STUDY OF WATER QUALITY OF THREE RIVERS AROUND DHAKA CITY

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KARTICK CHANDRA GHOSH
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ROLL NO: 921113 F

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

CERTIFICATION OF THESIS WORK

We, the undersigned, certify that ***KARTICK CHANDRA GHOSH*** candidate for the degree of ***Master of Science in Engineering (Chemical)*** has presented his thesis on the subject " **STUDY OF WATER QUALITY OF THREE RIVERS AROUND DHAKA CITY"**. The thesis is acceptable in form and content. The student demonstrated a satisfactory knowledge of the field covered by this thesis in an oral examination held on Decmber, 1996.

Dr. M. Hanif Siddique — Chairman
Associate Professor,
Dept. of Chemical Engineering,
BUET, Dhaka.

Nooruddin ahmed

Dr. Nooruddin Ahmed — Member
Professor and Head
Dept. of Chemical Engineering,
BUET, Dhaka.

Dr. A. K. M. A. Quader — Member
Professor,
Dept. of Chemical Engineering,
BUET, Dhaka.

M. F. ahmed

Dr. M. Feroz Ahmed — Member (External)
Professor,
Dept. of Civil Engineering,
BUET, Dhaka.

ABSTRACT

Study of water quality from different rivers around Dhaka City were conducted for the period from September' 95 to February' 96. Different tests were performed at regular intervals of one month. The rivers Turag, Balu, Shitalakhya, and Buriganga around Dhaka City were segmented into 10 station points. The station points were concentrated near the industrial belt, and at each station points, water samples were taken from various depths, and distances from the river bank. With the samples some physical parameters such as total suspended solids(TSS), total dissolved solids(TDS), conductivity, and turbidity, and some chemical parameters such as p^{H}, dissolved oxygen(DO), Biochemical oxygen demand(BOD), chemical oxygen demand(COD), total sulfate, total phosphate, chloride, nitrate, total lead, hexavalent and total chromium, total iron, and ammonium were investigated. Different industries along the river side, and their used chemicals were also investigated.

Data analysis indicated that Buriganga river is the most polluted river. Pollution load is mainly from sewage and human excreta. Industrial pollution load is much less in quantity, but in localized areas such as Turag river at Tongi, Buriganga river ar Hazaribugh and Pagla, and Shitalakhya river at Demra and Adamji, concentrations of different constituents are alarmingly high.

All the experimental findings are critically discussed, conclusions drawn and recommendations are made for proper treatment and further studies.

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CHAPTER-1

INTRODUCTION

1.1. General

Substantial data is available on water qualities of few rivers of Bangladesh. However, some of these data may lack authenticity. It is likely that river water at several locations in this country are contaminated to levels that may be harmful to aquatic life, their consumer and water users. Department of Environment or other concerned government agencies are yet to form a Water Management Strategy to improve an understanding of the extent, and severity of water pollution, and to propose control, and remediation programs. In this regard, it is worthy of noting that polluted water is the precursor of contaminated sediment.

The water pollutants of greatest concern appear to be heavy metals (soluble form), and persistent, toxic, bioaccumulative organic compounds. Potential sources of these pollution are municipal wastewater treatment plants, industrial discharges of process waters, runoff, and leachate from hazardous waste, and solid waste disposal site, runoff from industrial manufacturing, and storage sites, and atmospheric deposition of contaminants.

Monitoring of water-quality is an essential step in environment protection or environment management program. It is the first step in knowing whether there is any need for concern or action. Meaningful goals, targets or schedules of action cannot be set without knowing the base point. Field monitoring data for this purpose is essential for evaluating the performance of policies adopted for protection of the environment from pollution.[16]

The quality of water in lakes, rivers, ponds, and streams greatly influences the use that water is put to. Activities such as fishing, swimming, boating, shipping, and waste disposal have different requirements for different qualities of water. In many parts of the world, the introduction of pollutants from human activity has seriously degraded the quality of water.[2]

River water is the ultimate dumping depot of all physical, chemical, and biological pollutants, i.e, river system is the natural drainage channel for receiving of all pollution from the land surface. We must be able to measure the pollutants, predict the impact of the pollutant on the river water quality determine the background water quality which would be present without human intervention, and decide the levels acceptable for intended uses of the water.[2]

The impact of pollution on a river depends both on the nature of the pollutant, and the unique characteristics of the individual river. Some of the most important characteristics include the volume and speed of water flowing in the river, the river's depth, the type of bottom, and the surrounding vegetation. Other factors include the physical, and chemical characteristics. The physical characteristics include total solid content, temperature, conductivity, turbidity etc. The chemical characteristics include pH, dissolve oxygen, BOD, COD, different anion, and cation etc.[10]

Some pollutants, particularly oxygen-demanding wastes and nutrients, are so common, and have such a profound impact on almost all types of rivers that they deserve special emphasis.

Water is absolutely essential for human life. Adequate good quality water for the maintenance, and development of public health is a vital requirement with rapid pace of industrialization, and increase in human pollution, effluents have posed a serious threat to the vast and varied fishery resources of the country. Water quality of major river systems is getting rapidly degraded due to massive discharge of industrial wastes of diverse origin, domestic sewage, fly ash, mine drainage, oils, surfactants, radioactive material etc. Extensive use of pesticides and insecticides have put the interest of agriculture, and aquaculture at cross purposes. Fish kills in the rivers, and estuaries due to different metallic pollutants like mercury, lead, zinc, cadmium, copper, etc. are common.

In Bangladesh most of the pollution of river water is caused by the industrial, sewage, and agricultural wastes. During the monsoon the pollution problem of river water is less. But the actual problem occurs during the dry season when the river flow is sluggish, and this may aggravate with saline intrusion and other ecological and limological changes due to diversion of rivers water upstream in the neighbouring countries.

Due to lack of safe water supply, and proper environmental sanitation, about 70% of the total population of Bangladesh suffer from different water borne diseases like cholera, dysenteries, typhoid, paratyphoid, hepatitis, and various types of diarrhoeal disorders.[16]

In addition, most of the industries are situated along the river side in different zones in Bangladesh. These industries simultaneously use river water for water sources, and as transmitting media of different industrial waste, without treatment. Different types of chemicals are used by these industries of which some are very toxic, and make major contribution to the pollution extent of water quality.[16]

1.2. Water Quality Parameters

The nature and extent of pollution is characterised by several physical, chemical, and biological parameters.

(i) Physical parameters: These characteristics are: color, odor, temperature, turbidity, and density which affect our senses.[2]

(ii) Chemical parameters: These are total dissolved salts, suspended solids, nature, and amount of soluble salts, hardness, p^H, dissolved oxygen, and other gases, organic chemicals, and radioactivity. Some metalloides, and ions of Fe, Cu, Mn, As, Pb, Cd, Hg, Na, Li, K, Ca, Mg, S, NO_3^-, NH_4^+, PO_4^{-3}, F^-, Cl^-, and Si if present, above certain limits become toxic to man, animals, and aquatic life.[2]

The detergents which are surface active agents are composed mainly of alkyl benzene sulphonate, and also create water quality problem. Floating oil, mostly from ships, engine boat, petrochemicals, oil refinery wastes, industrial plant wastes, and storm drains pollute water.[2]

The organic pollutants can be further divided into two classes, viz., biodegradable, and non-biodegradable. The first kinds are sugars, starch, fats, proteins, carbohydrates, polymers etc., which are not toxic to some microorganisms that carry out biological oxidation process. However, the second kinds are those that persist in the aquatic system for a longer period of time like pesticides.[2]

(iii) Biological parameters: Bacterial pollution in water is caused by the excreta of warm blooded animals including man, domestic, and wild animals, and birds by a wide variety of genera. The main ones are:
(a) Coliform group, and certain subgroups, (b) Faecal streptococci, and certain subgroups, (c) Miscellaneous organisms. These cause disease as dysentery, typhoid fever, para-typhoid fever, cholera, and gastroenteritis.[2]

1.3. Objectives

The purpose of this study is to evalute the water quality parameters of three rivers around Dhaka City.

A. **Water quality parameters:** The following wastewater characteristics are investigated:
Total suspended solids (TSS), total dissolved solids (TDS) conductivity, p^H, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total phosphate (PO_4^{-3}), total sulfate (SO_4^{-2}), chloride(Cl^-), nitrate (NO_3^-), ammonia (NH_4^+), total lead, hexavalent and total Chromium, total iron,

B. **Data analysis:** Using the observed water quality parameters, assess the pollution level with respect to water usages drinking, fishing and industrial.

C. **Industrial survey:** Identification of industrial areas around Dhaka City. Isolate the pollution casing industries by investigation of their raw material usages and waste disposal method.

1.4. Scope

The study would provide useful information to prepare a database on water quality of surrounding rivers of Dhaka City. It would also provide the extent of water pollution and fate of pollutants discharged to the river.

CHAPTER-2

LITERATURE REVIEW

2.1. Water Pollution

Water resources have been the most exploited natural system since man strode the earth. Rapid population growth, increasing living standards, wide spheres of human activities, and industrialization have resulted in greater demand of good quality water while pollution of water resources is increasing steadily.[2]

The term pollution may be defined as the deterioration in the chemical, physical, and biological properties of water brought about mainly by human activities. Pollution can be natural caused by hydrological processes also in which the decomposed animal, and vegetable materials, and weathering products of rocks, minerals, and soil ingredients are brought into the main water resources. All these processes lead to degradation of the natural environment .[2]

Natural sources of water pollution:

- bottom sediment degassing.
- volcanic, and other geothermal activities.
- storm water runoff.
- deposition of harmful gases by rain.

Water pollution resulting from human activities:

- acceleration of soil erosion and deposition on water bodies due to deforestation, and desertification.
- excavation and transportation of surface materials during large-scale civil engineering works (roads, dams, tunnels etc.).
- alteration of earths crust.
- exploitation of mines, runoff from mines.
- indiscriminate discharge of industrial processes.
- use and disposal of components that exerts oxygen demand in water bodies.

2.2. Pollution Sources

The wide range of pollutants that are being discharged to surface waters can be grouped into broad classes, which also includes the principal sources of each pollutant group.[5] The characteristics of different wastewater, and their sources are given in table-2.1, and table-2.2.

Point sources: Domestic sewage and industrial wastes are called point sources because they are generally collected by a network of pipes or channels and conveyed to a single point of discharge into the receiving water. Domestic sewage consists of wastes from homes, schools, office buildings, and stores. The term municipal sewage is used to mean domestic sewage into which industrial wastes are also discharged. In general, point source pollution can be reduced or eliminated through proper wastewater treatment prior to discharge to a natural water body.[5]

Non-point sources: Urban and agricultural runoff are characterized by multiple discharge points. These are called non-point sources. Often the flow of polluted water flows over the surface of the land or along natural drainage channels to the nearest water body. Even when urban or agricultural runoff waters are collected in pipes of channels, they are generally transported the shortest possible distance for discharge, so that wastewater treatment at each outlet is not economically feasible. Much of the non-point source pollution occurs during rain storms or spring snowmelt resulting in large flow rates that make

Table-2.1.

Physical, Chemical and biological characteristics of wastewater and their sources.[1]

Characteristic	*Sources*
Physical properties:	
Color	*Domestic and industrial wastes, natural decay of organic materials*
Odor	*Decomposing wastewater, industrial wastes*
Solids	*Domestic water supply, domestic and industrial wastes, soil erosion, inflow/infiltration*
Temperature	*Domestic and industrial wastes*
Chemical Constituents:	
Organic:	
Carbohydrates	*Domestic, commercial, and industrial wastes*
Fats, Oils and grease	*Domestic, commercial, and industrial wastes*
Pesticides	*Agricultural wastes*
Phenols	*Industrial wastes*
Proteins	*Domestic, commercial, and industrial wastes*
Priority pollutants	*Domestic, commercial, and industrial wastes*
Surfactants	*Domestic, commercial, and industrial wastes*
Volatile organic compounds	*Domestic, commercial, and industrial wastes*
Other	*Natural decay of organic materials*
Inorganic:	
Alkalinity	*Domestic wastes, domestic water supply, groundwater infiltration*
Chlorides	*Domestic wastes, domestic water supply, groundwater infiltration*
Heavy metals	*Industrial wastes*
Nitrogen	*Domestic and agricultural wastes*
p^H	*Domestic, commercial, and industrial wastes*
Phosphorus	*Domestic, commercial, and industrial wastes; natural runoff*
Priority pollutants	*Domestic, commercial, and industrial wastes*
Sulfur	*Domestic water supply; domestic, commercial, and industrial wastes*
Gases:	
Hydrogen sulfide	*Decomposition of domestic wastes*
Methane	*Decomposition of domestic wastes*
Oxygen	*Domestic water supply, surface-water infiltration*
Biological Constituents:	
Animals	*Open watercourses and treatment plants*
Plants	*Open watercourses and treatment plants*
Protists:	
Eubacteria	*Domestic wastes, surface-water infiltration, treatment plants*
Archaebacteria	*Domestic wastes, surface-water infiltration, treatment plants*
Viruses	*Domestic wastes*

Table-2.2.

