceased. About 2 mL of $K_2CrO_4$ was added and the solution was titrated to the first permanent appearance of red $K_2CrO_4$.

**B. Procedure:**

At first 100 mL of water sample was filtered and taken in a 250 mL conical flask. 1 mL of $K_2CrO_4$ indicator was added to the flask and shaken slowly. Then sample was titrated with 0.0141 N $AgNO_3$ until the brick red color was arrived indicating the end point. Noted the mL of 0.0141 N $AgNO_3$ used for titration.

**C. Calculation:**

$$\text{Chloride } (Cl^-, \text{mg/L}) = \frac{(A \times N)}{V} \times 35450$$

Where, A= mL of 0.0141 N $AgNO_3$ used for titration from burette

N=Normality of $AgNO_3$=0.0141 N

V=Volume of water sample taken=100 mL

### VI. Potassium (K)

The potassium ion in water samples was determined using Atomic Absorption method, which describes as follows:

**A. Apparatus:** AAS wave length at 766.49 nm with 0.7 nm silt.

**B. Reagent:**

**(a) 1000 mg/L standard solution:** The standard solution of potassium ion was prepared by exactly taking 1.910 g of analytically pure (99%) KCl in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

(**b) Suppressing agents:**

**0.1% potassium:** 1 g of KCl was dissolved in a 100 mL volumetric flask and made up to the mark with distilled water gradually. To reduce percentage of relative standard deviation (RSD), 2 drops of 0.1% potassium solution was used for maintained in every standard and sample.

**C. Standard curve:** The proportions of 2, 8 and 10 mL K ion contained standard solutions were taken in three different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark with distilled water. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.3 in Appendix-2).

**D. Calculation:**

Potassium (K, mg/L) = Concentration of K (mg/L) from standard curve

### VII. Calcium (Ca)

The calcium ion in water samples was determined using Atomic Absorption method, which describes as follows:

**A. Apparatus:** AAS wave length at 422.7 nm with 0.7 nm silt.

**B. Reagent:**

**(a) 1000 mg/L standard solution:** The standard solution of calcium ion was prepared by exactly taking 0.250 g of analytically pure (99%) $CaCO_3$ in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

**(b) Suppressing agents:**

**0.2% Lanthanum solution:** The solution of 2% lanthanum was prepared by exactly taken 2 g of lanthanum chloride in a 100 mL volumetric flask and added to the 3 mL of 1M HCl. Again it was dissolved distilled water and finally, made up to the mark with distilled water gradually and shaken well. Then 10 mL of 2% lanthanum was taken and diluted 100 mL with distilled water to make the final concentrated of 0.2% lanthanum. That solution was used for maintained in every standard and sample.

**C. Standard curve:** The proportions of 0.5, 1 and 2 mL Ca ion contained standard solutions were taken in three different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark with distilled water. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.4 in Appendix-2).

**D. Calculation:**

Calcium (Ca, mg/L) = Concentration of Ca (mg/L) from standard curve × dilution factor.

### VIII. Magnesium (Mg)

The magnesium ion in water samples was determined using Atomic Absorption method, which describes as follows:

**A. Apparatus:** AAS wave length at 285.21 nm with 0.7 nm silt.

**B. Reagent:**

**(a) 1000 mg/L standard solution:** The standard solution of magnesium ion was prepared by exactly taking 1.650 g of analytically pure (99%) MgO in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

**b) Suppressing agent:**

**0.1% Lanthanum solution:** The solution of 1% lanthanum (La) was prepared by exactly taken 1 g of lanthanum chloride in a 100 mL volumetric flask and added to the 1.50 mL of 1M HCl. Then it was dissolved distilled water and finally, made up to the mark with distilled water gradually and shaken well. 10 mL of 1 % lanthanum was taken and diluted 100 mL with distilled water to make the final concentrated of 0.1% La. This solution was used for maintained in every standard and sample.

**C. Standard curve:** The proportions of 50, 100, 150 and 200 mL Mg ion contained standard solutions were taken in four different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark with distilled water. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.2 in Appendix-2)

**D. Calculation:**

Magnesium (Mg, mg/L)

$$= (\text{CmoL concentration of Mg from standard curve} \times \text{dilution factor}) \times 1000$$

### IX. Sodium (Na)

The sodium ion in groundwater samples was determined using Atomic Absorption method, which describes as follows:

**A. Apparatus:** AAS wave length at 330.2 nm with 0.7 nm silt.

**B. Reagent:**

**(a) 1000 mg/L standard solution:** The standard solution of sodium ion was prepared by exactly taking 2.540 g of analytically pure (99%) NaCl in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

**b) Suppressing agent:**

**0.1% potassium:** 5.20 g of KCl was dissolved in a 1000 mL volumetric flask and made up to the mark with distilled water gradually. Then 100 mL of 1% potassium ion solution was taken and diluted 1000 mL with distilled water to make the final concentrated of 0.1% K. To reduce percentage of relative standard deviation (RSD), 2 drops of 0.1% potassium solution was used for maintained in every standard and sample.

**C. Procedure:**

**(a) Sample preparation:** 100 mL water sample was taken in a beaker and added 2 mL concentrated $HNO_3$ and 3 mL concentration HCl. The beaker was heated 90-95°C on a hot plate until the volume of water was reached at 10-15 mL. Then, it was removed from hot plate and allowed to cool. Then samples were filtered through 0.45 µm pore membrane filter. Finally, the volume was made up to 100 mL with distilled water. Similar procedure was followed for the samples preparation of Mg, K, Ca, Mn, Fe, Cu, Zn, As, Cd and Pb.

**(b) Standard curve:** The proportions of 2, 5, 8 and 10 mL Na ion contained standard solutions were taken in four different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.1 in Appendix-2).

**D. calculation:**

Sodium (Na, mg/L) = Concentration of Na (mg/L) from standard curve × dilution factor

### X. Copper (Cu)

The copper ion in water samples was determined using Atomic Absorption method, which describes as follows:

**A. Apparatus:** AAS wave length at 324.75 nm with 0.7 nm silt.

**B. Reagent:**

**1000 mg/L standard solution:** The standard solution of copper ion was prepared by exactly taking 3.930 g of analytically pure (99%) $CuSO_4.5H_2O$ in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

**C. Standard curve:** The proportions of 0.5, 1 and 2 mL Cu ion contained standard solutions were taken in three different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark with distilled water. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.7 in Appendix-2).

**D. Calculation:**

Copper (Cu, mg/L) = Concentration of Cu (mg/L) from standard curve

### XI. Iron (Fe)

The iron ion in water samples was determined using Atomic Absorption method, which describes as follows:

**A. Apparatus**: AAS wave length at 248.3 nm with 0.7 nm silt.

**B. Reagent:**

**1000 mg/L standard solution:** The standard solution of iron ion was prepared by exactly taking 4.980 g of analytically pure (99%) $FeSO_4.7H_2O$ in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

**C. Standard curve:** The proportions of 0.50, 1 and 2 mL Fe ion contained standard solutions were taken in three different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark with distilled water. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.6 in Appendix-2).

**D. Calculation:**

Iron (Fe, mg/L) = Concentration of Fe (mg/L) from standard curve) × dilution factor

### XII. Manganese (Mn)

The manganese ion in water samples was determined using Atomic Absorption method, which describes as follows:

**A. Apparatus:** AAS wave length at 279.48 nm with 0.2 nm silt.

**B. Reagent:**

**(a) 1000 mg/l standard solution:** The standard solution of manganese ion was prepared by exactly taking 3.070 g of analytically pure (99%) $MnSO_4.10H_2O$ in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

**b) Suppressing agent:**

**0.2% Calcium:** The solution of 2% calcium was prepared by exactly taken 2 g of $CaCO_3$ in a 100 mL volumetric flask and added to the 3 mL of 1M HCl. Then it was dissolved distilled water and finally, made up to the mark with distilled water gradually and shaken well. Then 10 mL of 2% $CaCO_3$ solution was taken and diluted 100 ml with distilled water to make the final concentrated of 0.2% $CaCO_3$. This solution was used for maintained in every standard and sample.

**C. Standard curve:** The proportions of 1, 3 and 5 mL Mn ion contained standard solutions were taken in three different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark with distilled water. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.5 in Appendix-2).

**D. Calculation:**

Manganese (Mn, mg/L) = Concentration of Mn (mg/L) from standard curve

### XIII. Zinc (Zn)

The zinc ion in water samples was determined using Atomic Absorption method, which describes as follows:

**A. Apparatus:** AAS wave length at 213.86 nm with 0.7 nm silt.

**B. Reagent:**

**1000 mg/L standard solution:** The standard solution of zinc ion was prepared by exactly taking 4.980 g of analytically pure (99%) $ZnSO_4.7H_2O$ in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

**C. Standard curve:** The proportions of 1, 3 and 5 mL Cu ion contained standard solutions were taken in three different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark with distilled water. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.8 in Appendix-2).

**D. Calculation:**

Zinc (Zn, mg/L) = Concentration of Zn (mg/L) from standard curve

### XIV. Arsenic (As)

The arsenic ion in water samples was determined using Atomic Absorption method by graphite furnace, which describes as follows:

**A. Apparatus:** AAS wave length at 193.70 nm with 0.7 nm silt.

**B. Reagent:**

**1000 mg/L standard solution:** The standard solution of arsenic ion was prepared by exactly taking 1.3203 g of analytically pure (99%) $As_2O_3$ in a 1000 mL volumetric flask and added distilled water slowly and shaken well and finally made up to the mark with distilled water.

**C. Standard curve**: The proportions of 4, 12 and 20 ppm As ion contained standard solutions were taken in three different 1000 mL volumetric flasks and distillated water was gradually added and thoroughly shaken and finally made up to the mark with distilled water. Absorbance of the water samples were determined by AAS. A standard curve was made by plotting the absorbance against the concentration (Figure 2.9 in Appendix-2).

**D. Calculation:**

$$\text{Total inorganic Arsenic (As, mg/L)} = \text{Concentration of As } (\mu\text{g/L}) \text{ from standard curve} \times 1000$$

### 2.4.2 Collection of Noise Level Data

Noise was taken at day time by Sound Level Meter (DT-8850) Calibration at 94dB.

## 2.5 Flora and Fauna

Data of Flora and Fauna near the area of solid waste dumping site was taken by field survey of one year.

## 2.6 Metrological Data

Secondary data was taken from BBS and metrological department of Bangladesh.

# CHAPTER 3

# RESULTS AND DISCUSSION

# RESULTS AND DISCUSSION

Surface and ground water samples were collected in every second month covering two years. Surface water samples were collected from two surface water bodies available in the study area and ground water samples were collected from available shallow tube well in the study area. Soil samples were collected from three selected locations during pre and post- monsoon covering two years. During the field visit, available flora, fauna and noise data were collected in the study area. The collected samples were analyzed for some major physico-chemical parameters and their results are discussed here.

## 3.1 Physico-chemical Parameters of Soil and Water

### 3.1.1 Physico chemical Parameters of Water

### 3.1.1.1 Surface Water

There are two surface water bodies in the study area. The surface water sources are marked as sampling point S1, located adjacent to the dump site and S2, was about 100 meter away from the dump siteDuring dry season water level at sampling point S1 decreased and become almost dry and at the sampling point S2, water level went down but not completely dry. The analysis results of the surface water samples for some selected parameters are shown in Table 3.1 to Table 3.6.

### i. Physical Parameters (pH, EC, DO, $BOD_5$ and COD)

Table 3.1 and table 3.2 shows that pH of surface water increased with time during the study period. pH was recorded 6.6 and 7.0 in the beginning for the locations S1 and S2, respectively and 7.9 and 7.8 at the end for locations S1 and S2, respectively. Location S1 was nearer to the center of the dump site comparing to location S2. Values of pH in both locations were almost the same and increased with time due to cause of regular solid waste dumping. The results indicate that the surface water pH at sampling location S1 and S2 were found within DoE Bangladesh standard. A pH range of 6.0 to 9.0 appears to provide protection for the life of freshwater fish and bottom dwelling invertebrates (ECR, 1997). The pH trends of the surface waters in the study area will lead to increase harmful effect on aquatic life in future. This observation is supported by Kaluli (2011).

**Table 3.1**

Surface water pH, EC, DO, $BOD_5$ and COD at location S1 during 2010 – 2012

| Month | pH | EC (µS/cm) | DO (mg/l) | $BOD_5$ (mg/l) | COD (mg/l) |
|---|---|---|---|---|---|
| August, 2010 | 6.6 | 1229 | 0.5 | 148.4 | 365.7 |
| October, 2010 | 6.5 | 1310 | 0.5 | 158.4 | 398 |
| December, 2010 | 6.6 | 1314 | 1.0 | 160.6 | 399.8 |
| February, 2011 | 7.5 | 1435 | 0.5 | 177.9 | 448.3 |
| April, 2011 | 7.6 | 1438 | 1.5 | 178.4 | 447.7 |
| June, 2011 | 7.8 | 1445 | 0.5 | 175.7 | 451.1 |
| August, 2011 | 7.6 | 1450 | 1.0 | 180 | 454 |
| October, 2011 | 7.7 | 1455 | 0.5 | 182.2 | 456 |
| December, 2011 | 7.6 | 1454 | 0.5 | 184.1 | 456.8 |
| February, 2012 | 7.6 | 1454 | 1.5 | 184.5 | 457.1 |
| April, 2012 | 7.6 | 1457 | 1.0 | 187.8 | 459.5 |
| June, 2012 | 7.7 | 1466 | 0.5 | 196.1 | 465.2 |
| July, 2012 | 7.9 | 1480 | 0.5 | 210 | 475 |
| *DoE Standard* | *6-9* | *≤ 1200* | *4.5-8* | *≤ 50* | *≤ 200* |

The surface water EC (Electrical conductivity) was recorded 1229 µS/cm and 1011 µS/cm in the beginning at locations S1 and S2, respectively and at the end, it was 1480 µS/cm and 1210 µS/cm, respectively for the above locations (Table 3.1 and 3.2) . It was also found that the surface water EC at sampling location S1 were higher than DoE, Bangladesh standard from the beginning of the study. But in case of location S2, the EC value was found within DoE, Bangladesh standard till June, 2012 but it was exceeded the limit in July, 2012. The table shows that EC increased gradually in both locations. Report showed that conductivity varies with water source, ground water, water drained from agricultural fields, municipal waste water and rainfall. The study observes that leachate from the open dump contaminated the surrounding surface water body may be the cause of increasing conductivity. Irshad (2011) stated that, the higher EC indicates the greater amount of salts in the water due to dumping of solid waste. Maas and Hofhan (1977) stated that irrigation water quality may cause significant yield reduction for certain crops. Thus the surface water around the dump site could not be used for irrigation purpose.

**Table 3.2**

Surface water pH, EC, DO, $BOD_5$ and COD at location S2 during 2010 – 2012

| Month | pH | EC (µS/cm) | DO (mg/l) | $BOD_5$ (mg/l) | COD (mg/l) |
|---|---|---|---|---|---|
| August, 2010 | 7.0 | 1011 | 0.5 | 128.7 | 327.9 |
| October, 2010 | 7.2 | 1070 | 1.0 | 132.8 | 342.2 |
| December, 2010 | 7.2 | 1073 | 1.5 | 136.9 | 348.1 |
| February, 2011 | 7.8 | 1161 | 1.5 | 148.6 | 350 |
| April, 2011 | 7.8 | 1168 | 2.0 | 145.7 | 363.8 |
| June, 2011 | 8.0 | 1167 | 1.5 | 145.8 | 373.6 |
| August, 2011 | 7.9 | 1172 | 2.5 | 146.8 | 372.1 |
| October, 2011 | 7.8 | 1178 | 1.0 | 147.1 | 376.9 |
| December, 2011 | 7.8 | 1177 | 0.5 | 148.6 | 374.2 |
| February, 2012 | 7.7 | 1177 | 3.0 | 148.9 | 374.7 |
| April, 2012 | 7.8 | 1181 | 2.0 | 148.8 | 375.2 |
| June, 2012 | 7.7 | 1192 | 2.5 | 147.9 | 376.8 |
| July, 2012 | 7.8 | 1210 | 3.0 | 149.3 | 379.5 |
| *DoE Standard* | *6-9* | *≤ 1200* | *4.5-8* | *≤ 50* | *≤ 200* |

In the beginning surface water DO was found 0.5 mg/l and at the end, it was 0.5 mg/l at location S1 (Table 3.1 and 3.2). Similarly DO at location S2 was found to be 0.5 mg/l in the beginning and 3.0 mg/l at the end of the study. Water quality at location S2 was better than location S1 and surface water DO at both locations were found within DoE, Bangladesh standard limit. The lower DO values indicate oxygen consumption during respiration and decomposition of microorganisms in water. M. S. Islam (2012) stated that disposal of solid waste was the main source of microorganisms in water, reduced DO level. Oxygen is necessary for terrestrial animals, fish and other aquatic organisms to live, and thus minimum amount of dissolved oxygen need to be present in water to sustain aquatic life.Oxygen also is needed by virtually all algae and all macrophytes, and for many chemical reactions that are important to lake functioning stated by Michaud (1991). The results illustrate that DO level in surface water around the dump site was found very low indicating poor water quality.

Table 3.1 and 3.2 shows that surface water $BOD_5$ was found to be 148.4 mg/l and 128.7 mg/l at sampling locations S1 and S2, respectively in the beginning of the study(August, 2010) and at the end of the study it was 210 mg/l and 149.3 mg/l (July, 2012) at locations S1 and S2, respectively. The result shows that $BOD_5$ was higher than DoE standard from the beginning of the study and increased gradually with time for both locations. The $BOD_5$ values in all case were found far above the DoE, Bangladesh standard indicating plenty of organic matter present that is available energy for organism. M. S. Islam (2012) stated that the DO is the amount of oxygen dissolved in water, while the BOD is the amount of oxygen used by the biological organisms during biodegradation. Therefore, when the BOD is high in a water body then the amount of DO is low. A similar observation was found in the study where low values of DO were recorded.

COD test is commonly used to indirectly measure the amount of organic compounds in water. In table 3.1 and 3.2, COD was found to be 365.7 mg/l and 327.9 mg/l at locations S1 and S2, respectively in the beginning and it was 475 mg/l and 379.5 mg/l, respectively for the same locations at the end of the study. All COD values were found higher than the DoE standard. The study observed that COD increased with time for both locations. Most applications of COD determine the amount of organic pollutants found in surface water or wastewater, making COD a useful measure of water quality stated by Clair N. Sawyer (2003). The study results show that all COD values were found higher than the DoE standard indicating higher pollution level in the area.

### i i. Anionic Parameters ($HCO_3^-$ and $Cl^-$)

The surface water $HCO_3^-$ (Bicarbonate )was recorded to be 392 mg/l and 600 mg/l in the beginning at locations S1 and S2, respectively and at the end, it was 446 mg/l and 684 mg/l, respectively for the same locations (Table 3.3 and table 3.4). It was also found that the surface water $HCO_3^-$ at sampling location S2 were higher than those of location S1. DoE, Bangladesh has yet to set the standard values for $HCO_3^-$. Result shows that $HCO_3^-$ increased gradually in both locations. Landfill leachate may be the cause of high concentration of $HCO_3^-$ indicating the pollution of water bodies (Azim, 2011). Incorporation of cations and anions affect the alkalinity stated Butler (1982).

**Table 3.3**

Surface water $HCO_3^-$ and $Cl^-$ at location S1 during 2010 – 2012

| Month | $HCO_3^-$ (mg/l) | $Cl^-$ (mg/l) |
|---|---|---|
| August, 2010 | 392 | 504.84 |
| October, 2010 | 398 | 513.44 |
| December, 2010 | 402 | 517.75 |
| February, 2011 | 409 | 527.41 |
| April, 2011 | 413 | 532.26 |
| June, 2011 | 422 | 544.35 |
| August, 2011 | 432 | 556.45 |
| October, 2011 | 434 | 558.7 |
| December, 2011 | 435 | 559.83 |
| February, 2012 | 438 | 562.37 |
| April, 2012 | 439 | 563.64 |
| June, 2012 | 442 | 566.82 |
| July, 2012 | 446 | 570 |
| *DoE Standard* | *NYS* | $\leq$ *600* |

Table 3.3 and 3.4 shows that $Cl^-$ (Chloride) of surface water increased with time during the study period. $Cl^-$ was recorded 504.84 mg/l and 339.89 mg/l in the beginning for the locations S1 and S2, respectively and 570 mg/l and 390 mg/l at the end for the locations S1 and S2, respectively. The results indicate that the surface water $Cl^-$ at sampling location S1 and S2 were found within DoE Bangladesh standard.

**Table 3.4**

Surface water $HCO_3^-$ and $Cl^-$ at location S2 during 2010 – 2012

| Month | $HCO_3^-$ (mg/l) | $Cl^-$ (mg/l) |
|---|---|---|
| August, 2010 | 600 | 339.89 |
| October, 2010 | 610 | 345.85 |
| December, 2010 | 616 | 348.84 |
| February, 2011 | 628 | 355.52 |
| April, 2011 | 634 | 358.9 |
| June, 2011 | 649 | 367.29 |
| August, 2011 | 664 | 375.69 |
| October, 2011 | 667 | 378.07 |
| December, 2011 | 669 | 379.26 |
| February, 2012 | 672 | 381.95 |
| April, 2012 | 674 | 383.29 |
| June, 2012 | 679 | 386.64 |
| July, 2012 | 684 | 390 |
| *DoE Standard* | *NYS* | $\leq$*600* |

Azim (2011) stated that landfill leachate was also the main source of high $Cl^-$ concentration in the water body. Birge (1985) reported that in order to protect aquatic life and its uses, for any consecutive 3-day period, the chloride concentration should not exceed 600 mg/L. MacDonald (1997) illustrated that the solubility of sodium chloride is 35.7g/100g water at $0^oC$, in which they persist in dissociated form as chloride anions with their corresponding positively charged cations (e.g., sodium).

### iii. Cataonic Parameters ($K^+$, $Ca^{2+}$, $Mg^{2+}$, $Na^+$, $Cu^{2+}$, $Fe^{3+}$, $Mn^{2+}$ and $Zn^{2+}$)

$K^+$ (Potassium) occurs in various minerals, from which it may be dissolved through weathering processes. $K^+$ release from landfills for domestic waste is usually exceptionally high; this compound may be applied as an indicator for other toxic compounds in surface water. In the beginning $K^+$ in surface water was found to be 113 mg/l and at the end, it was 310 mg/l at the location S1 (Table 3.5 and 3.6). Similarly $K^+$ at location S2 was found to be 112 mg/l in the beginning and 1130 mg/l at the end of the study. $K^+$ level in both the location increased with time. The table shows that $K^+$ level at location S2 increased rapidly compare to the location $S_1$, particularly in August, 2011. July-August is the rainy season of Bangladesh and there might have some pollutant containing $K^+$ in solid waste which was washed out during that time. There is no DoE standard for $K^+$ concentration in surface water. High concentration of $K^+$ indicating the pollution of water bodies by landfill leachate stated by Md. Azim (2011). $K^+$ is a dietary requirement in playing an important role in nerve functions. $K^+$ plays a central role in plant growth, and it often limits it. $K^+$ salts may kill plant cells because of high osmotic activity stated in CRC (1990). However, higher $K^+$ concentration in surface water may have some harmful effects on aquatic live.

Table 3.5 and table 3.6 shows that $Ca^{2+}$ (Calcium) in surface water was found to be 8 mg/l and 27 mg/l at sampling locations S1 and S2, respectively in the beginning of the study (August, 2010) and at the end of the study it was 133 mg/l and 167 mg/l (July, 2012) at locations S1 and S2, respectively. The result shows that $Ca^{2+}$ was increased gradually with time for both locations. It was changed rapidly after August, 2011. Reason might be washed out of waste by rain water to the surface. There is no limit for $Ca^{2+}$ in surface water of DoE, Bangladesh. If $Ca^{2+}$ concentration in freshwater drops below 5 mg/L, it can support only sparse plant and animal life, this condition is known as oligotrophic that was stated on Water Quality with Vernier by Robyn L. Johnson et al.