Industrial wastes: Their origin and characteristics[12]

Industries Producing Wastes	Origin of major wastes	Major characteristics
1. Textiles	Cooking of febrics, desizing of fabrics.	Highly alkaline, colored, high BOD and temperature, high suspended solids.
2. Leather goods	Unhairing, soaking, deliming and bating of hides.	High total solids, hardness, salt, sulfides, Cr, p^H, Precipitated lime & BOD.
3. Laundry trades	Washing of fabrics.	High turbidity, alkalinity and organic solids.
4. Canned goods	Trimming, cutting, juicing and blanching fruits and vegetables.	High in suspended solids colloidal and of dissolved organic matter.
5. Dairy products	Dilution of whole milk, separated milk, butter milk and whey.	High in dissolved organic matter, mainly protein, fat and lactose.
6. Brewed & distilled beverages	Steeping & pressing grain, residue from distillation of alcohol condensated from stillage evaporation.	High in dissolved organic solids, containing nitrogen or their fermented products.
7. Meat & poultry products	Stockyards, slaughtering of bones & fats, residues in concentrates, grease and wash water, picking of chickens.	High in dissolved and suspended organic matter, blood, other proteins, and fats.
8. Animal feedlots	Excreta from animals.	High in organic suspended solids and BOD.
9. Beet sugar	Transfer, screening and juicing water, draining from lime.	High in dissolved and suspended organic matter containing sugar and protein.
10. Pharmaceutical products	Mycelium, spent filtrate and wash waters.	High in dissolved and suspended organic matter, including vitamins.
11. Yeast	Residue from yeast filtration.	High in solids (mainly organic) and BOD.
12. Pickles	Lime water, brine, alum and turmeric, syrup, seeds and pieces of cucumber.	Variable p^H, high suspended solids, color and organic matter.
13. Coffee	Pulping and fermenting of coffee bean	High BOD and suspended solids.
14. Fish	Rejects from centrifuge, pressed evaporator and other wash water wastes.	Very high BOD,total organic solids & odor.
15. Rice	Soaking, cooking and washing of rice.	High BOD, total suspended solids.
16. Bakeries	Washing & greasing of pans; floor washing.	High BOD, grease, sugar, flour,detergents.
17. Pulp and paper	Cooking, refining, washing of fibers, screening of paper pulp.	High or low p^H, color, high suspended colloidal and dissolved solids.
18. Steel	Cocking of coal, washing of blast furnace fuel gases, pickling of steel.	Low p^H, acids, cyanogen, phenol and ore, cokes, lime stone, alkali and fine SS.
19. Metal-plated	Stripping of oxides, cleaning and plating of metals.	Acid, toxic metals.
20. Iron-foundry	Wasting of used sand by hydraulic discharge.	High SS, mainly sand some clay and coal.
21. pesticides	Washing and purification products.	High organic matter toxic to aquatic life.
22. Detergents	Washing & purifying soaps & detergents.	High in BOD and saponified soaps.
23. Glue manufacturing	Lime & acid washes, extraction of proteins.	High COD, BOD, p^H, Cr, strong acids.
24. Acids	Dilute water wash, many dilute acids.	Low p^H, low organic content.

treatment even more difficult. Reduction of non-point source pollution generally requires changes in land use practices and improved education.[5]

Oxygen-demanding material: Anything that can be oxidized in the receiving water with the consumption of dissolved molecular oxygen is termed oxygen-demanding material. This material is usually biodegradable organic matter but also includes certain inorganic compounds. The consumption of dissolved oxygen, DO, poses a threat to higher forms of aquatic life that must have oxygen to live. The critical level of DO varies greatly among species. For example, brook trout may require about 7.5 mg/L of DO, while carp may survive at 3 mg/L.[5] As a rule, the most desirable commercial, and game fish require high levels of dissolved oxygen. Oxygen-demanding materials in domestic sewage come primarily from human waste, and food residue. Particularly noteworthy among the many industries which produce oxygen-demanding wastes are the food processors, and paper industry. Almost any naturally occurring organic matter, such as animal droppings, crop residues, or leaves, which get into the water from non-point sources, contribute to the depletion of DO.[5]

Nutrients: Nitrogen and phosphorus, two nutrients of primary concern, are considered pollutants because they are too much of a good thing. All living things require these nutrients for growth. Thus, they must be present in rivers and lakes to support the natural food chain. Problems arise when nutrient levels become excessive and the food web is grossly disturbed, which causes some organisms to proliferate at the expense of others. Excessive nutrients often lead to large growths of algae, which in turn become oxygen-demanding material when they die and settle to the bottom. Some major sources of nutrients are phosphorus-based detergents, fertilizer, and food-processing wastes.[5]

Toxic metals & toxic organic compounds:

Agricultural runoff often contains pesticides and herbicides that have been used on crops. Urban runoff is a major source of lead and zinc in many water bodies. The lead comes from the exhaust of automobiles using leaded gasoline, while the zinc comes from tire wear. Many industrial wastewaters contain either toxic metals or toxic organic substances. If discharged in large quantities, many of these materials can render a body of water nearly useless for long periods of time. Many toxic compounds are concentrated in the food chain, making fish and shellfish unsafe for human consumption. Thus, even small quantities in the water can be incompatible with the natural ecosystem and many human uses.[5]

Heat: Although heat is not often recognized as a pollutant, those in the electric power industry are well aware of the problems of disposing of waste heat. Also, many industrial process waters are much hotter than the receiving waters. In some environments an increase of water temperature can be beneficial. For example, production of clams, and oysters can be increased in some areas by warming the water.[5] On the other hand, increases in water temperature can have negative impacts. Many important commercial and game fish such as salmon and trout will only live in cool water. In some instances the discharge of heated water from a power plant can completely block salmon migration. Higher temperatures also increases the rate of oxygen depletion in areas where oxygen-demanding wastes are present.

2.3. Water Quality Parameters

The nature and extent of pollution is characterised by several physical, chemical, and biological parameters:

2.3.1. Physical parameters: The most important physical characteristic of wastewater is its total solids content, which is composed of floating matter, settleable matter, colloidal matter, and other matter in solution. Other important physical characteristics include odor, temperature, density, color, conductivity, and turbidity.[1]

Total solids: The total solids content of wastewater/natural watter is defined as all the matter that remains as residue upon evaporation at 103°C to 105°C. Matter that has a significant vapor pressure at this temperature is lost during evaporation, and is not defined as a solid. Total solids are divided into three main classes such as settleable or suspended solids (SS) with a nominal size of about 1.2 µm, filterable solids with an approximate size range from 0.001 to 1.0 µm and dissolved solids (TDS) with a size less than 0.001 µm. The discharge limit or standard of TDS and TSS for drinking water is 1000 mg/L and 10 mg/L, for industrial effluent is 1500 mg/L and 75 mg/L, and SS for fishing water is 25 mg/L.[15]

Turbidity: Turbidity, is a measure of light-transmitting properties of water, that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. Turbidity in water is caused by suspended matter, soluble colored organic compounds, plankton, and other microscopic organisms. Turbidity is significant in water supplies, it creates potential public health hazards, unpleasant appearance, and operational difficulties. It is expressed as formazin turbidity unit (FTU) or nephelometric turbidity unit (NTU). A formazin turbidity unit (FTU) is equivalent to a nephelometric turbidity unit (NTU).For Bangladeshi Standard, the turbidity is expressed in JTU unit, which is 10 for drinking water and 50 for industrial water.[15]

Conductivity: Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on the temperature of measurement. Solutions of most inorganic acids, bases, and salts are relatively good conductors. Conversely, molecules of organic compounds that do not dissociate in aqueous solution conduct current very poorly, if at all. The term 'conductivity' is preferred, and customarily is reported in micro-mhos per centimeter (µmhos/cm). In the International system of units (SI) the reciprocal of the ohm is the siemens, and conductivity is reported as milli-siemens per centimeter (ms/cm) and micro siemens/cm.[4]

Freshly distilled water has a conductivity of 0.5 to 2 µmhos/cm.

The conductivity of potable waters is in the ranges of 50 to 1500 μmhos/cm. The conductivity of domestic wastewaters may be near that of the local water supply, although some industrial wastes have conductivities above 10,000 μmhos/cm.[4] For Bangladesh the standard for conductivity in mhos/cm is from 800 to 1000 for industrial water and 750 for irrigation water.[15]

2.3.2. Chemical Parameters:

The important chemical parameters that causes the water pollution are described below:

Chlorides: Most water contain some chloride in solution. The amount present can be caused by the leaching of marine sedimentary deposits, by pollution from seawater, brine, or industrial, and domestic wastes. Chloride concentrations in excess of about 250 mg/L usually produce a noticeable taste in drinking water. An increase in chloride content in groundwater water may indicate possible pollution from sewage sources.[6] For Bangladeshi standard in mg/L unit from 150 to 600 for drinking water, 600 for fishing and irrigation water.[15]

Copper: Copper is found in some natural waters, particularly in areas where these ore deposits have been mined. Excessive amounts of copper can occur in corrosive water that passes through copper pipes. Copper in small amounts is not considered detrimental to health, but will impart an undesirable taste to the drinking water. The recommended limit for copper is 1.0 mg/L.[6] In Bangladesh, the limit of copper is 1 mg/L for drinking water, less than 0.4 mg/L for fishing water, and 0.2 for irrigation water.[15]

Fluorides: In some areas water sources contain natural fluorides. Where the concentrations approach optimum levels, beneficial health effects have been observed. The optimum concentrations ranges from 0.7 to 1.2 mg/L are recommended. Excessive fluorides in drinking water supplies may produce fluorosis (mottling) of teeth, which increases as the optimum fluoride level is exceeded.

Iron: Small amounts of iron are frequently present in water because of the large amount of iron present in the soil, and because corrosive water will pick up iron from pipes. The presence of iron in water is considered objectionable because it imparts staining of bathroom fixtures, and brownish color to laundered goods, and affects the taste of beverages, such as tea and coffee. It is indicated that eggs spoil faster when washed in water containing iron in excess of 10 mg/L. The recommended limit for iron is 0.3 mg/L.[6]

Lead: A brief or prolonged exposure of the body to lead can be seriously injurious to health. Prolonged exposure to relatively small quantities may result in serious illness or death. Lead taken into the body in quantities in excess of certain relatively low `normal′ limits is a cumulative poison. A maximum concentration of 0.05 mg/L of lead in water must not be exceeded.[6] Lead in water may come from industrial, mine, and smelter discharges or from the dissolution of old lead plumbing.[4] Bangladeshi standard for lead is 0.05 mg/L for drinking, and fishing water, 0.01 mg/L for industrial water and 0.1 mg/L for irrigation water.[15]

Nitrates: Nit`rate($NO_3-$) has caused methemoglobinemia (infant cyanosis or `blue baby disease´) in infants who have been given water or fed formulas prepared with water having high nitrites. A domestic water supply should not contain nitrate concentration in excess of 45 mg/L.[6] Nitrates in excess of normal concentrations, often in shallow wells, may be an indication of seepage from livestock manure deposits.

Sodium: For healthy persons, the sodium content of water is unimportant because the intake of salt from other sources is so much greater; but for persons placed on a low-sodium diet because of heart, kidney, or circulatory ailments or complications of pregnancy, sodium in water must be considered. The usual low-sodium diets allow for 20 mg/L sodium in the drinking water.[6]

Sulfates: Waters containing higher concentrations of sulfate caused by the leaching of natural deposits of magnesium sulfate or sodium sulfate may be undesirable because of their laxative effects. Sulfate content should not exceed 250 mg/L.[6]

Hardness: Hard water retards the cleaning action of soaps and detergents, causing an expense in the form of extra work and cleaning agents. Furthermore, when hard water is heated it will deposit a hard scale with a consequent waste of fuel.

Calcium and magnesium salts, which cause hardness in water supplies are divided into two general classifications: carbonate, or temporary hardness, and noncarbonated or permanent hardness.[1]

pH: p^H is the measure of the hydrogen ion concentration in water. It is also a measure of the acid or alkaline content. p^H values ranges from 0 to 14, where 7 indicates neutral water; values less than 7, increasing acidity; and values greater than 7, increasing alkalinity. The p^H of water in its natural state often varies from 5.5 to 9.0.[1]

Chromium: Chromium is used in tanneries, and textile mills, the effluent from there are potential sources of water pollution.[2] Chromium may be present in water as hexavalent or in the trivalent form, although trivalent chromium rarely occurs in potable water.[4] Hexavalent chromium enters a water supply through industrial wastes from metal plating bath and from industrial cooling towers where chromate is used to inhibit metal corrosion. Chromium is an objectionable contaminant in public drinking water supplies due to its suspected carcinogenic effects. Chromium present in potable waters above a 3 μg/L level indicates the possible presence of industrial wastes. Chromium is toxic in high concentrations to both plants and animals. It is reported to cause perforations, bronchiogenic carcinoma (cancer related) etc. continuously exposed humans. [2]

Phosphates: Phosphates that occur in natural water and in wastewater are classified as orthophosphate, condensed phosphates, and organically bounded phosphates. They occur in solution, in particles or detritus, or in the bodies of aquatic organisms. These forms of phosphate arise from a variety of sources. Small amounts of certain condensed phosphates are added to some water supplies during treatment. Larger quantities of the same compounds may be added when the water is used for laundering or other cleaning, because these materials are major constituents of many commercial cleaning preparations. Phosphates are used extensively in the treatment of boiler waters. Orthophosphate applied to agricultural or residential cultivated land as fertilizers or carried into surface water with storm runoff, and to a lesser extent with melting snow. Organic phosphates are formed primarily by biological processes. They are contributed to sewage by body wastes, and food residues, and also may be formed from orthophosphate in biological treatment processes or by receiving water biota.[4]

Phosphates i,e. phosphorus is essential to the growth of organisms and can be the nutrient that limits the primary productivity of a body of matter. In instances where phosphate is a growth-limiting nutrient, the discharge of raw or treated wastewater, agricultural drainage, or certain industrial wastes to that water may stimulate the growth of photosynthetic aquatic micro- and macro-organisms in nuisance quantities. Phosphates also occur in bottom sediments and in biological sludges, both as precipitated inorganic forms, and incorporated into organic compounds.[4]

The major deleterious effect of phosphates i,e. phosphorus is that it serves as a vital nutrient for the growth of algae. If the phosphorus availability meets the growth demands of the algae, there is an excessive production of algae. When the algae die, they become an oxygen-demanding organic material as bacteria seek to degrade them. This oxygen demand frequently overtaxes the DO supply of the water body, and as a consequence, causes fish to die.[1]

In Bangladesh, the limit of phosphate is 6 mg/L for drinking water, 10 mg/L for fishing and irrigation water.

Ammonium (NH4+): Ammonia is present naturally in surface water and wastewaters. Its concentration generally is low in groundwater because it adsorbs to soil particles and clays, and is not leached readily from soils. It is produced largely by deamination of organic nitrogen containing compounds, and by hydrolysis of urea. At some water treatment plants ammonia is added to react with chlorine to form a combined chlorine residual. Ammonia concentrations encountered in water vary from less than 10 µg/L to 30 mg/L.[4] Ammonia nitrogen present in aqueous solution as either ammonium ion or ammonia, depending on the p^H of the solution, in accordance with the following equilibrium reaction:

$$NH_3 + H_2O \longleftrightarrow NH_4^+ + HO^-$$

At p^H levels above 7, the equilibrium is displaced to the left, at levels below p^H 7, the ammonium ion is predominant.[1]

Dissolved Oxygen(DO): Dissolved oxygen is required for the respiration of aerobic microorganisms as well as other aerobic life forms. However, oxygen is only slightly soluble in water. The actual quantity of oxygen that can be present in water as dissolved oxygen is governed by (i) the solubility of oxygen (ii) partial pressure of oxygen in the atmosphere (iii) the temperature of the environment, and (iv) the purity (salinity, suspended solids, etc.) of the water.[1]

Because the rate of biochemical reactions that use oxygen increases with increasing temperature, dissolved-oxygen levels tends to be more critical in the summer months, because stream flows are usually lower, and thus the total quantity of oxygen available is also lower. The presence of dissolved oxygen in wastewater is desirable because it prevents the formation of noxious odors.[1]

Dissolved oxygen is important to aquatic life because detrimental effects can occur when DO levels drop below 4 to 5 mg/L, depending on the aquatic species. If the DO is completely removed, all higher animals are killed or driven out, and extremely noxious conditions result. The water becomes blackish and foul smelling as the sewage and dead animal decompose under anaerobic conditions.[5]

Biochemical Oxygen Demand(BOD): BOD is the amount of oxygen required for the biochemical degradation of organic material (Carbonaceous demand), and the oxygen used to oxidize inorganic material such as sulfides and ferrous iron. It is also a measure of the strength of wastewater.[4] The quantity of oxygen utilized by a mixed population of microorganisms in the aerobic oxidation (of the organic matter in a sample of wastewater) at a temperature of 20°C for five days is BOD_5.[8]

$$BOD_5,\ (mg/L) = \frac{D_1 - D_2}{P}$$

Where,

D_1 = Dissolved oxygen of the sample or diluted sample before incubation, mg/L.