$Mg^{2+}$ (Magnesium) is the eighth most abundant natural element. It makes up 2.5 percent of the Earth's crust and is commonly found in such minerals as magnesite, dolomite, olivine, serpentine, talc, and asbestos. It is present in all natural waters and is a major contributor to water hardness stated by Day, F.H. (1963). In Table 3.5 and table 3.6, $Mg^{2+}$ was found to be 47 mg/l and 46 mg/l at locations S1 and S2, respectively in the beginning and it was 720 mg/l and 830 mg/l, respectively for the same locations at the end of the study. It was changed rapidly after August, 2011. July-August is the rainy season of Bangladesh and there might have some pollutant in solid waste which was washed out during that time to that surface water. There is no DoE standard for $Mg^{2+}$ in surface water.

**Table 3.5**

Surface water $K^+$, $Ca^{2+}$, $Mg^{2+}$, $Na^+$, $Cu^{2+}$, $Fe^{3+}$, $Mn^{2+}$ and $Zn^{2+}$ at location S1 during 2010 – 2012

| Month | $K^+$ (mg/l) | $Ca^{2+}$ (mg/l) | $Mg^{2+}$ (mg/l) | $Na^+$ (mg/l) | $Cu^{2+}$ (mg/l) | $Fe^{3+}$ (mg/l) | $Mn^{2+}$ (mg/l) | $Zn^{2+}$ (mg/l) |
|---|---|---|---|---|---|---|---|---|
| August, 2010 | 113 | 8 | 47 | 135 | 0.01 | 0.11 | 0.27 | - |
| October, 2010 | 115 | 9 | 55 | 135 | 0.01 | 0.11 | 0.27 | - |
| December, 2010 | 116 | 10 | 59 | 136 | 0.01 | 0.11 | 0.27 | - |
| February, 2011 | 118 | 11 | 68 | 136 | 0.02 | 0.11 | 0.28 | 0.01 |
| April, 2011 | 119 | 12 | 73 | 137 | 0.02 | 0.12 | 0.28 | 0.01 |
| June, 2011 | 122 | 14 | 84 | 138 | 0.02 | 0.12 | 0.29 | 0.01 |
| August, 2011 | 125 | 16 | 96 | 139 | 0.02 | 0.12 | 0.3 | 0.02 |
| October, 2011 | 155 | 41 | 200 | 249 | 0.02 | 0.25 | 0.3 | 0.04 |
| December, 2011 | 171 | 54 | 252 | 304 | 0.04 | 0.31 | 0.31 | 0.06 |
| February, 2012 | 205 | 83 | 369 | 428 | 0.07 | 0.46 | 0.32 | 0.06 |
| April, 2012 | 223 | 97 | 427 | 490 | 0.09 | 0.53 | 0.32 | 0.09 |
| June, 2012 | 266 | 133 | 573 | 645 | 0.13 | 0.71 | 0.33 | 0.1 |
| July, 2012 | 310 | 170 | 720 | 800 | 0.17 | 0.90 | 0.35 | 0.1 |
| *DoE Standard* | *NYS* | *NYS* | *NYS* | *NYS* | *≤0.5* | *≤2.0* | *≤5.0* | *≤5.0* |

**Table 3.6**

Surface water $K^+$, $Ca^{2+}$, $Mg^{2+}$, $Na^+$, $Cu^{2+}$, $Fe^{3+}$, $Mn^{2+}$ and $Zn^{2+}$ at location S2 during 2010 – 2012

| Month | $K^+$ (mg/l) | $Ca^{2+}$ (mg/l) | $Mg^{2+}$ (mg/l) | $Na^+$ (mg/l) | $Cu^{2+}$ (mg/l) | $Fe^{3+}$ (mg/l) | $Mn^{2+}$ (mg/l) | $Zn^{2+}$ (mg/l) |
|---|---|---|---|---|---|---|---|---|
| August, 2010 | 112 | 27 | 46 | 134 | 0.04 | 8.84 | 0.16 | - |
| October, 2010 | 113 | 26 | 56 | 135 | 0.03 | 9 | 0.18 | - |
| December, 2010 | 117 | 26 | 61 | 135 | 0.03 | 9.08 | 0.19 | - |
| February, 2011 | 116 | 28 | 72 | 135 | 0.04 | 9.26 | 0.20 | - |
| April, 2011 | 119 | 27 | 78 | 138 | 0.04 | 9.35 | 0.26 | - |
| June, 2011 | 120 | 27 | 92 | 139 | 0.04 | 9.57 | 0.26 | 0.01 |
| August, 2011 | 125 | 27 | 107 | 139 | 0.04 | 9.8 | 0.29 | 0.01 |
| October, 2011 | 292 | 57 | 227 | 282 | 0.06 | 8.57 | 0.32 | 0.01 |
| December, 2011 | 376 | 72 | 287 | 354 | 0.08 | 7.95 | 0.48 | 0.02 |
| February, 2012 | 564 | 107 | 423 | 515 | 0.11 | 6.57 | 0.84 | 0.04 |
| April, 2012 | 658 | 124 | 491 | 596 | 0.12 | 5.87 | 1.02 | 0.05 |
| June, 2012 | 894 | 167 | 660 | 798 | 0.16 | 4.14 | 1.47 | 0.1 |
| July, 2012 | 1130 | 210 | 830 | 1000 | 0.20 | 2.42 | 1.92 | 0.1 |
| *DoE Standard* | *NYS* | *NYS* | *NYS* | *NYS* | *≤0.5* | *≤2.0* | *≤5.0* | *≤5.0* |

Natural water contains some $Na^+$ (Sodium). Table 3.5 and 3.6 show that $Na^+$ in surface water increased with time during the study period. $Na^+$ concentration was 135 mg/l and 134 mg/l in the beginning for the locations S1 and S2, respectively and 800 mg/l and

1000 mg/l at the end for the same locations, respectively. Values of $Na^+$ in both locations were increased with time probably resulted from excessive salt using in cattle feed, which was leachate out of the ions by rain water. There is no DoE standard for $Na^+$ in surface water but exceeded USEPA (USEPA, 2000). Cow HAAT is near to the dump site, salt is used for food of cow, therefore that may be one of the reason for increasing of $Na^+$ at the area. Relatively high $Na^+$ content in water reduces the infiltration rate at which irrigation water enters soil to such an extent that sufficient water cannot be infiltrated to supply the crop adequately from one irrigation to the next, stated by R.S. Ayers and D.W. Westcot (1998).

$Cu^{2+}$ (Cupper) in surface water was recorded to be 0.01 mg/l and 0.04 mg/l in the beginning at locations S1 and S2, respectively and at the end, it was 0.17 mg/l and 0.2 mg/l, respectively for the same locations (Table 3.5 and 3.6). It was also found that the surface water $Cu^{2+}$ of both locations increased with time but all the values were found within DoE, Bangladesh standard during study period. According to DoE, Bangladesh standard, $Cu^{2+}$ of surface water should be less than 0.5 mg/l. M. S. Islam (2012) reported that $Cu^{2+}$ concentration in surface water near a solid waste dump site was 0.05-0.1 mg/l and this observation supported the present study results. $Cu^{2+}$ is generally present in surface waters as the primary form in natural surface waters. In freshwater systems, naturally occurring concentrations of $Cu^{2+}$ range from 0.2 μg/L to 30 μg/L stated by Bowen (1985). Acute toxic effects may include mortality of organisms; chronic toxicity can result in reductions in survival, reproduction, and growth stated in Water Quality Criteria Copper Aquatic Life Criteria, United States Environmental Protection Agencies. Fortunately, $Cu^{2+}$ concentration was found within the standard limit at both the locations during the study period indicating that the solid wastes contained less metallic component.

In the beginning surface water $Fe^{3+}$ (Iron) was found to be 0.11 mg/l and at the end, it was 0.9 mg/l at location S1 (Table 3.5 and 3.6). It was increased with time but it was within DoE, Bangladesh standard. Similarly $Fe^{3+}$ at location S2 was found to be 8.84 mg/l in the beginning and 2.42 mg/l at the end of the study. $Fe^{3+}$ at location S2 increased from August, 2010 to August, 2011 and then it decreased gradually with time. It was also observed from the study, that DO of the location S2 was found comparatively high from February, 2012 to July, 2012 hence oxidation might be a reason of decrease of $Fe^{3+}$. Amount of $Fe^{3+}$ in surface water at location S2 exceeded DoE, Bangladesh standard. $Fe^{3+}$ is a dietary requirement for most organisms, and plays an important role in natural processes in binary and tertiary form. $Fe^{3+}$ is often a limiting factor for water organisms in surface layers. When chelation ligands are absent, water insoluble tertiary iron hydroxides precipitate. This is not thought to be hazardous for aquatic life, because not much is known about hazards of water borne $Fe^{3+}$ stated by Helsinki (1995).

Table 3.5 and 3.6 shows that surface water $Mn^{2+}$ (Manganese) was found to be 0.27 mg/l and 0.16 mg/l at sampling locations S1 and S2, respectively in the beginning of the study (August, 2010) and at the end of the study it was 0.33 mg/l and 1.47 mg/l (July, 2012) at locations S1 and S2, respectively. The result shows that $Mn^{2+}$ was found within DoE standard from the beginning of the study but increased gradually with time for both locations. The $Mn^{2+}$ values in all case were found below the DoE, Bangladesh standard. But increasing tendency of $Mn^{2+}$ in surface water could increase threat to environmet in future. $Mn^{2+}$ is generally present in natural surface waters as dissolved or suspended matter stated in Canadian water quality guidelines (1987).

Table 3.5 and 3.6 show that $Zn^{2+}$ (Zinc) was not detected in location S1 in the beginning of the study in December, 2010 but it was found to be 0.01 mg/l in February, 2011 and at the end of the study it was 0.10 mg/l in July, 2012. Similarly $Zn^{2+}$ was also not detected in location S2 in the beginning of the study in April, 2011 but it was found 0.01 mg/l in June, 2011 and at the end of the study it was 0.01 mg/l in July, 2012. $Zn^{2+}$ is an essential element and is generally considered to be non-toxic. Intake of $Zn^{2+}$ from food is more than sufficient to satisfy the recommended daily requirements. Toxicity from dietary $Zn^{2+}$ has not been reported, although occupational exposure or pharmacological interventions can produce symptoms stated by Browing (1969). The industrial waste has significant amounts of $Zn^{2+}$ stated by Duval (1980). During study it was also observed that industrial solid wastes are also dumped at the study area along with domestic waste and it might be the reason for increase of concentration of $Zn^{2+}$ in surface water at study area.

No As (Arsenic) was detected in surface water samples at location S1 and S2 during the study period indicating no threat to environment. In natural water As participates in oxidation and reduction reactions, coagulation and adsorption. Adsorption of As to fine particles in water and precipitation with aluminium or iron hydroxides causes arsenic to enter sediments.

In the beginning at location S1, the mean concentrations of the cations in surface water samples were followed in the order: $Na^{+} > K^{+} > Mg^{2+} > Ca^{2+} > Mn^{2+} > Fe^{3+} > Cu^{2+} > Zn^{2+}$ and at the end they were followed the order: $Na^{+} > Mg^{2+} > K^{+} > Ca^{2+} > Fe^{3+} > Mn^{2+} > Cu^{2+} > Zn^{2+}$. It was observed that the concentration of all the cations increased with time. The results show that the concentration of most of the analyzed cations changed rapidly considering their initial value. The results show that $Na^{+}$, $K^{+}$**,** $Mg^{2+}$ and $Ca^{2+}$ increased about 6, 3, 15 and 21 times in two years study period for the location S1 and increased about 7, 10, 18 and 8 times during the same period at location S2 for above cations, respectively. Similarly, in the beginning, the mean concentrations of cations for the location S2 were followed in the order: $Na^{+} > K^{+} > Mg^{2+} > Ca^{2+} > Fe^{3+} > Mn^{2+} > Cu^{2+} > Zn^{2+}$ and at the end of the study, they were: $K^{+} > Na^{+} > Mg^{2+} > Ca^{2+} > Fe^{3+} > Mn^{2+} > Cu^{2+} > Zn^{2+}$.