D_2 = Dissolved oxygen of the sample or of diluted sample after 5 days incubation at 20°C, mg/L.

P = decimal volumetric fraction of sample used.

Almost all oxidizable compounds can be oxidized by biochemical oxidation. Basically this reaction is written as:

Oxidizable Compound + Bacteria + Nutrient + Oxygen -------> Oxidized inorganic + CO_2 + H_2O.

The actual BOD is less than the theoretical amount due to the incorporation of some of the carbon into new bacterial cells.[4]

Chemical Oxygen Demand(COD): The chemical oxygen demand (COD) is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant.[4] The COD of a waste, in general, will be greater than the BOD_5, because more compounds can be oxidized chemically than can be oxidized biologically, and because BOD_5 does not equal ultimate BOD.[5] The dichromate reflux method is preferred over procedures using other oxidants because of its superior oxidizing ability, applicability to a wide variety of samples, and ease of manipulation. Oxidation of most organic compounds is 95 to 100% of the theoretical value.[4]

2.3.3. Biological Parameters: [1]

Water for drinking and cooking purposes must be made free from disease-producing organisms. The organisms that present in the water are the following:

Microorganisms: The principal groups of organisms that found in surface water and wastewater are classified as protista, plants, and animals. The category protista includes bacteria, fungi, and algae. Seed plants, ferns, and mosses and liverworts are classified as plants. Invertebrates and vertebrates are classified as animals. Viruses, which are also found in wastewater, are classified according to the host infected.

Bacteria played the extensive and fundamental role in the decomposition and stabilization of organic matter. Coliform bacteria are also used as an indicator of pollution by human wastes. The presence of algae affects the value of water for water supply because they often cause taste and odor problems.

Pathogenic organisms: Microorganisms found in wastewater include bacteria, viruses, and protozoa exerted by diseased persons or animals. When discharged into surface waters, they make the water unfit for drinking (that is non-potable). If the concentration of pathogens is sufficiently high, the water may also be unsafe for swimming and fishing. Certain shellfish can be toxic because they concentrate pathogenic organisms in their tissues, making the toxicity levels in the shellfish much greater than the levels in the surrounding water.[5]

2.4. Environmental Legislation

The objective of the water pollution control legislation is to restore and maintain the chemical, physical, and biological integrity of a nation's waters. In the USA the key federal group that is responsible for the protection of the environment is the Environment Protection Agency (EPA). This is a regulatory agency. It must establish and enforce environmental standards for pollution control effort. Research and monitoring are also the principle areas of concern for EPA. It is the purpose of EPA to research, and suggest solutions, and at the same time it has the obligation to monitor, and analyze the environment, and also to conduct scientific studies in an effort to find cause and effect of pollution. Once the causes, and effects are known, control techniques can be established.[7]

The Water Pollution Control Ordinance, 1970 was promulgated exclusively for the abatement and control of water pollution in Bangladesh. It was amended after the emergence of Bangladesh by the Water Pollution Control (Amendment) order, 1973. In 1977, in the face of growing environmental pollution, the Water Pollution Control Ordinance, 1970 was repealed and the Environmental Pollution Control (EPC) Ordinance, 1977 was promulgated. The act provided for the control, prevention and abatement of the pollution of the environment of Bangladesh. The Pollution Control Cell created under the EPC ordinance 1977 grew into the Department of Environmental Pollution Control (DEPC) and subsequently to the Department of Environment (DOE). The Environmental Protection Act, 1995 has been enacted repealing the EPC Ordinance 1977 for environmental protection, improvement, pollution abatement and control.[23] Besides, the Paurasava Ordinance 1977, Local Government Ordinance 1982 and 1983, WASA Act, 1996 etc. provide the local government bodies and authorities with the responsibilities for safe water supply, sanitation, protection of public bathing places, control and administration of public water courses, prevention of contamination of sources of drinking water etc.[23]

Water Quality Standards

The first water quality standards of Bangladesh for drinking, fishing and recreational water were published in December 1976 by the then Water Pollution Control Board. The drinking water standards were based on the WHO 1963 and WHO 1971 International Drinking Water Standards. These standards were followed by Department of Public Health Engineering (DPHE) for the development of water supplies for both urban and rural areas. In 1984, the WHO published the Guideline values for a large number of water quality parameters to promote development of national standards by individual countries depending on availability of water, socio-economic conditions and technical capabilities.

The Bangaldesh Standard Specification for Drinking Water (BDS 1240: 1989) prepared and published by the Bangladesh Standard and Testing Institution (BSTI) is now in force for the control of quality of drinking water.[23]

In 1991, the Department of Environment prepared and published draft Environment Quality Standards (EQS) for the protection of the environment. The EQS provide the standard values for drinking, industrial, agricultural, recreational, fishing, livestock and coastal waters and sewage and industrial effluents for discharges in natural waters and sewer system. The Environmental Quality Standards are yet to be adopted by Gazette notification under the provision of the Environmental Protection Act, 1995.[23]

2.5. Consequences of Water Pollution

Of the water available on earth less than 1% is available to man. It is therefore the bounden duty of man towards future generations that the quality of water is handed down in a condition at least not worse than it was before. A wide variety of pollutants physical, chemical, biological, and radiological have been identified in the environment consequent to urbanization industrialization, and new technological developments.[2]

With the expansion of chemical and pharmaceutical industries since World War II, hundreds of new products are being placed on the market each year many of which are time or other helpful to man and other life. Among toxic organic compounds are the pesticides used to kill insects, rodents and weeds. These substances are sprayed on farms, and accumulate with repeated applications. The widely used synthetic detergents are difficult and expensive to remove from wastewater, and hence they collect in our water courses, and ground waters. They are toxic, and produce foam. Furthermore, with increased industrialization there has been a growing use of radioisotopes which results in the discharge of radioactive wastes in the water courses. Sources of pollution by trace metals like Pb, Hg, As, Cr, Zn, Cu, Mn, and Fe are mainly aquatic releases from industrial operations, atmospheric releases, domestic sewage discharge etc. They inhibit varying degree of toxicity.[2]

The various pollutants in the water are mutagenic, and/or carcinogenic or have serious ecological implications.

Various serious diseases like cholera, typhoid fever, bacillary dysentery, Amoebic dysentery, infections hepatitis are transmitted through polluted waters.[16]

Water resources are one of the most critical and valuable component of the natural resources in Bangladesh. Over a third of Bangladesh is reasonably inundated. Water resources is vital because the economy depends on agriculture and fisheries. Therefore, effective management of water both in respect of quantity as well as quality is the most crucial environmental issue in Bangladesh.[16]

Major pollution in the rivers of Bangladesh are by sewage pollution. Infectious agents contaminate surface water from excreta, domestic, and hospital wastewater becomes a media for carrying various diseases.[16]

Industrial pollution in Bangladesh is still limited within small pocket of areas. Most industries do not use any treatment for their effluents. Pollution in these pocket areas can be highly concentrated such as Tongi industrial area, Hazaribug tannery area, Narayangonj industrial area etc. Increasing use of agro chemicals are likely to contaminate ground water. Organic and chemical pollution sources are of concern to fisherman and other beneficial users of surface water. The self cleaning capacity of rivers is immense because of high dilution especially during rainy season. Therefore, pollution in some localized areas do not create significant impact on overall quality of rivers.[16]

Bangladesh have different industries in different zones. Many new industrial areas have been growing. Among different industries, the important types are pulp, and paper industries, rayon mills, tanneries, fertilizer factories, pharmaceutical industries, textile industries, jute mills, rubber processing industries, different types of chemical industries, steel mills, refineries, machine tool factories etc. Almost all of these industries are located near the bank of natural streams. These natural streams are simultaneously used for water sources, and as transmitting media of different industrial waste. These industries are using various types of chemical some of which are toxic, and are very important in deteriorating the water quality.[10]

With respect to other environmental parameters water pollution is much more important in Bangladesh, considering the geographical features, population explosion, present agro-based economy, and necessary rapid industrialization. It is obvious that in the not too distant future, the country will surely face a tremendous problem of water pollution which may well destroy the economy of the country by damaging the water resources of the riverain country to great extent, which will render the water quite unsuitable for domestic and industrial uses.[15] Health effects of different contaminants are given in table-2.3.

Table-2.3

Health effects of Contaminanted Water[12]

Contaminant	*Health Effect*
Microbiological organisms	*Cause various illness, some potentially fatal. Common waterborne diseases caused by microorganisms include gastroenteritis, typhoid, bacillary dysentery, infectious hepatitis, amebic dysentery, and giardiasis.*
Turbidity	*Protects microorganisms from chlorine and other disinfectants, acts as a food source for microorganisms, interferes with maintenance of a chlorine residual in the distribution system, and interferes with coliform testing.*
Arsenic	*Causes small sores on hands and feet, possibly developing into cancers.*
Chromium	*Causes skin sensitization, kidney damage.*
Lead	*Causes constipation; loss of appetite; anemia; tenderness; pain and gradual paralysis in the muscles, especially the arms.*
Mercury	*Causes inflammation of the mouth and gums; swelling of the salivary glands; loosening of the teeth.*
Selenium	*Causes staining of fingers, teeth and hair; general weakness; depression; irritation of the nose and throat.*
Silver	*Causes permanent gray discoloration of slin, eyes and mucous membranes.*
Fluoride	*Causes stained spots on teeth (mottling)- the amount of discoloration depends on the amount of fluoride ingested.*
Nitrate	*Causes temporary blood disorder in infants can be fatal.*
Pesticides *Endrine* *Lindane* *Methoxychlor* *Toxaphene*	*Cause symptoms of poisoning which differ in intensity. The severity is related to the concentration of these chemicals in the nervous system, primarily the brain. Mild exposure causes headaches, dizziness, numbness and weakness of the extremities. Severe exposure leads to spasms involving entire muscle groups, leading in some causes to convulsions. Suspected of being carcinogenic.*
Herbicides	*Cause liver damage and gastrointestinal irritation.*
Tihalomethanes	*Suspected as possible carcinogens.*

2.6. Water Quality Standard for Bangladesh

The quality of water is of vital concern for mankind since it is directly linked with human welfare. So recognizing the urgency of the Environmental quality standard, the Department of Environment in 1991, made the Water Quality Standard which are shown in table-2.4.[15]

Table-2.4

Standard Values for water qualities in Bangladesh

Parameters/ determinants	*Drinking water (mg/L)*	*Fishing water (mg/L)*	*Industrial water (mg/L)*	*Irrigation water (mg/L)*	*Livestock water (mg/L)*
Acidity	-	<20	-	-	-
Alkalinity (total)	-	70-100	-	-	-
Ammonia	0.5	0.025	-	3	-
Arsenic	0.05	-	-	1	1
Bicarbonate	-	-	-	-	500
B.O.D.	0.2	6	10	10	-
Chloride (as Cl)	150-600	600	600	2000	-
Chlorine (residual)	0.2	<0.01	-	-	-
Chromium (as Cr^{+6})	0.05	-	0.5	-	-
Chromium (total)	0.05	0.05	-	-	-
COD	4	-	3-10^a	-	-
Copper	1	<0.4	-	0.2	-
DO	6^b	4-6	5	5	4-6
EC (Unit mhos/cm)	-	800-1000	-	750	-
Hardness (as CaCO$_3$)	200-500	80-120	250^c	-	-
Iron	0.3-1	-	0.5^d	-	-
Lead	0.05	0.05	0.01	0.1	0.05
Nickel	0.1	-	-	0.5	-
Nitrate (as N)	10	-	-	-	250
p^H	6.5-8.5	6.5-8.5	6-9.5	6-8.5	5.5-9
Phosphate (as PO$_4$)	6	10	-	10	-
Sodium	200	-	-	-	1000
Sodium Chloride	-	-	-	-	2860-12000
S.S.	10	25	75	-	-
Sulfate (as SO$_4$)	400	-	-	1000	-
T.D.S.	1000	-	1500^e	2000	5000
Turbidity (as JTU)	10	-	50	-	-

a = For boiler feed water, depending on boiler pressure,
b = Desirable limit for drinking water,
c = For cooling water, d = Textile dyeing,
e = For boiler feed water 50-500 depending on boiler pressure.

2.7. Previous Work Data

Some water quality data published by the Department Environment of the different rivers around Dhaka City are shown in the table-2.5, 2.6, 2.7, 2.8, 2.9, and 2.10.

Table-2.5.

Water Quality Data of the Main drain of the Hazaribug Tannery at the discharge point of the river Buriganga.[13]

Date	Conductivity micro-mhos/cm	Turbidity JTU	p^H	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Cl^- mg/L	Cr mg/L	SO_4^{-2} mg/L	HN_4^+ mg/L	NO_3^- mg/L
21-01-90.	5800	200	8.5	4080	300	0.0	290	4000	2300	-	-	-	-
17-02-90.	7800	160	8.5	5470	442	0.0	190	1275	530	-	-	-	-
20-12-90.	6600	200	8.9	4630	870	0.0	-	-	470	-	-	-	-
20-02-90.	7100	200	8.4	4970	1750	0.0	330	-	2425	-	-	-	-
27-02-89.	-	-	-	-	3410	-	1050	2080	-	5.3	-	99	- [14]
08-02-88.	9800	1200	8.5	1098	186	0.0	413.3	-	1420	-	-	-	-
12-12-88.	9300	200	7.1	6510	400	0.0	260	2340	2950	-	-	-	-
03-01-85.	1000	-	8.5	5413	1316	0.4	3.9	2304	7150	1.77	-	-	-
06-02-85.	1000	-	8.2	6781	792	0.0	160	2110	5200	-	-	1.16	-
04-01-84.	8500	-	8.2	5213	1106	1.0	36	-	1060	-	-	-	-
09-02-84.	3500	-	8.1	1891	232	7.3	0.6	-	9750	-	-	-	-
09-12-84.	8900	-	8.5	5333	1206	0.0	40	115	500	-	-	-	-
03-02-83.	10700	-	9.7	6583	2327	0.0	65	-	4600	-	-	-	1313
09-01-80.	11250	1000	8.5	13288	2525	0.0	18	2736	7750	-	-	-	-
Avg. 1977	5345	52	8.55	4480	845	0.0	502	2250	1307	14.0	-	432	- [22]

Table-2.6.