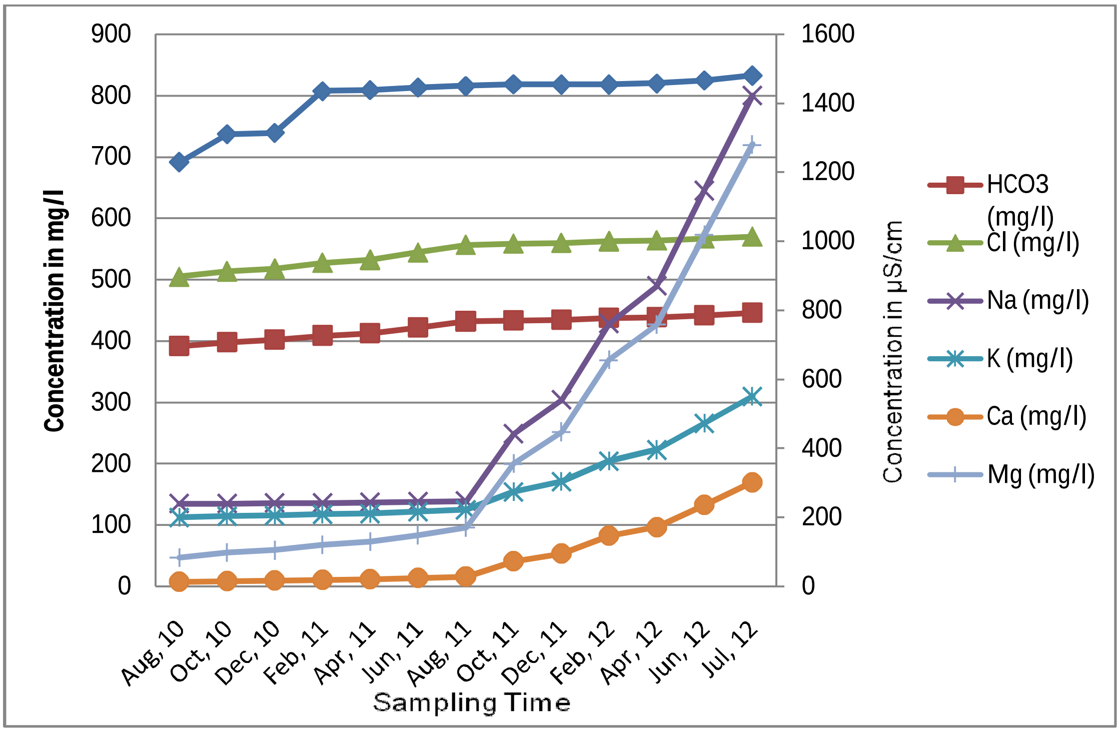

**Figure: 3.1 Variation of EC, major cations and anions with time at location S1**

Variations of EC, major cations and anions with time are shown in Figure 3.1. In the begining concentration of all cations and anions increased slowly with time, but after August, 2011 major cations increased rapidly with time may be due to wash out leachate in surface water during monsoon. The figure illustrates that Na$^+$ and Cl$^-$ are the dominant ionic species influencing EC values.

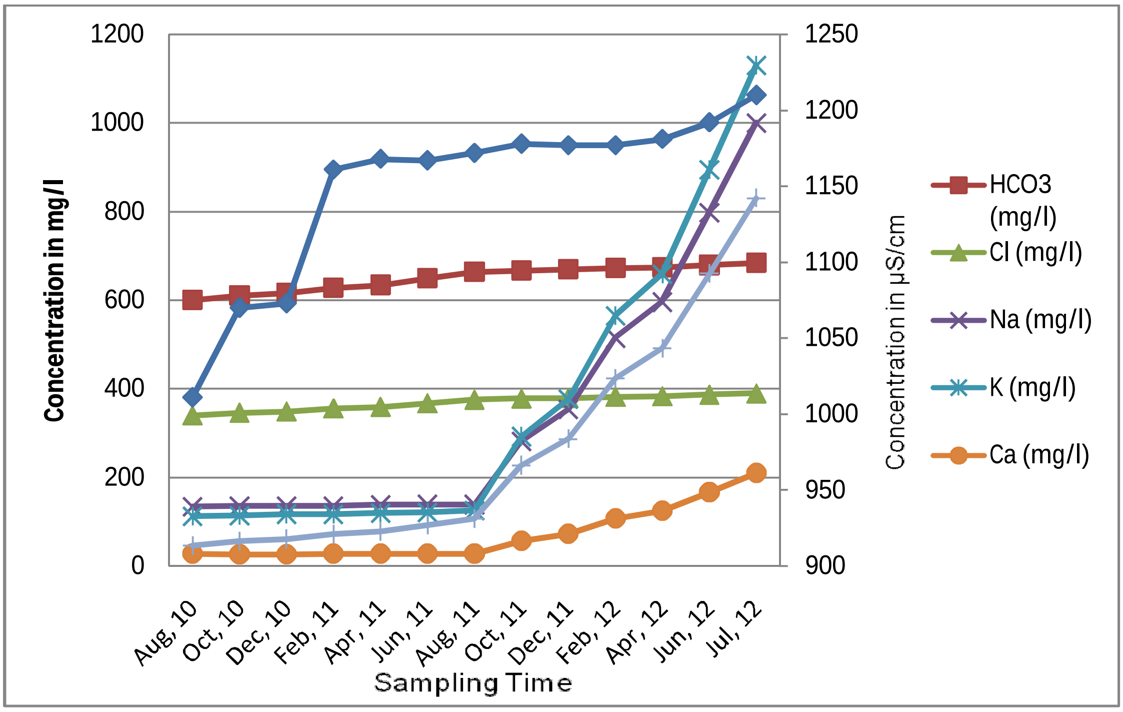

**Figure: 3.2 Variation of EC, major cations and anions with time at location S2**

Variation of EC, major cations and anions with time are shown in Figure 3.2. In the begining concentration of all cations and anions increased slowly with time, but after August, 2011 major cations increased rapidly with time may be due to wash out of leachate in surface water. It was also observed that dominent species are Cl$^-$, Na$^+$ and K$^+$ influencing EC value to increase.

### 3.1.1.2 Ground Water

Ground water samples were collected from a tube well located around 100m away from center of dump site. The ground water source is marked as S3 (Figure 2.2; Chapter 2). The ground water samples were collected in every second month during the study period (2010-

2012) and analyzed for some selected parameters. The analysis results are given in Table 3.7 -3.9.

### i. Physical Parameters (pH, EC, DO, BOD$_5$ and COD)

Table 3.7 shows that pH of ground water increased with time during the study period. pH was recorded to be 6.43 in the beginning and 8 at the end. The results indicate that the ground water pH was lower than the DoE, Bangladesh standard limit at the beginning of the study. It was increased gradually with time and found within DoE, Bangladesh standard limit during the study period. The pH level of water is a vital factor in measuring how healthy a body of water is and how well it can sustain life. Gunjan Bhalla et al. (2012) stated that pH in ground water near a dumpsite were 8.9 and 9.2 in two year's interval. The study observed that the leachate generated from the dump site may affect the groundwater quality in the adjacent areas through percolation in the subsoil.

The ground water EC was recorded to be 368 µS/cm in the beginning and at the end it was 430 µS/cm (Table 3.7). Yet there is no DoE standard for EC value. The Table shows that EC increased gradually with time. It was the contribution of leachate on the groundwater stated by S. Shenbagarani (2013). The moderately high concentration of EC in groundwater samples near the dumpsite indicates the deterioration of groundwater quality which could not be used for drinking and other domestic purposes.

In the beginning, ground water DO was found to be 3.2 mg/l and at the end, it was 1.8 mg/l (Table 3.7). Concentration of DO decreased with time indicates the presence of microorganism in ground water. According to DoE, Bangladesh standard, ground water DO should have to be minimum 6 mg/l. But result was well below the limit. Indication of oxygen depletion in the closest to the landfill inferred the presence of pollutants that use up the oxygen in water and unsafe for consumption stated by Christopher O. Akinbile (2011). Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. However, high DO levels speed up corrosion in water pipes. Low dissolved oxygen levels indicate an excessive demand on the oxygen of the system. Dissolved Oxygen concentration has a significant effect upon ground water quality by regulating the valence state of trace metals and also by constraining the bacterial metabolism of dissolved organic species stated by Seth Rose and Austin Long (1988).

**Table 3.7**

Ground water pH, EC, DO, $BOD_5$ and COD during 2010 – 2012

| Month | pH | EC (µS/cm) | DO (mg/l) | $BOD_5$ (mg/l) | COD (mg/l) |
|---|---|---|---|---|---|
| August, 2010 | 6.43 | 368 | 3.2 | 2.8 | 9.0 |
| October, 2010 | 6.43 | 369 | 3.1 | 2.9 | 9.0 |
| December, 2010 | 6.45 | 375 | 3.1 | 2.9 | 9.2 |
| February, 2011 | 7.12 | 405 | 3.0 | 3.0 | 9.3 |
| April, 2011 | 7.10 | 405 | 2.9 | 3.1 | 9.6 |
| June, 2011 | 7.15 | 408 | 2.9 | 3.0 | 9.6 |
| August, 2011 | 7.2 | 410 | 2.8 | 3.0 | 10 |
| October, 2011 | 7.34 | 413 | 2.63 | 3.01 | 10.13 |
| December, 2011 | 7.31 | 412 | 2.55 | 3.01 | 10.15 |
| February, 2012 | 7.32 | 413 | 2.36 | 3.01 | 10.17 |
| April, 2012 | 7.41 | 415 | 2.26 | 3.02 | 10.26 |
| June, 2012 | 7.63 | 420 | 2.03 | 3.05 | 10.53 |
| July, 2012 | 8 | 430 | 1.8 | 3.1 | 11 |
| *DoE Standard* | *6.5-8.5* | *NYS* | *6* | *≤0.2* | *≤4.0* |

Table 3.7 shows that ground water $BOD_5$ was found to be 2.8 mg/l in the beginning of the study (August, 2010) and at the end of the study it was 3.1 mg/l (July, 2012). The result shows that $BOD_5$ was higher than DoE standard from the beginning of the study and increased gradually with time. $BOD_5$ referred to as biological oxygen demand, is a quantitative expression of microbes ability to deplete the oxygen content of water. This depletion takes place due to the microbes consuming organic matter in the water via aerobic respiration. This type of respiration uses oxygen as an electron acceptor, and the organic material being consumed provides the energy source. In this study the $BOD_5$

values in all case were found above the DoE, Bangladesh standard indicating huge organic matter present in the solid wastes and the leachate generated from the dump site percolated through subsoil, increased $BOD_5$ in groundwater sample. This observation was supported by Rymshaw et al. (1992) stated that there were possibilities of contamination of leachate with ground water and DO decreased with time, hence $BOD_5$ increased with time that proved the contamination of leachate with ground water.

In Table 3.7, COD was found to be 9 mg/l in the beginning and it was 11 mg/l at the end of the study. It was gradually increased with time. According to DoE, Bangladesh standard, ground water COD should be less than 4 mg/l. Most landfill leachate has high BOD, COD, ammonia, chloride, sodium, potassium, hardness and boron levels (Sanjay S. Kale et al., 2008). The composition of leachate depends upon the nature of solid waste buried, chemical and biochemical processes responsible for the decomposition of waste materials, and water content in total waste. The high values of COD were found in groundwater samples indicating a heavily polluted water body. Suman Mor et al. (2005) illustrated that high level of COD in the groundwater samples indicated the presence of organic contaminants in the water. Considering all observations, the reasons of COD increasing in groundwater could easily be understood..

### i i. Anionic Parameters ($HCO_3^-$ and $Cl^-$)

The concentration of $HCO_3^-$ in ground water was measured to be 220.4 mg/l in the beginning and at the end, it was 210 mg/l (Table 3.8). The result shows that the $HCO_3^-$ concentration decreased gradually till August, 2011, then increased slowly and finally the concentration found 210 mg/l at the end of the study. Thus the overall concentrations of $HCO_3^-$ were almost unchanged during the study period. $HCO_3^-$ values of most of the groundwater samples were found within the DoE standard, Bangladesh, but increasing trend of $HCO_3^-$ shows that there might have possibility to exceed the DoE standard limit in the future. The study observed that after monsoon, the rainwater washed out leachate, perlulated through subsoil and finally increased $HCO_3^-$ concentration in groundwater. A report on soild waste dumpsite in Dhaka showed that the concentration of $HCO_3^-$ in ground water near a landfill area in exceeded the DoE, Bangladesh standard (Azim, 2008). The report supports the observation of the present study in assuming the impact of $HCO_3^-$ on groundwater.

Table 3.8 shows that $Cl^-$ of ground water decreased gradually till August, 2011 then it started to increase again. $Cl^-$ was recorded to be 15.99 mg/l in the beginning and 14 mg/l at the end of the study. The results indicate that concentration of $Cl^-$ in groundwater samples were far below than the standard of DoE, Bangladesh standard. An excess of $Cl^-$ in water is usually taken as an index of pollution and considered as tracer for groundwater contamination stated by Loizidou and Kapetanios (1993). A rise in the $Cl^-$ concentration can cause groundwater to become corrosive (Soveri, 1985). The concentration of $Cl^-$ in groundwater may be increased from landfill leachate due to rainfall during monsoon.

**Table 3.8**

Ground water $HCO_3^-$ and $Cl^-$ during 2010 – 2012

| Month | $HCO_3^-$ (mg/l) | $Cl^-$ (mg/l) |
|---|---|---|
| August, 2010 | 220.4 | 15.99 |
| October, 2010 | 213.6 | 15.45 |
| December, 2010 | 210.3 | 15.19 |
| February, 2011 | 202.7 | 14.59 |
| April, 2011 | 198.9 | 14.29 |
| June, 2011 | 189.4 | 13.54 |
| August, 2011 | 180 | 12.8 |
| October, 2011 | 185 | 13 |
| December, 2011 | 187.5 | 13.1 |
| February, 2012 | 193.1 | 13.32 |
| April, 2012 | 195.9 | 13.43 |
| June, 2012 | 202.9 | 13.71 |
| July, 2012 | 210 | 14 |
| *DoE Standard* | *200~500* | *150~600* |

### iii. Cataonic Parameters ($K^+$, $Ca^{2+}$, $Mg^{2+}$, $Na^+$, $Cu^{2+}$, $Fe^{3+}$, $Mn^{2+}$ and $Zn^{2+}$)

In the beginning surface water $K^+$ was found to be 10 mg/l and at the end, it was 6 mg/l (Table 3.9). $K^+$ concentration was decreased with time. DoE, Bangladesh standard for $K^+$ is below 12 mg/l and the study results show that the values were found within the standard limit. $K^+$ has been reported to be an indication of the leachate effect stated by Ellis (1980).

Table 3.9 shows that $Ca^{2+}$ in groundwater sample was found to be 39 mg/l in the beginning of the study (August, 2010) and at the end, it was 112 mg/l (July, 2012). The result shows that concentration of $Ca^{2+}$ was increased gradually with time. According to DoE, Bangladesh, $Ca^{2+}$ concentration for ground water is less than 75 mg/l. At the beginning of the study, $Ca^{2+}$ concentration was within the limit but it exceeded after August, 2011. Leachate generated from the dumpsite and percolated through subsoil may be the main reason of increasing $Ca^{2+}$ in groundwater. Very high concentrations of $Ca^{2+}$ may adversely affect the absorption of other essential minerals in the body.

In Table 3.9, $Mg^{2+}$ was found to be 46 mg/l in the beginning and it was 230 mg/l for the same locations at the end of the study. Concentration of $Mg^{2+}$ changed rapidly after June, 2011. According to DoE, Bangladesh, $Mg^{2+}$ concentration for ground water is 30-35 mg/l. Concentration of $Mg^{2+}$ exceeded the standard and it was found a very high at the end of the study indicating the presence of $Mg^{2+}$ containing solid waste dumping. The concentration of $Mg^{2+}$ ions varied from non-detectable to 220 mg/l stated by Suman Mor et al. (2005) in leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site.

**Table 3.9**

Ground water $K^+$, $Ca^{2+}$, $Mg^{2+}$, $Na^+$, $Cu^{2+}$, $Fe^{3+}$, $Mn^{2+}$ and $Zn^{2+}$ during 2010 – 2012

| Month | $K^+$ (mg/l) | $Ca^{2+}$ (mg/l) | $Mg^{2+}$ (mg/l) | $Na^+$ (mg/l) | $Cu^{2+}$ (mg/l) | $Fe^{3+}$ (mg/l) | $Mn^{2+}$ (mg/l) | $Zn^{2+}$ (mg/l) |
|---|---|---|---|---|---|---|---|---|
| August, 2010 | 10 | 39 | 46 | 135 | 0.01 | 0.02 | 0.26 | 0.01 |
| October, 2010 | 9 | 44 | 56 | 133 | 0.01 | 0.03 | 0.31 | 0.01 |
| December, 2010 | 9 | 47 | 61 | 132 | 0.01 | 0.02 | 0.32 | 0.01 |
| February, 2011 | 9 | 53 | 73 | 129 | 0.01 | 0.03 | 0.35 | 0.01 |
| April, 2011 | 8 | 57 | 79 | 128 | 0.01 | 0.03 | 0.35 | 0.01 |
| June, 2011 | 8 | 65 | 94 | 125 | 0.02 | 0.03 | 0.4 | 0.02 |
| August, 2011 | 8 | 73 | 109 | 123 | 0.04 | 0.03 | 0.42 | 0.02 |
| October, 2011 | 7 | 79 | 129 | 120 | 0.06 | 0.11 | 0.57 | 0.03 |
| December, 2011 | 7 | 82 | 139 | 120 | 0.07 | 0.16 | 0.86 | 0.05 |
| February, 2012 | 7 | 90 | 161 | 119 | 0.1 | 0.25 | 1.50 | 0.08 |
| April, 2012 | 6 | 93 | 173 | 117 | 0.12 | 0.3 | 1.82 | 0.1 |
| June, 2012 | 6 | 102 | 201 | 116 | 0.18 | 0.42 | 2.63 | 0.15 |
| July, 2012 | 6 | 112 | 230 | 114 | 0.24 | 0.55 | 3.44 | 0.2 |
| *DoE Standard* | *≤12.0* | *≤75.0* | *30-35* | *≤200.0* | *≤1.0* | *0.3~1.0* | *≤0.1* | *≤5.0* |

$Na^+$ was recorded to be 135 mg/l in the beginning and 114 mg/l at the end of the study period (Table 3.9). According to DoE, Bangladesh, $Na^+$ concentration for ground water is less than 200 mg/l. $Na^+$ was found within the standard during study period. Table 3.9 shows that $Na^+$ of ground water decreased with time during the study period suggesting that co-precipitation with carbonate minerals. Azim (2011) studied that $Na^+$ of ground water near a dump site was found at a range of 10~18 mg/l. The study results show comparatively higher values for Na+ concentration may be resulted from excessive salt used in cattle feeds during Haat. Probably the leachate from waste feeds were the main source of Na+ in groundwater.

Concentration of $Cu^{2+}$ in groundwater was found to be 0.01 mg/l in the beginning and at the end; it was 0.24 mg/l (Table 3.9). The results show that the concentration of $Cu^{2+}$ increased with time and the values were found within the DoE, Bangladesh standard during study period. Yanful et al. (1988) stated that heavy metals remain in the waste or at the waste–rock interface as a result of redox controlled precipitation reactions. $Cu^{2+}$ is released both naturally and through human activity it is very widespread in the environment. $Cu^{2+}$ founds near mines, industrial settings, landfills and waste disposals. Leachate may be the reson to increase $Cu^{2+}$ concentration in ground water.

In the beginning, $Fe^{3+}$ concentration in the water sample was found 0.02 mg/l and at the end, it was 0.55 mg/l (Table 3.9). Only slightly changed in concentration of $Fe^{3+}$ was observed between August, 2010 and August, 2011 but it started increasing gradually after August, 2011. According to DoE, Bangladesh, $Fe^{3+}$ concentration for ground water is 0.3~1.0 mg/l. Concentration of $Fe^{3+}$ was within the standard till April, 2012 but at the end of the study, it was found above the standard limit of DOE, Bangladesh. The results indicate that the dumping solid waste contained low metallic materials. Swopna Mishra (2013) stated that Iron concentration in ground water near a dump side increased in two years. Rowe et al. (1995) illustrated that presence of $Fe^{3+}$ in water can lead to change of color of groundwater.

Table 3.9 shows that $Mn^{2+}$ concentration in groundwater was found to be 0.26 mg/l in the beginning of the study (August, 2010) and at the end, it was 3.44 mg/l (July, 2012). Result shows that $Mn^{2+}$ concentration was increased gradually during the study period and concentration of $Mn^{2+}$ increased rapidly after August, 2011. According to DoE, Bangladesh standard, $Mn^{2+}$ concentration for ground water is less than 0.1 mg/l. The result shows that $Mn^{2+}$ concentration in all the groundwater samples were far above the standard limit. Suman Mor et al. (2005) stated the concentration of $Mn^{2+}$ under favorable conditions close to a landfill increased with time and might lead to a serious toxic risk. $Mn^{2+}$ is one out of three toxic essential trace elements, which means that it is not only necessary for humans to survive, but it is also toxic when too high concentrations are present in a human body. When $Mn^{2+}$ uptake takes place through the skin it can cause tremors and coordination failures. Kondakis (1989) stated that adverse neurological effects with exposure to $Mn^{2+}$ from drinking water. Adverse health effects can be caused by inadequate intake or over exposure stated by Keen (1999 and 2000). The results shows that $Mn^{2+}$ concentration in all groundwater samples were far above the standard limit indicating harmful to human health and not suitable for use in any purposes.

In Table 3.9, $Zn^{2+}$ concentration was found to be 0.01 mg/l at beginning of the study (August, 2010) and at the end, it was 0.10 mg/l (July, 2012). No major change was observed between August, 2010 and October, 2011. But it was increased gradually after October, 2011. According to DoE, Bangladesh standard, $Zn^{2+}$ concentration for ground water is less than 5 mg/l. Swopna Mishra et al. (2013) stated that increasing of $Zn^{2+}$ concentration in ground water may be the impact of municipal solid waste near dumping site. $Zn^{2+}$ occurs naturally in air, water and soil, but $Zn^{2+}$ concentrations are rising unnaturally, due to addition of $Zn^{2+}$ through human activities. $Zn^{2+}$ is a trace element that is essential for human health. The study results indicate that $Zn^{2+}$ concentration in all samples were found within the BoE standard limit and the landfill leachate contained less $Zn^{2+}$.

As concentration in the groundwater in the study area was below the detectable level. This can be due to its restricted mobility from geological formation which underlies the dump site. This study reveals that the concentration of As was below the detectable level in all the groundwater samples and therefore it is not considered to be a health risk.

In the beginning, the mean concentrations of the cations in groundwater samples were followed in the order: $Na^+ > Mg^{2+} > Ca^{2+} > K^+ > Mn^{2+} > Fe^{3+} > Cu^{2+}$ and $Zn^{2+}$ and at the end of the study cations were followed in the order: $Mg^{2+} > Na^+ > Ca^{2+} > K^+ > Mn^{2+} > Fe^{3+} > Cu^{2+} > Zn^{2+}$. It was observed that $K^+$ and $Na^+$ decreased at the end but other cations increased with time. It was also identified that, the concentration of $Fe^{3+}$ was lower than $Na^+$, $Mg^{2+}$, $Ca^{2+}$, $K^+$ and $Mn^{2+}$ at the beginning of the study but it was changed rapidly compare to others cations.

S2 (Figure 2.2) is surface water very near to the location of ground water. It was observed that $Fe^{3+}$ decreased with time at location S2 during study period, it was decreased from 8.84 mg/l to 2.42 mg/l from beginning to end of the study. Therefore that may be the main reason for increase of groundwater concentration of $Fe^{3+}$. At the end of the study, concentration of $Mg^{2+}$ higher that others observed cations. Variation of EC, major cations and anions are shown by below Figure 3.3. EC concentration in ground increased with time, and at the same time $K^+$ and $Ca^{2+}$ concentration in ground water also increased which might be the reason to increase EC.

Excessive level of pollutant present in water capable to cause harm to living organisms. The physical parameters $BOD_5$ and COD both increased with time and exceeded the standard limit. As the public health concern, the ground water should be within the limit. The people in and around the dumping site are depending upon the ground water for drinking and other domestic purposes. The Contamination of ground water and surface water is the major environmental risk related to unsanitary land filling of solid waste.