Water Quality Data of the river Sitalakhya at Demra Ferry Ghat.[13]

Date	Conductivity micro-mhos/cm	Turbidity JTU	p^H	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	NO_3^- mg/L	Cl^- mg/L	HN_4 mg/L
11-02-85.	275	-	7.85	180	60	6.15	3.85	-	24.5	-
10-01-80.	300	<25	7.4	160	12	6.4	5.9	-	8.0	-
20-02-80.	320	<25	7.0	170	16	7.7	5.4	-	10.5	-
Avg. 1977	178	38	7.6	-	48	7.5	1.7	1.8	-	4.5
06-01-75.	260	<25	6.7	194	4	6.4	3.25	2.12	8.0	1.3
05-02-75.	320	-	8.3	201	13	8.3	2.2	0.35	5.5	-

Table-2.7.

Water Quality Data of the river Buriganga at Pagla.(Horizontally 20 ft from the river waste discharge peat by WASA to the River, 4 ft depth).[13]

Date	Conductivity micro-mhos/cm	Turbidity JTU	p^H	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Cl- mg/L
19-02-90.	198	<25	7.7	144	39	6.2	1.2	-	37
11-09-90.	222	30	7.1	158	52	6.4	1.6	-	27
22-10-90.	272	32	7.0	194	48	6.9	1.4	-	31
13-11-90.	279	<25	7.1	198	42	6.9	1.4	-	32
17-12-90.	192	<25	7.2	164	27	6.1	-	-	29
17-01-89.	295	<25	7.3	205	42	6.5	3.1	-	20
08-02-89.	440	-	7.1	306	42	4.9	2.6	-	27
15-11-88.	280	38	7.1	196	72	5.2	1.9	-	14
07-12-89.	300	<25	7.2	198	54	5.4	2.3	-	28

Table-2.8.

Water Quality Data of the river Sitalakhya at Narayangonj.[13]

Date	Conductivity micro-mhos/cm	Turbidity JTU	p^H	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Cl- mg/L
11-01-80.	295	50	7.3	157	13	9.5	4.9	-	6.5
19-02-80.	300	35	7.0	165	21	11.1	6.5	-	12.5
25-11-90.	552	88	7.2	178	34	6.4	1.21	-	20.0
22-01-89.	208	116	7.2	148	32	7.4	1.9	-	8.0
19-11-89.	120	52	7.3	87	31	6.3	2.0	-	32.0
19-11-88.	125	32	7.1	88	24	6.4	3.1	-	11.0
15-10-87.	90	32	7.0	128	58	6.2	2.7	-	4.0
11-01-83.	300.5	-	7.25	210.5	46	9.01	3.0	-	16.5
13-09-83.	85	-	6.75	47.5	33.5	8.9	3.15	-	31.0
09-10-83.	95.5	-	6.85	57.5	35	5.3	2.5	-	245.0
15-11-83.	129	-	6.7	76.5	31.5	7.1	4.15	-	18.0
11-12-83.	225	-	7.15	131.5	60.5	6.15	2.4	-	23.5

Table-2.9

Water Quality Data analyses by atomic Energy Centre.[16]

Location	*Constituents*	*Concentration (mg/L)*
Buriganga river at Chandnighat, 1992.	*Cr*	*0.005*
	Pb	*0.012*
Sitalakhya River at WASA Plant, 1986	*Cr*	*0.008*
	Pb	*0.012*
	SO_4^{-2}	*24.6.*

Table-2.10.

Water Quality Data of the river Balu at Tongi near pulp and paper mill.[13]

Date	Conductivity micro-mhos/cm	Turbidity JTU	pH	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Cl^- mg/L
13-09-90.	298.0	34	7.1	170.0	55.0	7.1	2.0	-	30.0
21-10-90.	298.0	<30	7.3	211.0	47.0	6.6	1.7	-	32.0
17-11-90.	355.0	<25	7.3	252.0	37.0	6.2	1.6	-	32.0
13-12-90.	177.0	25	7.2	128.0	26.0	6.2	-	-	18.0
10-09-89.	120.0	30	7.2	86.0	34.0	6.5	2.4	-	16.0
20-11-89.	125.0	<25	7.4	92.0	34.0	6.2	2.2	-	19.0
13-10-88.	99.0	<32	6.9	72.0	24.0	6.1	3.3	-	7.0
12-11-88.	100.0	<35	6.9	72.0	21.0	6.8	1.7	-	9.0
03-12-88.	80.0	-	6.7	60.0	18.0	5.3	2.7	-	26.0
19-09-87.	100.0	45	6.8	75.0	54.0	6.3	1.8	-	8.5
11-10-87.	95.0	30	6.9	89.0	41.0	6.1	2.5	-	3.8
05-01-84.	247.5	-	7.5	150.5	44.5	6.9	3.9	-	24.5
08-02-84.	246.5	-	7.85	131.0	43.5	4.65	0.65	-	39.5
20-01-83.	287.0	-	7.0	202.5	73.5	6.6	2.05	-	16.5
08-02-83.	310.0	-	6.5	205.0	77.0	0.8	41.0	-	19.5
06-10-83.	87.5	-	6.8	61.5	21.5	1.7	19.0	-	5.5
08-11-83.	55.5	-	6.9	71.5	38.0	4.7	2.2	-	14.5
08-12-83.	176.0	-	7.15	99.5	47.0	9.95	3.9	-	19.5

CHAPTER-3

EXPERIMENTAL METHODS

3.1. General

The stretch from surrounding rivers of Dhaka City, that is the rivers Turag, Balu, Shitalakhya, and Buriganga were segmented into 10 station points shown in figure-3.1. The station points were concentrated near the industrial belt. The samples were taken from each station point at various water depths, and distances from the river bank. Periodic sampling were conducted from all sampling stations during september 95 to February '96. Samples were stored at 4^oC in plastic containers for a maximum of 24 hours in a refrigerator. Within the period, samples were analyzed.

3.2. Equipment Description

3.2.1. Spectrophotometer

(A) DR/200: The Hach Model DR/2000 Spectrophotometer was microprocessor-controlled, single-beam instrument suitable for colorimetric testing in the laboratory or the field. The instrument was pre-calibrated for over 120 different colorimetric measurements, and had provisions for user-entered calibrations as well as future Hach updates. The test result could be displayed in percent transmittance, absorbance or concentration in the

Map-1

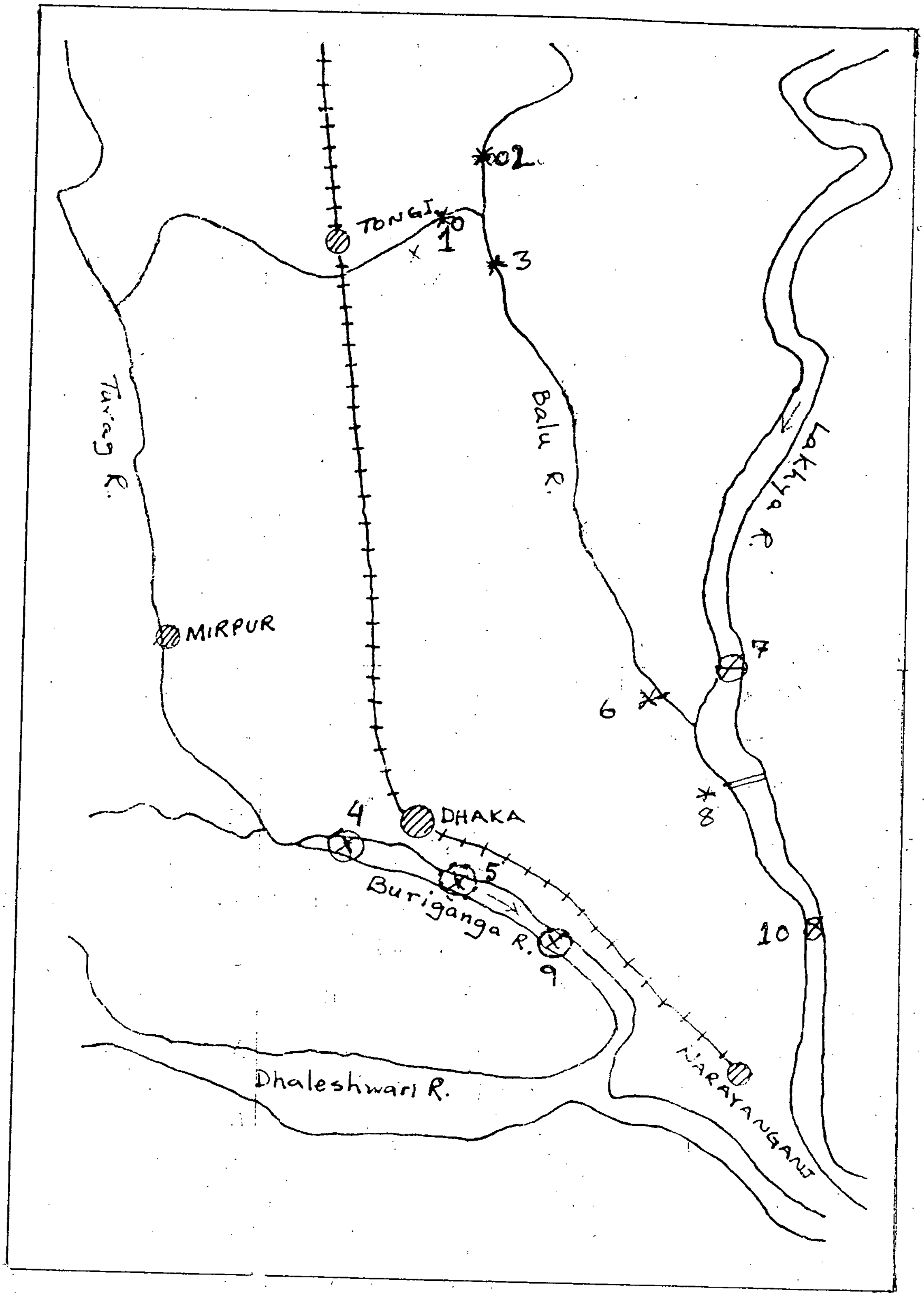

Figure:-3.1, Map of the different rivers around Dhaka City and locations of different station point.

appropriate units of measure. The instrument offers automatic ranging in the progrommed parameters, operator-selected languages, full prompting during testing, and error messages for procedural or instrument troubleshooting. A built-in timer helped the operator to observe specific reaction times called for in the test procedures by having the appropriate times programmed into the calibration data for that test. The spectrophotometer could be operated on battery power or AC line power using the battery eliminator or charger unit.

(B) SHIMADZU UV-1201:

The Shimadzu Spectrophotometer used for the analysis of water quality was UV-1201 with Water Analysis program Pack. The UV-1201 was designed to meet the wide-ranging needs of prospective users. The main Unit features fundamental photometric functions which were readily expandable using various application software packages, and attachments for enhanced convenience, and productivity.

3.2.2. Ciba Corning M-90:

The M90 was a portable, microprocessor based, p^H, conductivity, total dissolved solid, and dossolved oxygen meter. Different sensors were used for their respective measurement, such as p^H sensor for the measurement of pH of the samples, conductivity sensor used for TDS and conductivity, and DO sensor used for DO measurement.

Sample Analysis: Spectrophotometric method were employed for the measurements of the constituents turbidity, TSS, SO_4^{-2}, PO_4^{-3}, NO_3^{-1}, NH_4^+, Cl^-, Cr^{+6}, Cr^T, Fe^T, Pb, and COD. Calibration curves were prepared for the measurement of COD, Cr, PO_4^{-3}. But all other constituents that are mentioned above were measured with the chemicals (Powder Pillow) of the SIMUDZU. The conductivity, Dissolved oxygen, p^H, and total dissolved solids were measured with their respective meters or equipments.

Some of the constituents of water quality that were investigated in the study are briefly discussed in the following:

3.3. ASSAYS

3.3.1. BOD5[4]

The BOD_5 of the collected water samples were measured by measuring the DO of the samples which were contained in the 300 ml BOD bottle at the time of collecting the samples. The samples containing bottles were then stored in a room of 20°C temperature for 5 days. After 5 days the DO of the samples were measured again. The original samples were some times diluted to meet the higher BOD values. The DO of the samples were measured by the CIBA-CORNING, M90, DO meter. The BOD was calculated using the following equation:

$$\text{BOD, mg/L} = \frac{D_1 - D_2}{P}$$

where,

D_1 = Dissolved oxygen of the sample (or diluted sample) immediately after taking into the BOD bottle, mg/L.

D_2 = Dissolved oxygen of the sample after 5 days incubation at 20°C, mg/L

P= Decimal volumetric fraction of sample used (for diluted sample only).

3.3.2. Chemical Oxygen Demand(COD)[4]

For the measurement of COD, closed reflux, colorimetric method were used. A calibration curve is prepared. In the project a visible spectrophotometer was used, which covered essentially 380 to 750 nm, but might be included some of the UV or near infrared regions.

(A) Procedure for COD analysis

(i) Formation of a light-absorbing species: For the specific determination of any given substance a reagent should be added to form a new colored substance. The color forming substance should be selective in its reaction, and should not form interfering colors with foreign substances likely to be present. The reaction of the reagent, and the substance to be measured should be quick and quantitative, or at least reproducible.

Most type of organic matter were oxidized by a boiling mixture of chromic and sulfuric acid. The sample was refluxed in strongly acidic solution with an excess of potassium dichromate. Potassium dichromate was a colored compound. Straight chain aliphatic compounds were oxidized more effectively when silver sulfate ($AgSO_4$) was added as a catalyst. However, $AgSO_4$ reacts with chloride, bromide, and iodide to produce precipitates that were oxidized only partially. The difficulties caused by the presence of the halides could be overcome largely though not completely by complexing with mercuric sulfate ($HgSO_4$) before the refluxing procedure.

(ii) Selection of Wavelength

In absence of interferences, the wavelength chosen for a quantitative determination was the wavelength of maximum absorbance. Use of the wavelength was not always possible. It was fairly common for color forming reagent to absorb somewhat at the wavelength of maximum absorbance of the complex being measured. For COD determination the wavelength was set at 600 nm.

B) Reagents Used

(i) Digestion solution: Digestion solution was prepared by adding the following chemicals in a 500 ml round bottom flask.

Chemicals	Amounts
$K_2Cr_2O_7$	2.458 gm
Distilled water	250.0 ml
Concentrated H_2SO_4	83.5 ml
$HgSO_4$	16.65 gm

(ii) Sulfuric acid reagent: Sulfuric acid reagent was prepared by adding 2.75 gm Ag_2SO_4 to 271.7 ml. concentrated H_2SO_4 and the solution was then diluted to 500 ml. and stand the solution for 1 to 2 days to dissolved Ag_2SO_4.

(iii) Potassium hydrogen Phthalate (KHP) Standard: 425 mg of KHP was dissolved in deionized water, and diluted to 1000 ml. This solution had a theoretical COD of 500 mg/L.

(C) Preparation of Calibration Curve

Seven standard forms of potassium hydrogen phthalate solution with COD equivalents of 10, 20, 30, 50, 100, 200, 300 and 500mg/L were prepared.