### 3.1.2 Physico-Chemical Parameters of Soil

Soil samples were collected from three locations near the waste dump site during dry season (December, 2010) and monsoon (July, 2011). Soil sampling locations are marked as A, B and C. In each sampling location, three soil samples were collected from different depths. The sampling location map is shown in Figure 2.2 (Chapter 2). Location A was at the middle of dump site, location B was 100m from location A and location C was about 300m from location B. The collected soil samples were analyzed for some selected parameters. The results are illustrated in Table 3.10 to 3.12.

Tables 3.10, 3.11 and 3.12 show that most of the parameters of soil samples increased with time (December 2010 and July 2011). As executed previous reports supported the study results and stated that leachate from surrounding waste dumps increased pollution level of soil (Banar et al., 2006; Alloway, 1990; Tahri et al., 2005; Lin et al., 2002; Amadi et al., 2010; Bacud et al., 1994 and Awomeso et al., 2010).

**Table 3.10**

Characteristics of soil sample at location A during Decmber 2010 and July 2011

| Parameters | Sample Collected Location and Time | | | | | |
|---|---|---|---|---|---|---|
| | December, 2010 (dry season) | | | July, 2011 (monsoon) | | |
| | A0 | A1 | A2 | A0 | A1 | A2 |
| pH | 8.69 | 8.65 | 8.57 | 9.16 | 9.1 | 9.14 |
| Phosphorus (P), µg/g | 164.2 | 112.2 | 67.9 | 188 | 162 | 139.85 |
| Sulfur (S), µg/g | 245.3 | 187.9 | 168.9 | 255 | 226.3 | 216.8 |
| Potassium ($K^+$), µg/g | 2.83 | 2.69 | 2.46 | 3.12 | 3.05 | 2.93 |
| Calcium ($Ca^{2+}$), µg/g | 6.88 | 6.44 | 5.78 | 7.97 | 7.08 | 5.96 |
| Magnesium ($Mg^{2+}$), µg/g | 4.41 | 4.34 | 4.15 | 6.13 | 6.1 | 6 |
| Cupper ($Cu^{2+}$), µg/g | 17.05 | 11.96 | 11.62 | 14.64 | 12.1 | 11.93 |
| Iron ($Fe^{3+}$), µg/g | 126.6 | 114.5 | 64.9 | 165.7 | 141.5 | 76.2 |
| Manganese ($Mn^{2+}$), µg/g | 47 | 36.5 | 33.2 | 43.95 | 38.7 | 37.05 |
| Zink ($Zn^{2+}$), µg/g | 12.6 | 12.2 | 11.93 | 12.31 | 12.11 | 11.98 |

* Here A0, B0 and C0 are termed as top soil; A1, B1 and C1 are termed as soil from half meter depth and A2, B2 and C2 are termed as soil from 1 meter depth.

### i. Physical Parameters of Soil

Soil pH generally refers to the degree of soil acidity or alkalinity. From Table 3.10, 3.11 and 3.12, no major difference found for Soil pH at location A, B and C. Highest value of pH found to be 9.05 at location A in July, 2011 and lowest value of pH was 7.9 at location C in December, 2010. Soil pH at location C was comparatively lower than location A and B. It was also observed that pH values of all locations increased with time. High value of pH at location A may be due to the nearer to the center of the dumpsite. The pH values were deceased with distance from the dumpsite. Soil pH of all three locations found alkaline during study period. Soil pH affects the soil's physical, chemical, and biological properties and processes, as well as plant growth. The nutrition, growth, and yields of most crops decrease where pH is low and increase as pH rises. Many crops grow best if pH is close to neutral (pH 6 to 7.5) although a few crops prefer acid or alkaline soils. The mobility and degradation of herbicides and insecticides, and the solubility of heavy metals are pH dependent.

**Table 3.11**

Characteristics of soil sample at location B during Decmber 2010 and July 2011

| Parameters | Sample Collected Location and Time | | | | | |
|---|---|---|---|---|---|---|
| | December, 2010 (dry season) | | | July, 2011 (monsoon) | | |
| | B0 | B1 | B2 | B0 | B1 | B2 |
| pH | 8.5 | 8.2 | 8.1 | 9.05 | 8.9 | 8.85 |
| Phosphorus (P), µg/g | 22.6 | 6.7 | 5.2 | 26.7 | 18.75 | 18 |
| Sulfur (S), µg/g | 33.2 | 30.3 | 29.3 | 34.05 | 32.6 | 32.1 |
| Potassium ($K^+$), µg/g | 1.33 | 0.82 | 0.36 | 1.47 | 1.21 | 0.98 |
| Calcium ($Ca^{2+}$), µg/g | 5.86 | 5.18 | 4.48 | 8.79 | 7.43 | 4.71 |
| Magnesium ($Mg^{2+}$), µg/g | 4.61 | 4.45 | 4.3 | 4.67 | 4.59 | 4.52 |
| Cupper ($Cu^{2+}$), µg/g | 5.95 | 2.1 | 1.14 | 5.98 | 4.05 | 3.57 |
| Iron ($Fe^{3+}$), µg/g | 25.2 | 15.4 | 9.2 | 29.8 | 24.9 | 21.8 |
| Manganese ($Mn^{2+}$), µg/g | 17 | 9.6 | 6.8 | 18.5 | 14.8 | 13.4 |
| Zink ($Zn^{2+}$), µg/g | 1.33 | 0.18 | 0.15 | 1.28 | 0.69 | 0.70 |

### i i. Anionic Parameters of Soil

Table 3.10, 3.11 and 3.12 show high concentration of P and S at location A, and it was found comparatively low at location B and C. P concentration was increased at location A and B with time but no major variation was observed at location C. Highest concentration of P found 188 μg/g at location A and lowest concentration of P found 5.2 μg/g at location B. Similarly Highest concentration of S found 245.3 μg/g at location A and lowest concentration of S found 6.2 μg/g at location C. Leachate generated from solid waste may be the reason for highest concentration of P and S at location A.

**Table 3.12**

Characteristics of soil sample at location C during December 2010 and July 2011

| Parameters | Sample Collected Location and Time | | | | | |
|---|---|---|---|---|---|---|
| | December, 2010 (dry season) | | | July, 2011 (monsoon) | | |
| | C0 | C1 | C2 | C0 | C1 | C2 |
| pH | 8.6 | 8.5 | 7.9 | 8.45 | 8.1 | 8.4 |
| Phosphorus (P), μg/g | 8.2 | 6.8 | 5.8 | 7.8 | 7.1 | 6.6 |
| Sulfur (S), μg/g | 10.2 | 10 | 6.2 | 10.5 | 10.4 | 8.5 |
| Potassium ($K^+$), μg/g | 0.8 | 0.32 | 0.22 | 0.85 | 0.61 | 0.56 |
| Calcium ($Ca^{2+}$), μg/g | 4.19 | 3.65 | 3.55 | 4.7 | 4.43 | 4.38 |
| Magnesium ($Mg^{2+}$), μg/g | 3.33 | 3.28 | 1.8 | 4.5 | 4.41 | 1.98 |
| Cupper ($Cu^{2+}$), μg/g | 5.14 | 2.76 | 0.98 | 3.05 | 1.86 | 1 |
| Iron ($Fe^{3+}$), μg/g | 44.9 | 7.7 | 4.5 | 51.8 | 33.2 | 31.6 |
| Manganese ($Mn^{2+}$), μg/g | 12 | 4.9 | 4.6 | 15.2 | 11.65 | 11.5 |
| Zink ($Zn^{2+}$), μg/g | 0.52 | 0.08 | 0.07 | 0.52 | 0.28 | 0.27 |

Adequate P is needed for the promotion of early root formation and growth. P also improves crop quality and is necessary for seed formation stated by Gregory Mullins in Phosphorus, Agriculture and the Environment. During study period, P was found increasing trend and seemes to be better for soil quality. S is an essential element in the life processes of all living things, including microorganisms, higher plants, animals and man. It is an important part of the proteins needed to sustain life in all biological organisms. There are possibility of potential impacts of S on the environment stated by Robarge (1992), Maynard (1994) and Crawford (2009). On the other hand, S deficiency significantly effects the production and quality of winter wheat stated by Zhao (1999), McGrath (2003) and Györi (2005). S content of most soils is contained in the organic matter. It was observed at location A that increasing rate of S was comparatively higher and seemed to have positive impact on soil.

### iii. Cataonic Parameters of Soil

Table 3.10, 3.11 and 3.12 shows that highest concentration of $K^+$, $Ca^{2+}$, $Mg^{2+}$, $Cu^{2+}$, $Fe^{3+}$, $Mn^{2+}$ and $Zn^{2+}$ in soil were 3.12, 7.97, 6.13, 14.64, 165.7, 47 and 12.6 μg/g, respectively at location A. At the same time, lowest concentration of $K^+$, $Ca^{2+}$, $Mg^{2+}$, $Cu^{2+}$, $Fe^{3+}$, $Mn^{2+}$ and $Zn^{2+}$ in soil were 0.22, 3.55, 1.8, 1, 4,5, 4.6 and 0.07 μg/g, respectively at location C. Solid waste and and leachate generated from solid waste may be the main reason for high concentration of all measured cations at location A. Soil sample were taken during December, 2010 and July, 2011. All reasults shows high concentration of all cations at July, 2011. One of the reason is higher amount of solid waste because city corporation continuously dumping solid waste at that site and another reasion may be for moonsoon. A report shows similar results where higher level of cations concentration found in soil near a solid waste dumpsite(N.Raman, 2008).

$K^+$ is an essential plant mineral element (nutrient) having a significant influence on many human-health related quality compounds in fruits and vegetables (Usherwood, 1985; Marschner, 1995; Cakmak, 2005; Geraldson, 1985; Lester, 2005 and Kanai, 2007). During study, concentration of $K^+$ was found in increasing trend at location A, that shows positive for soil quality, specially for cultivation of land.

$Ca^{2+}$ is a component of several primary and secondary minerals in the soil, which are essentially insoluble for agricultural considerations. $Ca^{2+}$ found higher at location A, the center of the dump site compare to the location C about 300m from the center. It shows positive for soil quality due to presence of high concentration of $Ca^{2+}$ at the study area.

$Mg^{2+}$ is the central element of the chlorophyll molecule. $Mg^{2+}$ is carrier of P in the plant. High concentration of $Mg^{2+}$ at the center of the dump site shows positive impact on soil quality for aggricultural activity.

$Cu^{2+}$ increases yield and quality of crops (Pahlsson, 1989). $Cu^{2+}$ concentration was found relatively higher at the centare of the study area that shows positive for soil quality for cultivation. $Cu^{2+}$ concentration was also found in increasing trend during study. But also excessive soluble soil $Cu^{2+}$ can be toxic to plants stated by Paschke (2002) and White (2010). Therefore, $Cu^{2+}$ concentration mab be an important issue for its negative impact on environment in future.

$Fe^{3+}$ functions in plant are respiration, plant metabolism and also involved in nitrogen fixation. During study, concentration of $Fe^{3+}$ was found in increasing trend at location A, that shows positive for soil quality, specially for cultivation of land.

$Mn^{2+}$ is involved in the oxygen evolving step of photosynthesis and membrane function (Wiedenhoeft, 2006), $Mn^{2+}$ increased fruit yield (Bambal, 1991 and Labanauskas, 1963). $Mn^{2+}$ found higher at location A, the center of the dump site compare to the location C about 300m from the center. It shows positive for soil quality due to presence of high concentration of $Mn^{2+}$ at the study area.

$Zn^{2+}$ effects on the fruit yield and quality (Gibbson, 2006; Grotz, 2006; Shkoinik, 1984 and Kabata, 2001). High concentration of $Zn^{2+}$ at the center of the dump site shows positive impact on soil quality for aggricultural activity.

The analyzed results of the study showed for location A that at the beginning of the study the mean concentrations of cations at one meter depth were followed in the order: $Fe^{3+}$ > $Mn^{2+}$ > $Zn^{2+}$ > $Cu^{2+}$ > $Ca^{2+}$ > $Mg^{2+}$ > $K^{+}$ and at the end of the study cations were followed in the order: $Fe^{3+}$ > $Mn^{2+}$ > $Zn^{2+}$ > $Cu^{2+}$ > $Mg^{2+}$ > $Ca^{2+}$ > $K^{+}$. Similary the analyzed results of the study showed for location B that at the beginning of the study the mean concentrations of cations at one meter depth were followed in the order: $Mn^{2+}$ > $Fe^{3+}$ > $Ca^{2+}$ > $Mg^{2+}$ > $Cu^{2+}$ > $K^{+ >}$ $Zn^{2+}$ and at the end of the study cations were followed in the order: $Fe^{3+}$ > $Mn^{2+}$ > $Ca^{2+}$ > $Mg^{2+}$ > $Cu^{2+}$ > $K^{+ >}$ $Zn^{2+}$. At location C, the analyzed results of the study showed that at the beginning of the study the mean concentrations of cations at one meter depth were followed in the order: $Ca^{2+}$ > $Mn^{2+}$ > $Mg^{2+}$ > $Fe^{3+}$ > $Cu^{2+}$ > $K^{+ >}$ $Zn^{2+}$ and at the end of the study cations were followed in the order: $Fe^{3+}$ > $Mn^{2+}$ > $Ca^{2+}$ > $Mg^{2+}$ > $Cu^{2+}$ > $K^{+ >}$ $Zn^{2+}$.

## 3.2 Biological Environment

Forests, pasture lands, rivers, surface water and other water bodies etc. are the most important natural ecosystems. They are the foundation on which conservation of biological diversity depends. Biological diversity, which refers to genetic variation as well as to the diversity of human populations and ecosystems, is a resource that belongs not only to regions and to nations but also to all of humankind.

Regarding the geographical setting of the area as it is mostly high and wet ecosystem with greenery quite at abundance. Several number of field survey during the study have made to assess and quantify the flora and fauna richness. All information was taken from local people of that area.

### 3.2.1 Flora

Lots of green area present around dump site. This includes roadside plantation and natural vegetation. Besides the other development project in the area, the remaining area is mostly lowland and generally interconnected with certain man made barriers here and there. But no flora species available in dump site.

Surrounding the dump site area is rich with floral diversities. Different fruit, fuel wood trees along with various shrubs are abundant. Among the trees, the most widely available ones are Shishu, Mehagani, Shimul, etc. Also there are some fruit trees such as Mango, Coconut, Jackfruit, guava etc. Details flora species found around dump site during the field visit are listed in Table 3.13.

**Table 3.13**

Flora species in the study area

| English Name | Scientific Name | Local Name | Tree type |
|---|---|---|---|
| Grass | *Spontaneum* | Khar | Fuel / Covering |
| Grass | *Saccharum* | Gash (Kaichi | |
| | *Cynodon dactylon* | Kash, Dubla etc.) | Soil binder |
| Lichi | *Lichi chinensis* | Lichu | Fruit |
| Mango | *Mangifera indica* | Aam | Fruit, Timber. |
| Date Palm | *Phoenix sylvestris* | Khejur | Fruit, Timber. |
| Black Berry | *Syzygium cumini* | Jam | Brown sugar |
| Jackrfuit | *heterophyllus* | Khatal | Fruit, Timber. |
| Coconut | *Cocos nucifera* | Narikel | Fruit, Timber. |
| Papaya | *Carica papaya* | Pape | Fruit, Fuel |
| Gauva | *Psidium guajva* | Piara | Fruit, |
| Banana | *Musa sepientum* | Kala | Fruit, Fuel |

Flora species adjacent to the study area was looking quite healthy, specially the surrounding low land. During study, cations and anions of the soil increased with time, that makes the land more fertile. But there might have some toxic elements in that soil as well as in leachate, therefore may have adverse effect on flora species due to presence of high concentration of cations and anions in soil.

### 3.2.2 Fauna

During study period, available fauna around the study area were collected from local people of that place. Available fishes around that area include catfishes (Magur and Shing), major carps (Rui), minor carps (Puti), etc. The common types of reptiles were also available in the area, water snake, house lizard, soft-shell, turtle etc. A number birds, were also available in the area, those were including common kingfishers, house crow, house sparrow, little fern etc. Details of fauna species found during field visit are listed in Table 3.14.

**Table 3.14**

Fauna species in the study area

| **Scientific Name** | **English Name** | **Local Name** |
|---|---|---|
| **1 REPTILES** | | |
| *Enhudris enhydris* | Smooth Water Snake | Painnya Shap/ Huriya |
| *Hemidactylus* | House Lizard | Goda Tik Tiki |
| *Chitra indicad* | Turtle | Chitra Katchap |
| **2 AMPHIBIANS** | | |
| *Bufo melanostictus* | Common Toad | Bang |
| **3 MAMMALS** | | |
| *Cynopterus spinex* | Short nosed fruit Bat | Badur |
| *Funumbalus pennanti* | Squirrel | Kat Biral |
| *Herpestes* | Mongoose | Bheji |
| *Mus booduga* | Field Mouse | Idur |
| *Mus musculus* | House Mouse | Nengti Idur |
| *Pteropus giganteus* | Gaint Flying Fox | Boro Badur |
| **4 BIRDS** | | |
| *Alcedo atthis* | Common Kingfisher | Machranga |
| *Copsychus saularis* | Robin | Doel |
| *Corvus splendens* | House Crow | Kak |
| *Egretta albe* | Great Egret | Boro Bak |
| *Egretta gazetta* | Small Egret | Chhoto Bak |
| *Dirrurus adsimilies* | Black Drongo | Fingry |
| *Passer domesticus* | House Sparrow | Choroi |
| **5 FISH** | | |
| *Macrobrachium malcolmsoni* | Prawn | Icha |
| *Mystus vittatus* | Cat Fish | Tengra |
| *Mystus vittatus* | | Golisha Tengra |
| *Labeo rohita* | Major Carps | Rui |
| *Puntius sophore* | Minor Carps | Puti |
| *Channa punctatus* | Snakehead | Taki |
| *Mastacembelus armatus* | Eel | Bain |
| *Amblypharyngodon mola* | | Mola |
| *Pscudeutropicus atberinoides* | | Batasi |

There were two surface water bodie inside the study area. During field survey, no fauna species was observed at those surface water bodies except some water insects and common toad in darked shape. Local people of that area also informed that there was no fish in those surface water bodies. Lots of crow were there in the study area but no other birds were found during study inside the solid waste dump site.

## 3.3 Noise Level

The noise level parameters were studied at all the four directions in December, 2011 of the site at day time and they are illustrated in Table 3.15. The area can be considered as mixed zone. According to ECR'97, noise level at day time found within limit.

**Table 3.15**

Noise level of the study area

| **Sl No** | **Location** | in dBa | DoE, Standard at day time in dBa |
|---|---|---|---|
| 1 | West | 57.35 | 60 |
| 2 | East | 55.87 | |
| 3 | North | 53.96 | |
| 4 | South | 54.29 | |

## 3.4 Air Quality

Air quality depends on substances, which are present in atmosphere in such concentrations that they produce undesirable effects on human beings, animal and as well as plant life. These substances include gases ($CH_4$, $SO_X$, $NO_X$, etc.), Suspended Particulate Matter (smoke, dust, fumes, etc.), and many others. Concentration of different pollutants above allowable level can have adverse impacts on plant, animal and human life. $CH_4$ is an important greenhouse gas generated from decomposition of organic waste. But due to some restriction and unavailibility of instrument, air quality of the study area could not measure during study period.

## 3.5 Community Involvement

Many local people were engaged with solid waste dumping. Also some local people collect materials from dumping site called TOKAI. There is a cow Haat (Haat is a weekly market) adjacent to study area and many people's come to that place during Haat time. There are also small restaurant and tea stall for Haat day. All people of that area at risk from the unscientific disposal of solid waste especially waste workers. Other high-risk group includes population living close to a waste dump and those, whose using surface and ground water has become contaminated either due to waste dumping or leakage from landfill sites. Decomposition of organic waste creates conditions favorable to the survival and growth of microbial pathogens.

Both organic and inorganic waste dumped at dump site. Open dumping of solid waste has adverse effect on surrounding environment. Proper methods of waste disposal have to be undertaken to ensure that it does not affect the environment around the area or cause health hazards to the people. Need special arrangement for the organic part of the waste that is generated decomposes more easily, attracts insects and causes disease. Organic waste can be composted and then used as a fertilizer. It also need restriction of people to enter the site without having proper Personal Protective Equipment (PPE). There are lots of agricultural lands around study area. To prevent environmental pollution should have to adopt proper solid waste dumping method. It is very important to change the City Cow Hat location from dumping site. A municipal dumping site should have to be far away from public place.

Leachate generated from solid waste was not only contaminated surface water but also contaminated ground water. Presence of high concentration of some cations, $BOD_5$ and COD suggesting that the ground water sample collected from dump site is not suitable for human consumption.

Although on the short term, the experimental results of this study indicate impacts of solid waste leachate on soil and groundwater, the study recommends that a more detail study on unplanned municipal dumpsite would be taken to assess the field site and onsite leaching process to understand the long-term impacts of solid waste on soil and water. Further recommendations are to characterize flora and fauna in the study area to understand toxiccity level and details environmental impact assessment study of the dump site.

# CHAPTER 4

# CONCLUSION

# CONCLUSION

The management of solid waste is an area of universal concern for both the developed and developing world. Solid waste consisting of everyday items we consume and discard. Economic development, urbanization and improving living standard in cities of developing countries have lead to increase in the quantity and complex composition of municipal solid waste. The study was carried out a comprehensive baseline assessment of solid waste dumping impact scenario near a dump site in Rajshahi City Corporation. The main objective was to identify the impact of solid waste dumping on nearby surface and ground water, and soil near the dump site.

A total of two surface water, one gounnd water (shallow tubewell) and three soil samples were collected from study area, respectively from August 2010 to July 2012 at two months interval. Also a total of three soil samples were collected from top soil, half meter depth and one meter depth at study area from August 2010 to July 2012 at two months interval. The experimental data were analyzed using various software and the results were illustrated to interpret the impact on surface and ground water, and soil at the study area due to solid waste dumping.

The concentrations of $Na^+$ and $Zn^{2+}$ were found in surface water at location S1 in the highest and lowest quantities among cations, respectively and at the end of the stuady the amount were 310 mg/l and 0.1 mg/l. Among anions, $HCO_3^-$ and $Cl^-$ were found 446 mg/l and 570 mg/l. The results of the analyses showed that the mean concentration of cations were followed the order $Na^+ > Mg^{2+} > K^+ > Ca^{2+} > Fe^{3+} > Mn^{2+} > Cu^{2+} > Zn^{2+}$. At the same time, the concentration of $K^+$ and $Zn^{2+}$ were found in surface water at location S2 in the highest and lowest quantities among cations, respectively and at the end of the stuady the amount were 1130 mg/l and 0.1 mg/l. Among anions, $HCO_3^-$ and $Cl^-$ were found 684 mg/l and 390 mg/l. The results of the analyses showed that the mean concentration of cations were followed the order $K^+ > Na^+ > Mg^{2+} > Ca^{2+} > Fe^{3+} > Mn^{2+} > Cu^{2+} > Zn^{2+}$. The analysis results show that the concentration of the analyzed cations increasied with time.

The analysis results of the hydro-chemical composition of the shallow tubewell water in the study area showed that $BOD_5$ and COD of the groundwater were too high than the standard of DoE, Bangladesh. $Mg^{2+}$ was the dominant ionic species among the cations of the shallow tubewells water samples, and at the end of the study it was found 230 mg/l whilst the other determined cations were $K^+$ (6 mg/l), $Ca^{2+}$ (112 mg/l), $Na^+$ (114 mg/l), $Cu^{2+}$ (0.24 mg/l), $Fe^{3+}$ (0.55 mg/l), $Mn^{2+}$ (3.44 mg/l) and $Zn^{2+}$ (0.2 mg/l). Among the anions, $HCO_3^-$ and $Cl^-$ were found 210 mg/l and 14 mg/l at the end of the study. At the end of the study, the major anions of the shallow tubewell water was followed the order of $Mg^{2+} > Na^+ > Ca^{2+} > K^+ > Mn^{2+} > Fe^{3+} > Cu^{2+} > Zn^{2+}$. It was also found that, $Ca^{2+}$, $Mg^{2+}$ and $Mn^{2+}$ exceeded the limits of DoE, Bangladesh. No Arsenic was present at ground water of that place. From above result, it was found adverse effect of solid waste on surface water and ground water. As the public health concern, tested all parameters of the ground water should be within the limit. The people in and around the dumping site are depending upon the ground water for drinking and other domestic purposes. The Contamination of ground water and surface water is the major environmental risk related to unsanitary land filling of solid waste. Presence of high concentration of some cations, $BOD_5$ and COD suggesting that the ground water sample collected from dump site is not suitable for human consumption.