Procedure: 30 ml culture tubes, and caps were washed with 20% H_2SO_4 before first used to prevent contamination. KHP solution was placed in 30 ml ampules, and then digestion solution was added with it. Sulfuric acid reagent was run carefully inside of the ampules.The composition of different samples for COD calibration curve is presented in table-3.1. The ampules were tightly capped, and inverted several times to mix completely. Ampules were placed in an oven preheated to 150°C, and refluxed for 2 hr. Ampules were then cooled to room temperature, and absorbance was measured by spectrophotometer.

Table-3.1

Composition of different samples for COD calibration curve.

COD	KHP Solution (ml)	Digestion Solution (ml)	H2SO4 Reagent (ml)	Deionized water (ml)
10	0.167	5.0	11.67	8.163
20	0.334	5.0	11.67	8.070
30	0.501	5.0	11.67	7.846
50	0.835	5.0	11.67	7.500
100	1.670	5.0	11.67	6.670
200	3.340	5.0	11.67	5.000
300	5.000	5.0	11.67	3.330
500	8.330	5.0	11.67	0.000

When real samples were used instead of KHP solution the sample volumes were taken as 8.330 ml. Samples were also used in diluted form as illustrated in the table-3.1 with dilution factors. By measuring the absorbance of the sample solution the COD could immediately be read from the calibration curve. The experimental data for COD calibration curve is shown in table-A1 and the COD calibration curve is shown in figure-A1 in appendix A.

3.3.3 Phosphate (PO43−)[4]

(i) General Discussion (Ascorbic Acid Method)

(a) Principle: Ammonium molybdate, and potassium antimonyl tartrate reacted in acid medium with orthophosphate to form a heteropoly acid-phosphomolybdic acid-that was reduced to intensely colored molybdenum blue by ascorbic acid.

(b) Interference: Arsenates reacted with the molybdate reagent to produce a blue color similar to that formed with phosphate. Concentrations as low as 0.1 mg As/L interfere with the phosphate determination. Hexavalent chromium, and NO_2^- interfere to give results about 3% low at concentrations of 1 mg/L and 10 to 15% low at 10 mg/L. Sulfide (Na_2S), and silicate not to interfere at concentrations of 1.0 and 10 mg/L.

(c) Minimum Detectable Concentration: Approximately 10 μg P/L. P ranges are as follows:

Approximate P Range mg/L	Light Path cm
0.30 - 2.0	0.5
0.15 - 1.30	1.0
0.01 - 0.25	5.0

(ii) Apparatus

(a) Colorimetic Equipment: Spectrophotometer, with infrared photo-tube for used at 880 nm, providing a light path of 2.5 cm or longer.

(b) Acid-washed Glassware: By Using acid-washed glassware for determining low concentrations of phosphorus. Phosphate contamination was common because of its absorption on glass surfaces. Avoided using commercial detergents containing phosphate. All glassware were cleaned with hot dilute HCl, and rinse well with distilled water. Preferably, reserved the glassware only for phosphate determination, and after used, washed, and kept filled with water until needed. If that was done, acid treatment was required only occasionally.

(iii) Reagents

(a) Sulfuric acid, H_2SO_4, 5N: Dilute 70 ml conc. H_2SO_4 to 500ml with distilled water.

(b) Potassium antimonyl tartrate solution: Dissolve 1.3715 g $K(SbO)C_4H_4O.1/2H_2O$ in 400 ml distilled water in a 500 ml volumetric flask, and dilute to volume. Store in a glass-stoppered bottle.

(c) Ammonium molybdate solution: Dissolved 20 g $(NH_4)_6Mo_7O_{24}.4H_2O$ in a 500ml distilled water. Stored the solution in a glass-stoppered bottle.

(d) Ascorbic acid, 0.01M: Dissolved 1.76 g ascorbic acid in 100 ml distilled water. The solution was stable for about 1 week at 4°C.

(e) Combined reagent: The above reagents were mixed in the following proportions for 100 ml of the combined reagent: 50 ml 5N H_2SO_4, 5 ml potassium antimonyl tartrate solution, 15 ml ammonium molybdate solution, and 30 ml ascorbic acid solution. Mixed after addition of each reagent. By reaching all reagents at room temperature before they were mixed and mix in order given. If turbidity formed in the combined reagent, shake, and let stand for a few minutes until turbidity disappeared before proceeding. The reagent was stable for 4 h.

(f) Stock phosphate solution: Dissolved in distilled water 219.5 mg anhydrous KH_2PO_4 and diluted to 1000 ml;
1.00 ml = 50.0 µg PO_4^{3-} - P.

(g) Standard Phosphate solution: Diluted 50.0 ml stock phosphate solution to 1000 ml with distilled water;
1.00 ml = 2.50 µg P.

(iv) Procedure

(a) Treatment of sample: Pipet 50.0 ml sample into a cleaned, dry test tube or 125 ml erlenmeyer flask. Adding 0.05 ml (1 drop)

Phenolphthalein indicator. If red color was developed then adding 5N H_2SO_4 solution dropwise to just discharged the color. Then adding 8.0 ml combined reagent, and mixed thoroughly. After at least 10 min but no more than 30 min, absorbance of each sample at 880 nm, was measured using reagent blank as the reference.

(b) Correction for turbidity or interfering color: Natural color of water generally not to interfere at the high wavelength used. For highly colored or turbidity waters, prepared a blank by adding all reagents except ascorbic acid, and antimonyl potassium tartrate to the sample. The blank absorbance was subtracted of each sample.

(c) Preparation of calibration curve: Calibration curve was Prepared by taking phosphate solutions as 0.2, 0.4, 0.6, and 0.8 mg/L. Distilled water blank was used with the combined reagent to make photometric readings for the calibration curve. Plot absorbance vs. phosphate concentration to give a straight line passing through the origin as shown in figure-A2 in appendix A. By measuring the absorbance of the sample solution adding combined reagents, the concentration of PO_4^{-3} immediately read from the calibration curve. The experimental data for the calibration curve of phosphate is shown in table-A2 in appendix A.

3.3.4. Chromium[4]

(i) General Discussion (Colorimetric Method)

(a) Principle: The procedure measured only hexavalent chromium (Cr^{6+}). Therefore, to determine total chromium convert all the chromium to the hexavalent state by oxidation with potassium permanganate. The hexavalent chromium was determined colometrically by reaction with diphenylcarbazide in acid solution. A red-violet color of unknown composition was produced. The reaction was very sensitive, the molar absorptivity based on chromium being about 40000 L $g^{-1}cm^{-1}$ at 540 nm. To determine total chromium, the sample was digested with a sulfuric-nitric acid mixture, and then oxidized with potassium permanganate before reacted with the diphenylcarbazide.

(b) Interferences: The reaction with diphenylcarbazide was

(b) Interferences: The reaction with diphenylcarbazide was nearly specific for chromium. Hexavalent molybdenum, and mercury salts would react to form color with the reagent but the intensities were much lower than that for chromimum at the specified p^H. Concentrations as high as 200 mg Mo or Hg/L could be tolerated. Vanadium interferes strongly but concentrations up to 10 times that of chromium would not cause trouble. Potential interference from permanganate was eliminated by prior reduction with azide. Iron in concentrations greater than 1 mg/L may be produced a yellow color but the ferric ion (Fe^{3+}) color was not strong, and no difficulty was encountered normally if the absorbance was measured photometrically at the appropriate wavelength. Interfering amounts of molybdenum, vanadium, iron, and copper could be removed by extraction of the cupferrates of these metals into chloroform ($CHCl_3$). A procedure for the extraction was provided but not to use it unless necessary, because residual cupferron, and $CHCl_3$ in the aqueous solution complicated the later oxidation. Therefore, follow the extraction by additional treatment with acid fuming to decompose these compounds.

(ii) Apparatus

Spectrophotometer, for use at 540 nm, with a light path of 1 cm or longer.

(iii) Reagents

Used deionized water to prepare reagents.

(a) Stock chromium solution: Dissolve 141.4 mg $K_2Cr_2O_7$ in water, and dilute to 1000 ml; 1.00 ml = 50.0 μg Cr. From the stock solution four more sample solutions were prepared of concentrations 40 mg/L, 30 mg/L, 20 mg/L, 10 mg/L respectively.

(b) Standard chromium solution: Dilute 10.0 ml stock chromium solution to 100 ml; 1.00 ml = 5.00 μg Cr.

(c) Nitric acid, HNO_3 conc.

(d) Sulfuric acid, H_2SO_4, 1 + 1.

(e) Methyl orange indicator solution.

(j) Diphenylcarbazide solution: It was prepared by dissolving 250 mg 1,5-diphenylcarbazide in 50 ml acetone. The solution was discolored.

(iv) Procedure

(a) Preparation of calibration curve: To compensate for possible slight losses of chromium during digestion or other analytical operations, chromium standard was treated by pipetting measured volumes of standard chromium solution (5ml/L) ranging from 2.00 to 20.0 ml, to give standards for 10 to 100 mg Cr, into 250 ml beakers or conical flasks. Calibration curve was prepared for these samples by developing color in the samples, and transferring suitable portion (25 ml) of each colored solution to a sample cell, and absorbance was measured at 540 nm. Correct absorbance readings of the standards were measured by subtracting absorbance of a reagent blank carried through the method.

(b) Oxidation of trivalent chromium: A portion of digested sample, with interference removed, and containing 10 to 100 mg Cr, was taken into a 125 ml conical flask. Using methyl orange as indicator, conc. NH_4OH solution was added until the solution was just basic to methyl orange indicator. 1 + 1 H_2SO_4 is added dropwise until it was acidic. 1 ml of excess H_2SO_4 was also added to adjust the volume about 40 ml. Some boiling chip were added into the flask, and the solution was heated to boiling. Then 2 drops of $KMnO_4$ solution was added to the solution, and to give a dark red color. If fading was occurred then added $KMnO_4$ dropwise to maintain an excess of about 2 drops. Boiled for two min.longer. 1 ml of NaN_3 solution was added to the flask, and boiling was continued gently. If red color were not to be fade completely after boiling for approximately 30 seconds, another 1 ml NaN_3 solution was added, and boiling was continued for disappearance of color indicates completed oxidation of tri-valent chromium. Then the solution was cooled, and added by 0.25 ml H_3PO_4.

(c) Color Development and Measurement: Using 0.2N H_2SO_4, and a p^H meter for the adjustment of solution to p^H 1.0 ± 0.3. The data for p^H adjustment is shown in thable-A3 in appendix A. Then the solution was transferred to a 100 ml volumetric flask, and diluted to 100 ml, and swirl to mix. 2.0 ml diphenylcarbazide solution was added to the flask, and swirl to mix, and stand 5 to 10 min. for full color development. Appropriate portion of the solution (25 ml) was transferred to the sample cell and measured the absorbance at 540 nm. Absorbance readings were corrected by using sample blank throughout the method. The concentration of Cr in the water sample was obtained from the calibration curve, which is shown in figure-A3 in appendix A. The experimental data for Cr calibration curve is presented in table-A4 in appendix A.

3.4. Powder Pillow, and Program pack Methods:

The following constituents of water sample were measured by calibrated programe of the spectrophotometer with or without powder pillow, and respective sensor of the equipment.

3.4.1. Total Suspended solids

The total suspended solids of the collected water samples were measured employing a HACH spectrophotometer, supplied by HACH Company, Loveland, Colorado, USA. A manufacturer calibrated program no. 630, was used for TSS.

3.4.2. Turbidity

The turbidity of the collected water samples were determined employing a HACH spectrophotometer, supplied by HACH Company, Loveland, Colorado, USA. A manufacturer calibrated program no. 750 was used for turbidity.

3.4.3. Total Dissolved Solids

The total dissolved solids of the collected water samples were measured by CIBA-CORNING, M90 microprocessor based Cond/TDS meter, supplied by Ciba Corning Analytical Division of Mettle Toledo Ltd., Halstead, Essex, U.K. The Meter was calibrated for TDS by holding the sensor in the free air; which showed 0.00 mg/L TDS.

3.4.4. Conductivity

The conductivity of the collected water samples were measured by CIBA-CORNING, M90, microprocessor based Cond/TDS meter, supplied by Ciba Corning Analytical Division of Mettle Toledo Ltd., Halstead, Essex, U.K. The Meter was calibrated for Conductivity by holding the sensor in the free air; which showed 0.00 μs Conductivity.

3.4.5. Dissolved Oxygen (DO)

The dissolved oxygen of the collected water samples were measured by CIBA-CORNING, M90, potable DO meter at the sampling station point, supplied by Ciba Corning Analytical Division of Mettle Toledo Ltd., Halstead, Essex, U.K. The Meter was calibrated for DO by holding the sensor in air 10 mm above fresh water; which showed 100% O_2.

3.4.6. pH

The p^H of the collected water samples were determined by CIBA-CORNING, M90 microprocessor based p^H meter, supplied by Ciba Corning Analytical Division of Mettle Toledo Ltd., Halstead, Essex, U.K. The Meter was calibrated for p^H by holding the meter sensor in p^H-7 buffer solution; which showed p^H-7.

3.4.7. Sulfate (SO4-2)

Sulfate of the collected water samples were measured employing a HACH spectrophotometer, supplied by HACH Company, Loveland, Colorado, USA. A manufacturer calibrated program no. 680 with sulfate powdered pillow supplied by HACH Company.

3.4.8. Chloride (Cl-)

Chloride of the collected water sample was measured by the SHIMADZU spectrophotometer with Water Analysis Program Pack, and the chemical Reagent No.10, supplied by the SHIMADZUS CORPORATION.

3.4.9. Nitrate (NO3−)

Nitrate of the collected water sample was measured by the SHIMADZU spectrophotometer With Water Analysis Program Pack, and the chemical Reagent No.19, supplied by the SHIMADZUS CORPORATION, Kyoto, Japan.

3.4.10. Ammonium (NH4+)

Ammonium of the collected water sample was measured by the SHIMADZU spectrophotometer With Water Analysis Program Pack, and the chemical Reagent No.17B, supplied by the SHIMADZUS CORPORATION, Kyoto, Japan.

3.4.11. Total Iron (FeT)

Total iron of the collected water sample was measured by the SHIMADZU spectrophotometer With Water Analysis Program Pack, and the chemical Reagent No.41A, supplied by the SHIMADZUS CORPORATION, Kyoto, Japan.

3.4.12. Lead (Pb)

Total Lead of the collected water sample was measured by the SHIMADZU spectrophotometer With Water Analysis Program Pack, and the chemical Reagent No.35, supplied by the SHIMADZUS CORPORATION, Kyoto, Japan.

CHAPTER-4

INDUSTRIAL SURVEY

4.1. Tongi:

Tongi is about 15 miles north of Dhaka City. It is an important industrial area set up in Bangladesh. Various types of industries are in operation and many new being set up.

The important industrial area having mixed type of industries extends an influence on the environment of the entire area. Among different type of industries, pulp and paper, textile, Rubber industries, detergent, and Paint industries, Pharmaceutical industry, dyeing industries, etc. are very important from environmental point of view. Various types of chemicals and raw materials are used every day; some of which are really toxic in nature. The effluents of waste products from the industries are discharged on low lying areas where from they find their way into the adjacent river Turag and Balu.

The samples are taken from the rivers Turag and Balu which are near Moinertaek at Tongi. There are three station points. Station Point-1, is at the river Turag which is 300 m upstream from the intersection point of the rivers Turag and Balu. Station Point-2, is at the river Balu which is 100 m upstream from the intersection point of the rivers Turag and Balu. The Station Point-3, is at the river Balu, which is 300 m downstream from the intersection point of the rivers Turag and Balu. At each of the station point four samples are taken. Two from the surface water and two at a depth of 3.5 ft.

4.2. Hazaribagh

Leather and leather goods are very important in our daily life. The effluent and solid waste discharged by tannery are one of the most polluting industrial wastes. Suitable treatment of the effluent is therefore necessary for the environmental pollution control and public health in the areas where the tannery industries are situated. The problem becomes acute particularly in the developing countries where quite a good number of small and/or big size tanneries are established without planning and operated in unscientific manner.

Hazaribagh area situated on the south-west periphery of Dhaka City is a mixed type of locality both residential and industrial having tannery industries scattered all over it.

The leather is produced from the hides and skins of animals cow, buffaloes, deer, oxen, sheep, goats, etc. The tanning process removes the layers of the hides and skins. Nature of the environmental pollution is both organic and inorganic. The liquid waste comprising of waste water, organic particles, and toxic chemicals used in the processes is discharged through small individual drains ultimately finds its way into the river Buriganga passing nearby. The biologically oxidizable material present in wastes exerts a deoxygenating effect in the river, streams etc. Chrome tan wastes are toxic to fish and aquatic life. The chromium and arsenic found in the tannery wastes have rendered drinking water unsuitable for human consumption. Seepage of untreated effluents on ground results in ground water pollution. High content of chloride present in the wastes makes the well water saline.

The samples are taken from the river Buriganga. Two sampling stations are selected at the river; one, (Station Point-5) is at the discharge point to the river, and the other (Station Point-4) is 300 m upstream from the station point-5. At each station point two samples are taken from the surface, and two at a depth of 3.5 ft.

4.3. Demra Bazar, Balu River

Damra bazar is about 10 miles from Dkaka City. It is situated along the side of the Balu at Dhaka.

The river is receiving different types of industrial and domestic wastes from the industrial belt. Most of the industries are using the river as a source of supply, and as transmitting media of their waste. The industries present in the area are mostly jute, and textile Mills. The industries discharge their effluents into the river without treatment.

The samples are taken from the Balu river near Demra Bazar (Station Point-6).

4.4. Demra, Sitalakhya River

The Sitalakhya river runs along the eastern side of Dhaka City from Ghorashal to Narayangonj. The river is about 32 miles long, and width varies from quarter of a miles to less at some points. The river is used mainly for navigation and fishing purposes. Besides domestic and recreational uses by the villagers living on the banks are also very much in practice. There are large number of industries situated on both sides of the river and big market places along the whole stretch of the river.

The Industries though dispersed all along the length of the river are more clustered around Demra at Dhaka. The types of industries are mainly jut, and textile. Paper mills, re-rolling mills, refine soyabeen oil mill, glass factory, food industry, etc. are also located along the river side. Another important industry situated at the upstream side is Ghorashal Fertilizer Factory. Most of the industries use ground water as source of their water supply. Few of them are found to use surface water with treatments as per their requirement. Large industries use as much as one lakh gallon per day of process water, have residential facilities for its staff, and worker producing appreciable amount of domestic waste.

The chemicals used varies within a wide range depending on the type of raw materials used, and products made. The most common that are used in large quantities are caustic soda (NaOH), soda ash (Na_2CO_3), ammonium sulfate, hydrochloric acid, sulfuric acid, bleaching powder, jute batching oil, mobile, furnish Oil, grease, kerosine, etc. Most of the industries discharge their effluents into the river without treatment.

The samples that are taken from the Sitalakhya river are one Station Point (Station Point-7) near the Demar Ferry Ghat and the other Station Point (Station Point-8) near Kachpur bridge.

4.5. Pagla, Buriganga River.

Pagla is about 10 miles from Dhaka city, and is situated on the bank of the Buriganga river. Several of industries are growing day by day on both banks of the river. The river receive different types of industrial, and domestic wastes from the industrial belt.

The industries that are situated along the river Buriganga near Pagla at Narayangonj are using the river water as a source of supply, and as transmitting media of their waste. The density of industries is much, and it is apparent that a remarkable volume of industrial waste finds way into the river. The types of industries that are situated along the river sides include match factories, glass factories, textile processing industries, oil mills, vegetable oil mill, rubber industries, Padma, and Jamuna Petroleum, brick fields, steel factories, textile mills, salt factories, Pagla bazar etc. Above all the WASA discharge their treated sludge to the river at Pagla. The above mentioned industries use following chemicals are calcium carbonate, zinc oxide, sulphur, titanium di-oxide, paraffin, potassium chloride, nitric acid, mobil, grease, kerosene, caustic soda, soda ash, sodium nitrate, lime, ammonia, alum, petrol, cast iron, etc. Most of the industries and factories discharge their effluents direct to the river without treatment.

Samples are taken from the Buriganga river near Pagla(Station Point -9)

4.6. Adamji, Sitalakhya River.

Adamji is about 15 miles from Dhaka City, and situated on the bank of the river Sitalakhya at Narayangonj.

The type of industries near Adamge are mainly jute and textile. The river is used mainly for navigation and fishing purposes. There are large numbers of industries (like Adamge Jute Mills) situated on both sides of the river. There are also present pharmaceutical industries, textile processing industries, leather industries, etc. The unloading station of the Meghna, and Jamuna Petroleum is at Adamji. The industries that use the following chemicals, bleaching powder, caustic soda, soda ash, ammonium sulfate, hydrochloric acid, sulfuric acid, jute batching oil, petroleum, ammonium chloride, common salt, lime stone, sodium nitrate, etc. Most of the industries discharge their wastes into the river without treatment.

The samples are collected from the Sitalakhya river (station point-10) near the unloading station of the Meghna and Jamuna Petroleum near Adamji at Narayangonj.

CHAPTER-5

RESULTS AND DISCUSSIONS

5.1. General

Study of the water quality from different rivers around Dhaka City were conducted for the period from September' 95 to February' 96. Laboratory tests were performed at regular intervals of one month. The test results are presented in a tabular form. The important parameters are also presented graphically.

5.2. Sampling Positions

Ten sampling stations were selected from four rivers around Dhaka City. Station points-1, 2 and 3 were near Moinerteak at Tongi. Station point-1 was in the river Turag which, was 300 meters upstream from the intersection point of the rivers Turag and Balu. Station point-2, was in the river Balu, which was 300 meters upstream from the intersection point of the rivers Turag and Balu. The Station point-3 was in Balu, which was 300 meters downstream from the intersection point of the rivers Turag and Balu. Station point-4 was in the Balu river near Demra bazar, which was 300 meters upstream from the intersection point of the rivers Balu and Shitalakhya at Dhaka. Station point-5, was in the Shitalakhya river and was 300 meters upstream from the intersection point of the rivers Balu and Shitalakhya near Demra bazar at Dhaka. Station point-6 was in the Shitalakhya river near katchpur bridge at Dhaka. Station point-7 was in the Shitalakhya river near Adamji at Narayangonj. Station points-8 was selected in the river Buriganga near Hazaribugh, which was 300 meter upstream from the the effluent discharge point of the tannery waste to the river. Station point-9 was at the effluent discharge point of the tannery waste to the river. Station point-10 was in the Buriganga river, which was 100 meters downstream from the treated sludge discharge point of WASA near Pagla at Narayangonj.

All the station points are shown in Figure-3.1. Four samples were collected at each station point. First, surface water horizontally 5 ft from the river bank. Second, surface water horizontally 15 ft from the river bank. Third, horizontally 15 ft from the river bank at 3.5 ft water depth. Fourth, horizontally 25 ft from the river bank at 3.5 ft water depth.

The results for calibration of COD, phosphate and chromium assays using spectrophotometer are provided in Table A1, A2, and A4 in appendix A. Concentration versus absorbance plots for the three assays are provided in figures A1, A2, and A3 in appendix A.

Experimental results of different water quality parameters are presented in tabular form in section 5.3 and graphically in figures 5.1 to 5.12.

5.3. Experimental Data

Table-5-1.1.

Experimental Data for station point-1 of Turag river for December'95 near Moinerteak at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	19. 12. 95	137.0	129	6.61	78	121	-	-
Horizontally 15′ from the River bank (Surface water)	19. 12. 95	135.7	127	6.58	80	122	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	19. 12. 95	136.8	131.0	6.57	77	125.0	15	-
Horizontally 25′ from the River bank (3.5 ft depth)	19. 12. 95	138.1	130.0	6.60	79	126.0	16	0.158

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	7.43
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	8.17
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.6	2.2	11.88
Horizontally 25′ from the River bank (3.5 ft depth)	1.586	3.057	0.036	0.043	0.379	1.447	0.248	4.7	2.5	13.40

Table-5-1.2.

Experimental Data at station point-1 of Turag river for January '96 near Moinerteak at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	21. 01. 96	361.0	49.0	6.60	30	181.0	-	-
Horizontally 15′ from the River bank (Surface water)	21. 01. 96	362.0	45.0	6.63	31	182.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	21. 01. 96	365.0	44.0	6.68	33	184.0	19	-
Horizontally 25′ from the River bank (3.5 ft depth)	21. 01. 96	368.0	44.0	6.84	35	78.8	19	0.219

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	10.40
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	11.88
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.3	3.3	17.07
Horizontally 25′ from the River bank (3.5 ft depth)	5.409	2.732	0.047	0.059	0.396	4.597	0.573	4.4	3.4	17.60

Table-5-1.3.

Experimental Data at station point-1 of Turag river for February'96 near Moinertaek at Tongi.

Sample Location/Station	Date	Conductivity (µs/ms)	Turdidity (FTU)	PH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	11. 02. 96	480.0	35	7.27	29	241	-	-
Horizontally 15′ from the River bank (Surface water)	11. 02. 96	481.0	37	7.31	28	241	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	11. 02. 96	485.0	35	7.35	30	242.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	11. 02. 96	486.0	38	7.45	31	245.0	21	0.645

Sample Location/Station	NO_3^- (mg/L)	CI^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.7	-	11.88
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.9	-	12.62
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	5.2	4.1	20.78
Horizontally 25′ from the River bank (3.5 ft depth)	12.16	4.553	0.062	0.073	0.464	9.605	3.825	5.4	4.2	22.27

Table-5-2.1.

Experimental Data for station point-2 of Balu river for December'95 near Moinerteak at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	19. 12. 95	89.2	138	7.05	75	60.5	-	-
Horizontally 15′ from the River bank (Surface water)	19. 12. 95	89.7	138	7.06	76	61.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	19. 12. 95	90.1	147	7.10	79	63.2	12	-
Horizontally 25′ from the River bank (3.5 ft depth)	19. 12. 95	90.5	148	7.11	80	63.9	13	0.263

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.7	-	7.20
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.8	-	7.43
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.9	2.7	14.33
Horizontally 25′ from the River bank (3.5 ft depth)	0.978	2.361	0.008	0.012	0.335	1.364	0.266	5.0	2.7	16.11

Table-5-2.2.

Experimental Data at station point-2 of Balu river for January'96 near Moinertaek at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	21. 01. 96	361.0	70	7.07	44	179.0	-	-
Horizontally 15′ from the River bank (Surface water)	21. 01. 96	362.0	72	7.08	45	178.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	21. 01. 96	365.0	110	7.12	77	179.0	15	-
Horizontally 25′ from the River bank (3.5 ft depth)	21. 01. 96	367.0	115	7.15	78	179.0	15	0.365

Sample Location/Station	NO_3^- (mg/L)	Ci^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	11.14
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.5	-	13.37
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.8	3.6	17.29
Horizontally 25′ from the River bank (3.5 ft depth)	2.250	3.579	0.025	0.035	0.536	1.579	0.654	5.0	3.7	20.26

Table-5-2.3.

Experimental Data at station point-2 of Balu river for February'96 near Moinertaek at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	11. 02. 96	489.0	35	7.71	34	243.0	-	-
Horizontally 15′ from the River bank (Surface water)	11. 02. 96	497.0	36	7.73	35	247.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	11. 02. 96	494.0	42	7.73	40	247.0	18	-
Horizontally 25′ from the River bank (3.5 ft depth)	11. 02. 96	523.0	44	7.80	44	261.0	18	1.375

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	6.5	-	13.37
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	6.7	-	13.37
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	7.0	4.5	21.53
Horizontally 25′ from the River bank (3.5 ft depth)	6.731	5.531	0.028	0.041	0.732	1.938	6.435	7.2	4.5	23.00

Table-5-3.1.

Experimental Data for station point-3 of Balu river for December '95 near Moinerteak at Tongi

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	19. 12. 95	354.0	130.0	7.17	66.0	56.3	-	-
Horizontally 15′ from the River bank (Surface water)	19. 12. 95	353.0	130.0	7.18	68.0	57.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	19. 12. 95	355.0	138.0	7.20	75.0	59.0	14.0	-
Horizontally 25′ from the River bank (3.5 ft depth)	19. 12. 95	356.0	140.0	7.21	75.0	59.8	15.0	0.151

Sample Location/Station	NO_3^- mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	7.93
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	9.14
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.6	2.8	15.34
Horizontally 25′ from the River bank (3.5 ft depth)	1.004	2.050	0.024	0.035	0.511	1.402	0.303	4.7	2.9	16.83

Table-5-3.2.

Experimental Data for station point-3 of Balu river for January'96 near Moinertaek at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	21. 01. 96	335.0	76.0	7.26	55.0	177.0	-	-
Horizontally 15′ from the River bank (Surface water)	21. 01. 96	337.0	81.0	7.27	53.0	177.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	21. 01. 96	351.0	99.0	7.35	65.0	179.0	17.0	-
Horizontally 25′ from the River bank (3.5 ft depth)	21. 01. 96	354.0	101.0	7.38	65.0	180.0	17.0	0.203

Sample Location/Station	NO_3^- mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.5	-	13.12
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.7	-	13.12
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	5.4	3.9	15.56
Horizontally 25′ from the River bank (3.5 ft depth)	3.928	2.396	0.033	0.044	0.741	1..650	0.647	5.9	3.9	18.56

Table-5-3.3.