The concentrations of $Fe^{3+}$ and $K^+$ were found in the soil in the highest and lowest quantities among cations, respectively at location A and at the end of the study the amount were 165.7 µg/g and 3.12 µg/g respectively at top soil and among anions, S and P were found at concentrations of 255 µg/g and 188 µg/g at the end of the study. The results of the analysis showed that the mean concentration of cations were from highest to lowest, $Fe^{3+} > Mn^{2+} > Zn^{2+} > Cu^{2+} > Mg^{2+} > Ca^{2+} > K^+$. The concentrations of $Fe^{3+}$ and $Zn^{2+}$ were found in the soil in highest and lowest quantities among cations, respectively at location B at the end of the study and the concentrations were 29.8 µg/g and 1.28 µg/g respectively on top soil and among anions, S and P were found at concentrations of 34.05 µg/g and 26.7 µg/g at the end of the study. The results of the analysis showed that the mean concentration of cations were from highest to lowest, $Fe^{3+} > Mn^{2+} > Ca^{2+} > Mg^{2+} > Cu^{2+} > K^{+>} Zn^{2+}$. The concentrations of $Fe^{3+}$ and $Zn^{2+}$ were found in the soil in highest and lowest quantities among cations, respectively at location C and at the end of the study the concentrations were 51.8 µg/g and 0.52 µg/g respectively at on top soil and among anions, S and P were found 10.5 µg/g and 7.8 µg/g at the end of the study. The results of the analysis showed that the mean concentration of cations were from highest to lowest, $Fe^{3+} > Mn^{2+} > Ca^{2+} > Mg^{2+} > Cu^{2+} > K^{+ >}$ $Zn^{2+}$. These ionic parameters would dissolve in water under different geochemical processes and increase concentration of different ions in groundwater. Inside study area all parameters increased with time, which have a direct relation with surface and ground water of that place which also increased with time. Low concentration of these parameters of soil was found at far distance. The analysis results show that the concentration of the analyzed cations increasied with time.

During study period, present flora and fauna around study area were also collected by a short time survey. Flora around the study area was looking quite healthy. During study, cations and anions of the soil increased with time, that makes the land more fertile. But there might have some toxic elements in that soil as well as in leachate, therefore may have adverse effect on animals and human being after consuming vegitables and fruits from that area. There was also two surface water body inside the study area but during field survey, no fauna species was observed at those surface water bodies except some water insects and common toad .

The study concludes that there has adverse impact of open dumping surrounding environment of study area. Lots of local people working there without using personal protecting equipment and improper management of solid waste may create direct health effect. Surface water and ground water pollution caused by improper solid waste open dumping. Leachate generated from solid waste not only contaminated surface water but also contaminated ground water. This study recommends for proper solid waste disposal and also imposing restrictions to people entering the site without having proper personal protective equipments. There are lots of agricultural lands around study area. To prevent environmental pollution should have to adopt proper solid waste dumping method. It is very important to change the City Cow Haat location from dumping site. A municipal dumping site should have to be far away from public place. It could be thus concluded easily that the open dumping of municipal solid waste should manage properly in the study area as it is slowly damaging the environment. New modern sanitary landfill need to be developed to replace the present nearly indiscriminate disposal method. In addition, ground water monitoring shallow wells around the dumpsite need to be provided to know more about the quality changes of leachate due to the waste age.

Open dumping will continue to be the way of disposing waste by municipalities in Bangladesh due to inability to construct engineered landfills. Most local authorities pay little attention to their management because either they do not have adequate resources or they do not know of better systems. Open dumps are a threat to the environment as litter is blown out of the site and poisonous leachates continue to contaminate surface water and ground water. Presence of high concentration of some cations, $BOD_5$ and COD suggesting that the ground water sample collected from dump site is not suitable for consumption. It is therefore important to ensure that the open dumps are improved upon and attention is given so that they do not become environmental hazards.

Furthermore, the research findings would be of a great use to the policy makers, urban authorities, planners, researchers and students as well as to the environmentalists taking action in future research and development and also in all decision making on matters pertaining to solid waste dumping. Thus it could help to create a sustainable environment.

Although on the short term, the experimental results of this study indicate impacts of solid waste leachate on soil and groundwater, it is recommended that the experiment be repeated with larger in the field site and onsite leaching studies be conducted to explore the long-term impacts of solid waste.

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# *APPENDIX 1*

**Table 1.1:** Urbanization in Bangladesh from 1951 to 2001

| Year | Total Urban Population | Percent of Urban Population | Average Annual Growth Rate (%) |
|---|---|---|---|
| 1951 | 1819773 | 4.33 | 1.69 |
| 1961 | 2640726 | 5.19 | 3.75 |
| 1974 | 6273602 | 8.78 | 6.62 |
| 1981 | 13535963 | 15.54 | 10.63 |
| 1991 | 20872204 | 20.15 | 5.43 |
| 2001 | 28808477 | 23.39 | 3.27 |

*Source:* BBS, 1997; *BBS, 2001

**Table 1.2:** Different sources in total generation of MSW in the six major cities of Bangladesh

| Sources | MSW generated daily from different sources (%) | | | | | |
|---|---|---|---|---|---|---|
| | Dhaka | Chittagong | Khulna | Rajshahi | Barisal | Sylhet |
| Residential | 75.86 | 83.83 | 85.87 | 77.18 | 79.55 | 78.04 |
| Commercial | 22.07 | 13.92 | 11.6 | 18.59 | 15.52 | 18.48 |
| Institutional | 1.17 | 1.14 | 1.02 | 1.22 | 1.46 | 1.29 |
| Municipal Services | 0.53 | 0.51 | 0.55 | 1.24 | 1.15 | 0.8 |
| Others | 0.37 | 0.6 | 0.96 | 1.77 | 2.32 | 1.4 |

[Source: Alamgir et al. (2005)]

**Table 1.3** Physical composition of MSW in six major cities of Bangladesh (in wet weight %)

| MSW Composition | DCC | CCC | KCC | RCC | BCC | SCC | Avg. |
|---|---|---|---|---|---|---|---|
| Food & Vegetables | 68.3 | 73.6 | 78.9 | 71.1 | 81.1 | 73.8 | 74.5 |
| Paper & Paper Products | 10.7 | 9.9 | 9.5 | 8.9 | 7.2 | 8.4 | 9.1 |
| Polythene & Plastics | 4.3 | 2.8 | 3.1 | 4.0 | 3.5 | 3.4 | 3.5 |
| Textile & Woods | 2.2 | 2.1 | 1.3 | 1.9 | 1.9 | 2.1 | 1.9 |
| Rubber & Leathers | 1.4 | 1.0 | 0.5 | 1.1 | 0.1 | 0.6 | 0.8 |
| Metal & Tins | 2.0 | 2.2 | 1.1 | 1.1 | 1.2 | 1.1 | 1.4 |
| Glass & Ceramics | 0.7 | 1.0 | 0.5 | 1.1 | 0.5 | 0.7 | 0.8 |
| Brick, Concrete & Stone | 1.8 | 1.1 | 0.1 | 2.9 | 0.1 | 1.8 | 1.3 |
| Dust, Ash & Mud Products | 6.7 | 5.1 | 3.7 | 6.5 | 3.1 | 5.3 | 5.1 |
| Others (bone, rope etc.) | 1.9 | 1.2 | 1.2 | 1.3 | 1.3 | 2.8 | 1.6 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Note: DCC- Dhaka City Corporation, CCC- Chittagong City Corporation, KCC- Khulna City Corporation, RCC- Rajshahi City Corporation, BCC- Barisal City Corporation, SCC- Sylhet City Corporation; Avg.-Average
[Source: Alamgir et al. (2005)]

**Table 1.4** Domestic Waste Generation Rate in Rajshahi City Corporation

| Income Group | Waste Generation Rate (Kg/cap/day) | Population (%) | Average Domestic Waste Generation Rate (kg/cap/day) |
|---|---|---|---|
| Low Income | 0.167 | 40 | 0.203 |
| Middle Income | 0.228 | 50 | |
| High Income | 0.230 | 10 | |

[Source: Field Survey, March 2012; Final Report, Bangladesh Municipal Development Fund (Bmdf), Study on Municipal Solid Waste Management]

**Table 1.5:** Average Waste Generation of Rajshahi City Corporation.

| Description | Low Growth Rate (LGR) | Medium Growth Rate (MGR) | High Growth Rate (HGR) |
|---|---|---|---|
| Domestic Waste Generation Rate (kg/capita/day) | 0.203 | 0.203 | 0.203 |
| Population in RCC | 551124 | 795451 | 882246 |
| Total Domestic Waste (ton) | 112.120 | 161.825 | 179.483 |
| Market Waste | 32.738 | 32.738 | 32.738 |
| Total Waste (ton) | 187.9 | 194.6 | 255.3 |

[Source: Nazrul Islam et al. (2009)]

**Table 1.6:** Per Capita Domestic & Market Waste and Overall Waste Generation Rate in RCC

| Description | Waste Generation Rate (kg/capita/day) | | |
|---|---|---|---|
| | LGR | MGR | HGR |
| Per Capita Domestic Waste | 0.203 | 0.203 | 0.203 |
| Per Capita Market Waste | 0.059 | 0.041 | 0.037 |
| Overall Waste Generation Rate | 0.341 | 0.245 | 0.289 |

[Source: Nazrul Islam et al. (2009)]

**Table 1.7:** Physical Composition of Solid Waste in Rajshahi City Corporation

| Component | Household (%) | Market (%) | Landfill Site (%) |
|---|---|---|---|
| Vegetable, Food | 82.05 | 83.65 | 79.4 |
| Bones, Fishbone | 0.27 | 0.13 | 0.37 |
| Paper | 4.40 | 1.23 | 2.3 |
| Plastic | 6.63 | 1.98 | 3.53 |
| Textile, Rags, Jute | 1.50 | 2.55 | 2.2 |
| Glass | 0.51 | 0.40 | 0 |
| Leather, Rubber | 0.22 | 0.20 | 0.85 |
| Metals | 0.00 | 0.13 | 0 |
| Ceramic | 0.33 | 0.38 | 0.39 |
| Soil, Ash | 3.60 | 8.21 | 10.51 |
| Grass, Creepers, Herbs, Wood | 0.42 | 1.12 | 0.45 |
| Medicine, Chemical | 0.07 | 0.00 | 0 |
| Miscellaneous | 0.00 | 0.00 | 0 |
| Feather/coconut shell | 0.00 | 0.00 | 0 |
| Total | 100.00 | 100.00 | 100.00 |
| Compostable | 82.47 | 84.77 | 79.85 |
| Non-compostable | 13.93 | 7.02 | 9.64 |
| Ash content | 3.60 | 8.21 | 10.51 |

[Source: Field Survey, March 2012; Final Report, Bangladesh Municipal Development Fund (Bmdf), Study on Municipal Solid Waste Management]

**Table 1.8:** Data of Solid Waste Dumping Site of RCC

| SN | Particulars | Quantity |
|---|---|---|
| 01 | Quantity of solid waste in RCC | 350 MT/day |
| 02 | Quantity of solid waste dumping | 230 MT/day |
| 03 | Quantity of waste used for composting | 120 MT/day |
| 04 | No. of truck / tractor for waste transport | 12 |
| 05 | No. of rickshaw van for waste transport on main road | 33 |
| 06 | No. of rickshaw van for waste transport, ward wise | 180 |
| 07 | No. of wheel bar for waste transport on main road | 60 |
| 08 | No. of wheel bar for waste transport, ward wise | 90 |
| 09 | Permanent employee | 34 |
| 10 | Daily contractual employee | 1092 |
| 11 | Area of final waste dumping site at Nawdapara | 50 bigha (7,40,000 sft) |
| 12 | Secondary waste dumping point | 19 |
| 13 | Composting site | 14 no ward, terokhadia |

[Source: Rajshahi City Corporation, 2010]