Experimental Data for station point-3 of Balu river for Febuary'96 near Moinertaek at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	11. 02. 96	484.0	38.0	7.72	36.0	244.0	-	-
Horizontally 15′ from the River bank (Surface water)	11. 02. 96	481.0	41.0	7.75	47.0	244.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	11. 02. 96	486.0	47.0	7.76	50.0	246.0	19.0	-
Horizontally 25′ from the River bank (3.5 ft depth)	11. 02. 96	491.0	51.0	7.78	53.0	248.0	19.0	0.834

Sample Location/Station	NO_3^- mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	5.7	-	14.85
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	5.8	-	15.34
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	6.0	4.6	18.78
Horizontally 25′ from the River bank (3.5 ft depth)	5.440	5.089	0.051	0.062	0.862	1.938	7.375	6.5	4.7	23.83

Table-5-4.1.

Experimental Data for station point-4 of Balu river for December'95 near Demra bazar at Dhaka.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5' from the River bank (Surface water)	03. 12. 96	182.2	38.0	7.06	25.0	91.1	-	-
Horizontally 15' from the River bank (Surface water)	03. 12. 96	186.2	40.0	7.07	25.0	93.2	-	-
Horizontally 15' from the River bank (3.5 ft depth)	03. 12. 96	186.8	41.0	7.11	27.0	93.5	12.0	-
Horizontally 25' from the River bank (3.5 ft depth)	03. 12. 96	191.6	43.0	7.12	29.0	94.4	13.0	0.273

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5' from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	9.16
Horizontally 15' from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	9.16
Horizontally 15' from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.6	2.1	14.10
Horizontally 25' from the River bank (3.5 ft depth)	1.079	1.901	<.02	<.02	0.239	1.977	0.388	4.7	2.1	15.60

Table-5-4.2.

Experimental Data for station point-4 of Balu river for January'96 near Demra Bazar at Dhaka.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	01. 01. 96	304.0	38.0	7.03	33.0	153.0	-	-
Horizontally 15′ from the River bank (Surface water)	01. 01. 96	305.0	43.0	7.04	38.0	153.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	01. 01. 96	307.0	45.0	7.06	40.0	153.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	01. 01. 96	311.0	50.0	7.06	46.0	155.0	15.0	0.369

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.7	-	10.90
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.6	-	11.39
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.9	2.8	17.57
Horizontally 25′ from the River bank (3.5 ft depth)	5.341	2.011	<.02	<.02	0.397	2.247	0.966	5.3	2.7	18.31

Table-5-4.3.

Experimental Data for station point-4 of Balu river for February'96 near Demra bazar at Dhaka.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	04. 02. 96	385.0	7.0	7.06	18.0	193.0	-	-
Horizontally 15′ from the River bank (Surface water)	04. 02. 96	386.0	7.0	7.09	19.0	194.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	04. 02. 96	387.0	8.0	7.11	19.0	197.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	04. 02. 96	391.0	9.0	7.12	20.0	199.0	17.0	0.562

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.0	-	14.36
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	14.85
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.3	3.2	21.77
Horizontally 25′ from the River bank (3.5 ft depth)	9.825	2.663	<.020	<.02	0.440	2.323	1.365	4.6	3.2	22.51

Table-5-5.1.

Experimental Data for station point- 5 of Shitalakhya river for December'95 near Demra Ferry Ghat at Dhaka

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	03. 12. 95	197.0	31.0	7.16	20.0	98.0	-	-
Horizontally 15′ from the River bank (Surface water)	03. 12. 95	197.0	33.0	7.17	23.0	98.6	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	03. 12. 95	197.9	36.0	7.17	24.0	98.7	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	03. 12. 95	198.0	37.0	7.20	24.0	99.7	9.0	0.273

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	7.18
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	7.93
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.2	2.2	15.10
Horizontally 25′ from the River bank (3.5 ft depth)	3.619	1.214	0.034	0.039	0.111	1.944	0.576	4.3	2.3	16.09

Table-5-5.2.

Experimental Data for station point- 5 of Shitalakhya river for January'96 near Demra Ferry Ghat at Dhaka.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	01. 01. 96	302.0	20.0	7.23	12.0	151.0	-	-
Horizontally 15′ from the River bank (Surface water)	01. 01. 96	303.0	22.0	7.23	13.0	152.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	01. 01. 96	303.0	25.0	7.29	15.0	152.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	01. 01. 96	304.0	25.0	7.29	15.0	152.0	10.0	0.389

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	8.67
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	10.15
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.6	2.5	18.31
Horizontally 25′ from the River bank (3.5 ft depth)	15.213	2.461	0.042	0.057	0.239	2.465	0.905	4.6	2.5	18.56

Table-5-5.3.

Experimental Data for station point- 5 of Shitalakhya river for February'96 near Demra Ferry Ghat at Dhaka.

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	04. 02. 96	398.0	7.0	7.30	20.0	199.0	-	-
Horizontally 15′ from the River bank (Surface water)	04. 02. 96	400.0	9.0	7.33	20.0	200.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	04. 02. 96	401.0	9.0	7.33	23.0	200.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	04. 09. 95	402.0	9.0	7.36	24.0	201.0	11.0	0.529

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	11.14
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	11.39
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.1	2.9	17.32
Horizontally 25′ from the River bank (3.5 ft depth)	71.875	2.877	0.056	0.063	0.650	3.726	3.525	4.0	3.0	20.78

Table-5-6.1.

Experimental Data for station point- 6 of Shitalakhya river for December'95 near Katchpur bridge at Dhaka

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	03. 12. 95	208.0	71.0	7.11	50.0	103.0	-	-
Horizontally 15′ from the River bank (Surface water)	03. 12. 95	215.0	72.0	7.12	51.0	108.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	03. 12. 95	216.0	75.0	7.16	51.0	108.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	03. 12. 95	218.0	83.0	7.17	52.0	110.0	11.0	0.168

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.5	-	20.78
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.6	-	24.26
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	3.4	10.0	25.48
Horizontally 25′ from the River bank (3.5 ft depth)	4.638	2.098	0.060	0.067	0.243	1.030	0.319	3.2	9.0	27.46

Table-5-6.2.

Experimental Data for station point- 6 of Shitalakhya river for January'95 near Katchpur bridge at Narayangonj.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	01. 01. 96	320.0	59.0	7.22	46.0	156.0	-	-
Horizontally 15′ from the River bank (Surface water)	01. 01. 96	322.0	60.0	7.23	46.0	160.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	01. 01. 96	322.0	61.0	7.24	47.0	161.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	01. 01. 96	329.0	61.0	7.25	47.0	164.0	13.0	0.291

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.6	-	28.45
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.7	-	29.44
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	3.4	19.0	42.30
Horizontally 25′ from the River bank (3.5 ft depth)	11.585	2.400	0.083	0.090	0.322	1.879	0.653	3.4	19.0	42.54

Table-5-6.3.

Experimental Data for station point- 6 of Shitalakhya river for February'96 near Katchpur bridge at Narayangonj.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	04. 02. 96	401.0	13.0	7.26	27.0	200.0	-	-
Horizontally 15′ from the River bank (Surface water)	04. 02. 96	402.0	21.0	7.27	29.0	201.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	04. 02. 96	412.0	25.0	7.28	38.0	209.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	04. 02. 96	434.0	25.0	7.30	38.0	217.0	15.0	0.318

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	29.93
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	42.54
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	3.9	36.0	91.50
Horizontally 25′ from the River bank (3.5 ft depth)	133.275	3.085	0.087	0.096	0.436	2.410	2.500	4.2	36.0	91.26

Table-5-7.1.

Experimental Data for station point-7 of Shitalakhya river for December'95 near Adamji at Narayangonj

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	12. 12. 95	245.0	23.0	7.14	13.0	116.0	-	-
Horizontally 15′ from the River bank (Surface water)	12. 12. 95	245.0	24.0	7.15	14.0	116.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	12. 12. 95	249.0	25.0	7.16	15.0	116.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	12. 12. 95	250.0	25.0	7.16	16.0	118.0	11.0	0.317

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.2	-	8.67
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.3	-	10.15
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	2.8	2.1	12.87
Horizontally 25′ from the River bank (3.5 ft depth)	11.425	1.785	0.037	0.051	0.098	1.903	0.604	2.9	2.0	13.12

Table-5-7.2.

Experimental Data for station point-7 of Shitalakhya river for January'96 near Adamji at Narayangonj.

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	16. 01. 96	373.0	12.0	7.81	12.0	187.0	-	-
Horizontally 15′ from the River bank (Surface water)	16. 01. 96	373.0	12.0	7.80	12.0	187.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	16. 01. 96	375.0	14.0	7.82	16.0	187.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	16. 01. 96	377.0	14.0	7.80	20.0	188.0	12.0	0.487

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	12.87
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	13.61
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.1	2.9	18.06
Horizontally 25′ from the River bank (3.5 ft depth)	11.925	3.285	0.043	0.062	0.122	2.127	1.449	4.1	2.8	17.32

Table-5-7.3.

Experimental Data for station point-7 of Shitalakhya river for February'96 near Adamji at Narayangonj.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	07. 02. 96	390.0	12.0	7.51	10.0	194.0	-	-
Horizontally 15′ from the River bank (Surface water)	07. 02. 96	394.0	15.0	7.51	13.0	193.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	07. 02. 96	398.0	15.0	7.53	14.0	199.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	07. 02. 96	402.0	17.0	7.54	16.0	199.0	14.0	0.502

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.9	-	14.85
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	5.2	-	17.32
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	5.3	3.3	22.52
Horizontally 25′ from the River bank (3.5 ft depth)	14.500	6.643	0.069	0.069	0.271	3.827	1.995	5.3	3.3	28.67

Table-5-8.1.

Experimental Data for station point-8 of Buriganga river for December'95 near Hazaribug at Dhaka

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	27. 12. 95	363.0	39.0	7.26	37.0	182.0	-	-
Horizontally 15′ from the River bank (Surface water)	27. 12. 95	361.0	39.0	7.27	42.0	183.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	27. 12. 95	362.0	45.0	7.24	44.0	184.0	21.0	-
Horizontally 25′ from the River bank (3.5 ft depth)	27. 12. 95	366.0	45.0	7.28	45.0	189.0	21.0	0.535

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.6	-	20.78
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.7	-	21.53
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	5.2	9.0	28.20
Horizontally 25′ from the River bank (3.5 ft depth)	2.424	2.107	0.023	0.031	0.106	1.599	0.462	5.3	10.0	31.91

Table-5-8.2.

Experimental Data for station point-8 of Buriganga river for January'96 near Hazaribug at Dhaka.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	28. 01. 96	443.0	15.0	7.40	14.0	224.0	-	-
Horizontally 15′ from the River bank (Surface water)	28. 01. 96	447.0	16.0	7.40	14.0	223.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	28. 01. 96	447.0	16.0	7.40	18.0	231.0	23.0	-
Horizontally 25′ from the River bank (3.5 ft depth)	28. 01. 96	449.0	17.0	7.45	19.0	236.0	23.0	0.725

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	5.1	-	28.20
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	5.2	-	30.00
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	5.3	23.0	60.62
Horizontally 25′ from the River bank (3.5 ft depth)	3.281	2.796	0.021	0.026	0.128	1.769	0.987	5.5	23.0	60.84

Table-5-8.3.

Experimental Data for station point-8 of Buriganga river for February,96 near Hazaribug at Dhaka.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	12. 02. 96	600.0	21.0	7.41	16.0	304.0	-	-
Horizontally 15′ from the River bank (Surface water)	12. 02. 96	607.0	25.0	7.45	23.0	306.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	12. 02. 96	608.0	26.0	7.46	23.0	308.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	12. 02. 96	625.0	26.0	7.48	25.0	324.0	37.52	2.733

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	5.2	-	40.81
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	5.4	-	42.79
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	5.5	34.0	107.08
Horizontally 25′ from the River bank (3.5 ft depth)	10.292	21.51	0.025	0.046	0.375	2.920	8.92	5.8	33.0	96.45

Table-5-9.1.

Experimental Data for station point-9 of Buriganga river for December'95 near Hazaribug at Dhaka.

Sample Location/Station	Date	Conductivity (ms)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (g/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	27. 12. 95	2.95	140.0	7.72	122.0	1.44	-	-
Horizontally 15′ from the River bank (Surface water)	27. 12. 95	2.96	142.0	7.73	123.0	1.46	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	27. 12. 95	2.96	142.0	7.78	130.0	1.48	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	27. 12. 95	3.15	150.0	7.80	135.0	1.58	150.0	17.090

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.3	-	273.30
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.3	-	280.52
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	1.2	174.0	304.23
Horizontally 25′ from the River bank (3.5 ft depth)	0.794	133.85	0.317	0.435	0.458	3.300	33.70	1.2	180.0	298.05

Table-5-9.2.

Experimental Data for station point-9 of Buriganga river for January, 96 near Hazaribug at Dhaka.

Sample Location/Station	Date	Conductivity (ms)	Turdidity (FTU)	PH	TSS (mg/L)	TDS (g/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	28. 01. 96	3.13	141.0	7.72	134.0	1.560	-	-
Horizontally 15′ from the River bank (Surface water)	28. 01. 96	3.16	147.0	7.73	136.0	1.570	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	28. 01. 96	3.24	159.0	7.78	150.0	1.580	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	28. 01. 96	3.27	160.0	7.80	154.0	1.620	250.0	21.635

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.1	-	289.80
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.1	-	289.80
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	1.2	240.0	424.90
Horizontally 25′ from the River bank (3.5 ft depth)	1.563	255.75	0.422	0.697	0.767	5.510	83.65	1.1	225.0	412.78

Table-5-9.3.

Experimental Data for station point-9 of Buriganga river for February'96 near Hazaribug at Dhaka.

Sample Location/Station	Date	Conductivity (ms)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (g/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	12. 02. 96	3.15	159.0	7.97	150.0	1.58	-	-
Horizontally 15′ from the River bank (Surface water)	12. 02. 96	3.17	160.0	8.00	153.0	1.60	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	12. 02. 96	3.20	162.0	8.03	157.0	1.61	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	12. 02. 96	3.20	189.0	8.04	162.0	1.63	359.90	24.37

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.2	-	159.88
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.1	-	158.85
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	1.2	285.0	534.08
Horizontally 25′ from the River bank (3.5 ft depth)	1.679	307.75	0.571	0.836	2.660	17.215	89.85	1.2	300.0	649.32

Table-5-10.1.

Experimental Data for station point-10 of Buriganga river for December'95 near Pagla bazar at Narayangonj

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	12. 12. 95	348.0	15.0	6.78	13.0	164.0	-	-
Horizontally 15′ from the River bank (Surface water)	12. 12. 95	348.0	15.0	6.78	13.0	164.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	12. 12. 95	349.0	17.0	6.91	17.0	165.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	12. 12. 95	352.0	17.0	7.00	17.0	168.0	15.0	0.697

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	2.1	-	38.34
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	2.3	-	37.10
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	1.7	15.5	44.03
Horizontally 25′ from the River bank (3.5 ft depth)	1.813	2.906	0.044	0.055	-	2.891	1.985	1.4	16.0	44.03

Table-5-10.2.

Experimental Data for station point-10 of Buriganga river for January'96 near Pagla bazar at Narayangonj.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	16. 01. 96	506.0	24.0	7.60	17.0	253.0	-	-
Horizontally 15′ from the River bank (Surface water)	16. 01. 96	506.0	25.0	7.62	18.0	253.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	16. 01. 96	510.0	25.0	7.63	21.0	255.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	16. 01. 96	513.0	25.0	7.63	21.0	257.0	16.0	1.322

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	2.7	-	49.22
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	2.8	-	48.97
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	2.5	24.0	58.86
Horizontally 25′ from the River bank (3.5 ft depth)	1.919	10.530	0.049	0.057	-	3.861	4.730	2.4	25.0	59.85

Table-5-10.3.

Experimental Data for station point-10 of Buriganga river for February'96 near Pagla bazar at Narayangonj.

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	07. 02. 96	574.0	17.0	7.06	13.0	284.0	-	-
Horizontally 15′ from the River bank (Surface water)	07. 02. 96	571.0	19.0	7.13	14.0	289.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	07. 02. 96	569.0	20.0	7.19	17.0	289.0	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	07. 02. 96	579.0	22.0	7.19	18.0	291.0	18.0	1.566

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	62.57
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	65.05
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.6	37.0	93.98
Horizontally 25′ from the River bank (3.5 ft depth)	2.739	16.435	0.045	0.060	-	3.987	5.563	4.0	38.0	94.94

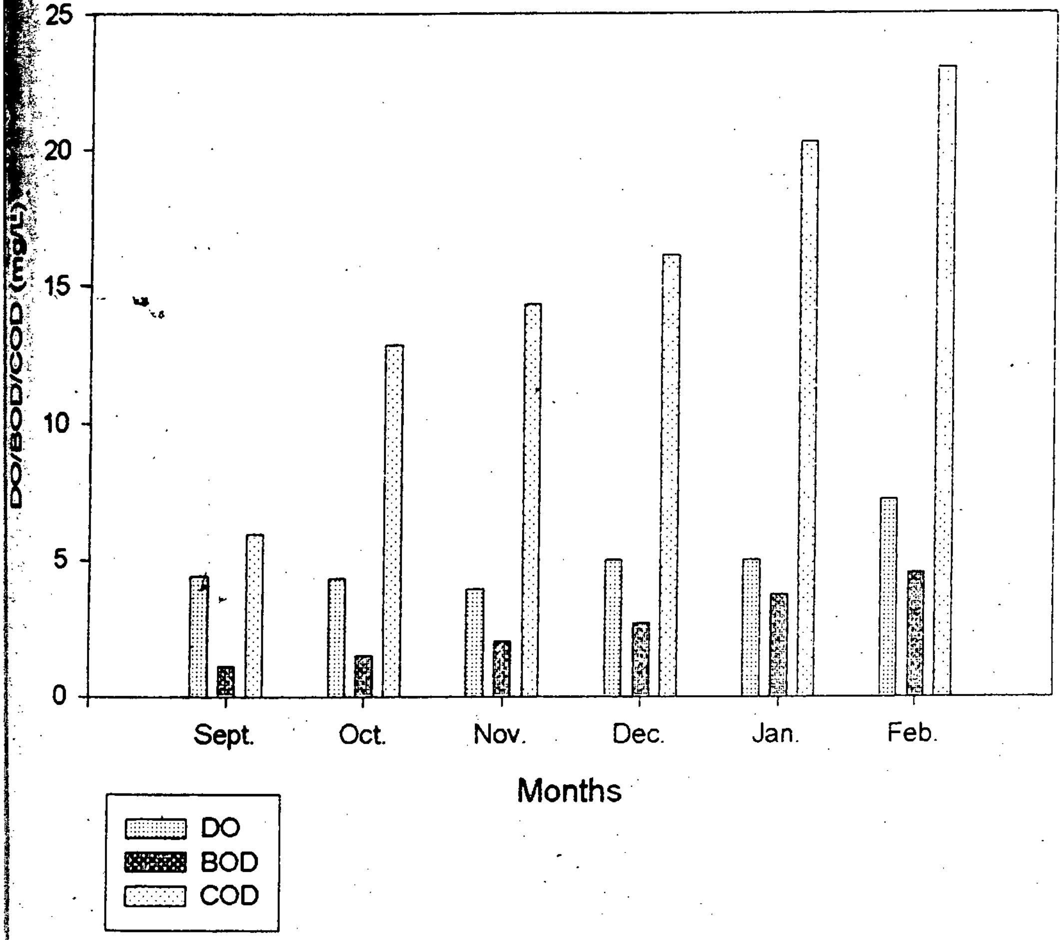

Figure:-5.1, Plot for DO/BOD/COD vs. Sampling Duration of Turag river Data (Station Point-1).

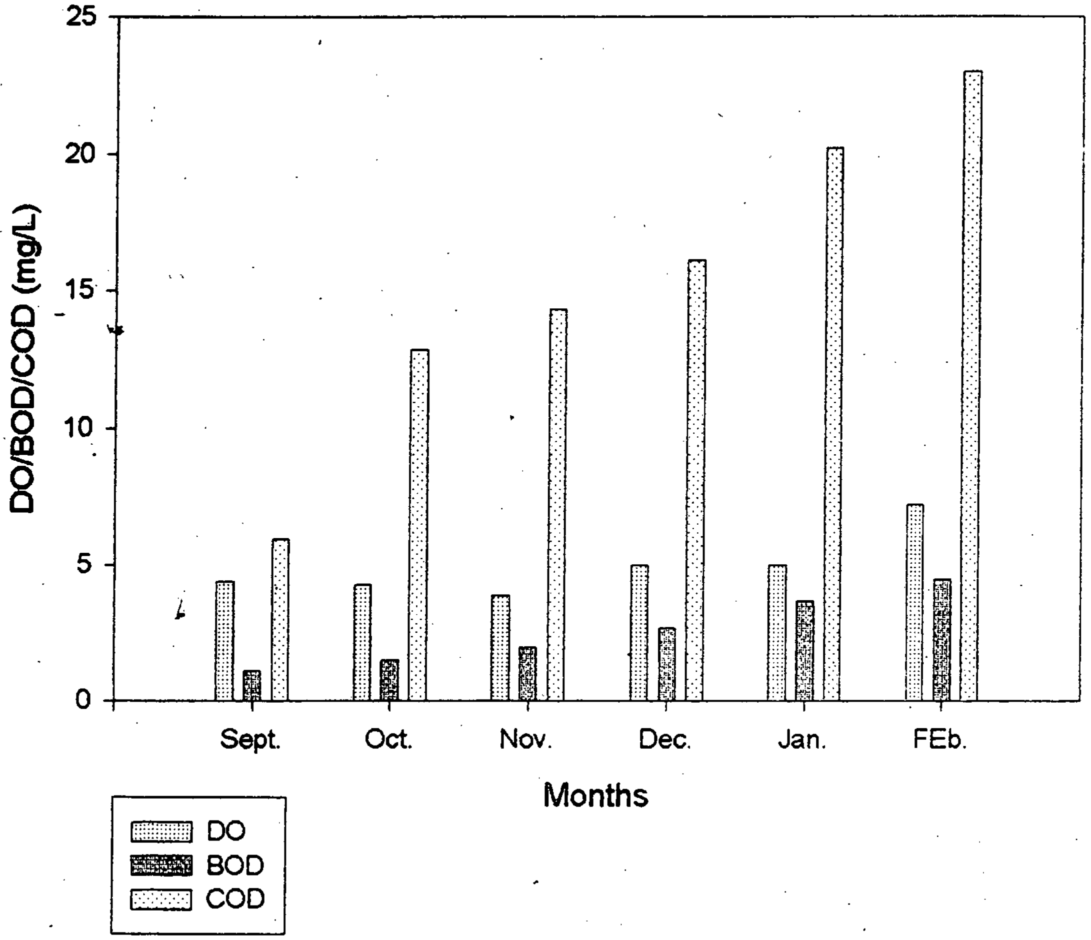

Figure:-5.2, Plot for DO/BOD/COD vs. Sampling Duration of Balu river Data (Station Point-2).

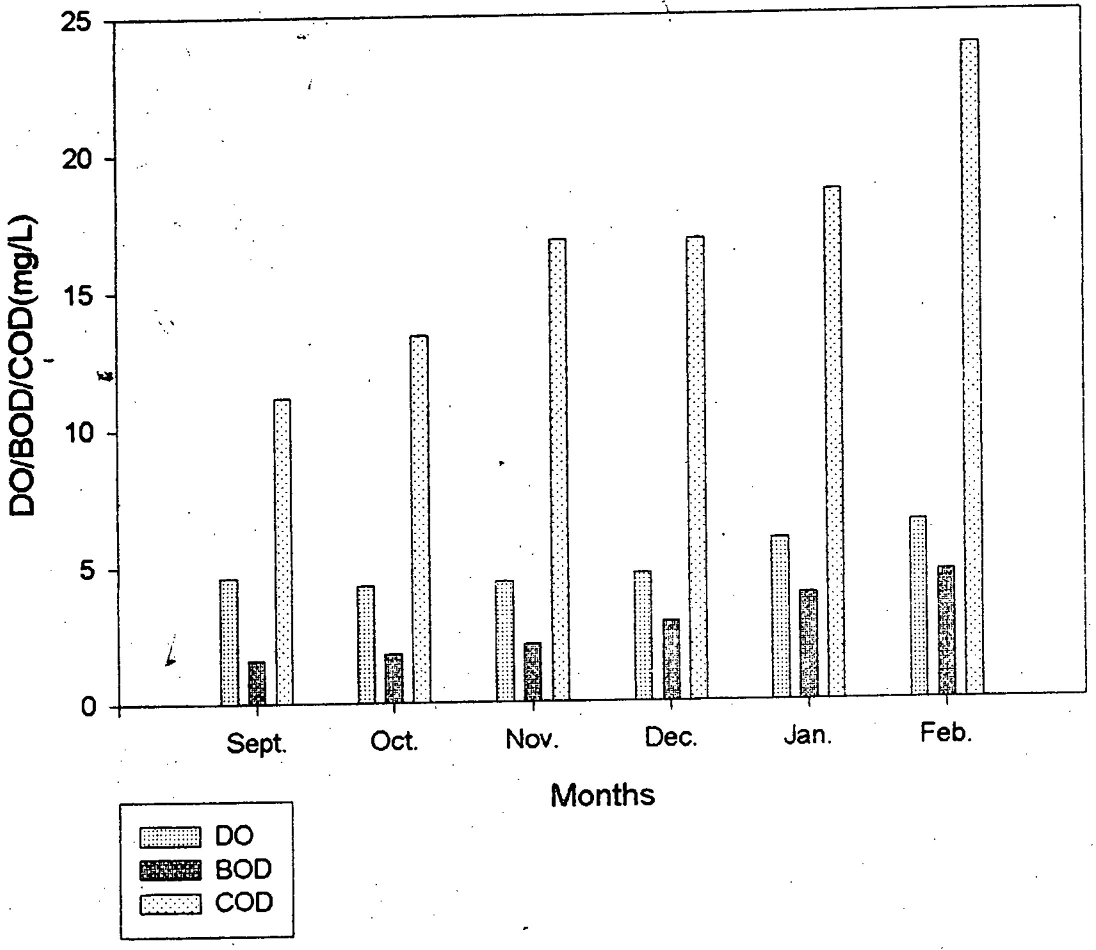

Figure:-5.3, Plot for DO/BOD/COD vs. Sampling Duration of Balu river Data (Station Point-3).

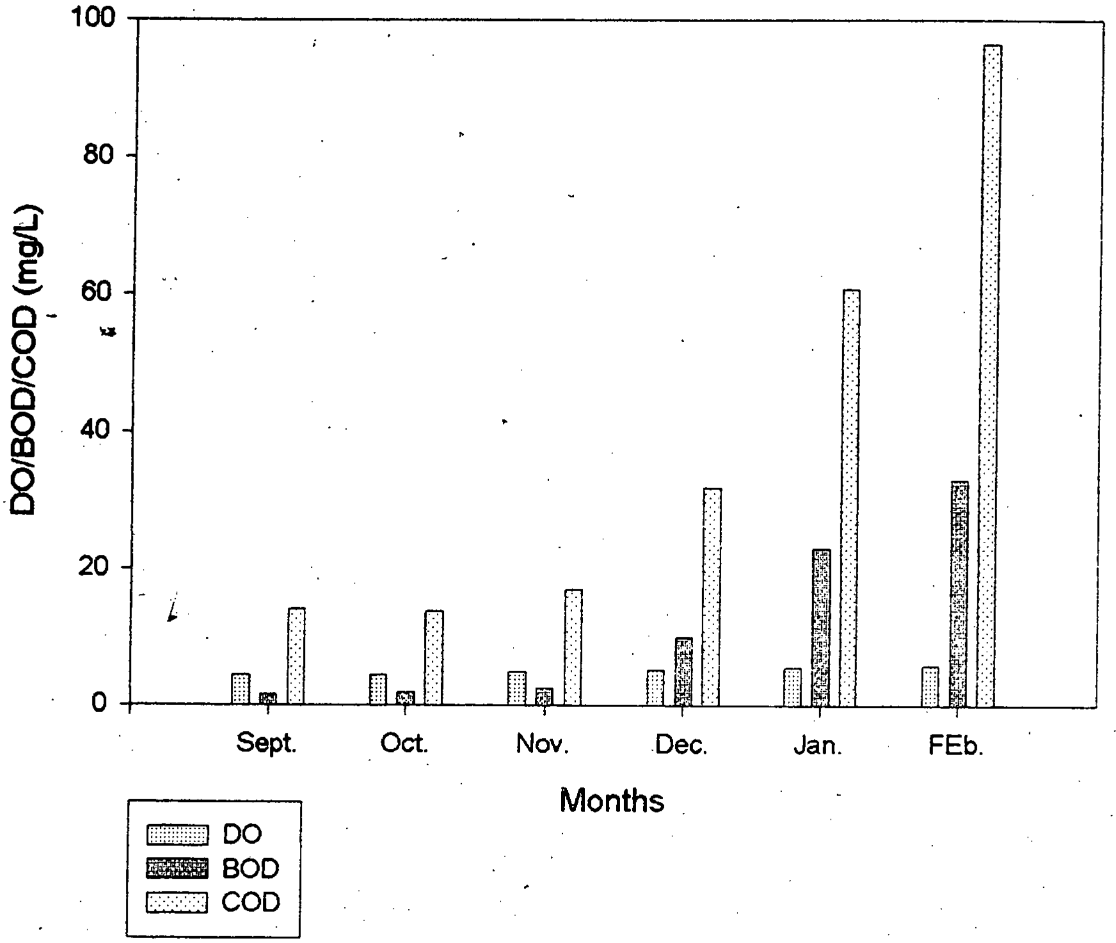

Figure:-5.4, Plot for DO/BOD/COD vs. Sampling Duration of Buriganga river Data (Station Point-4).

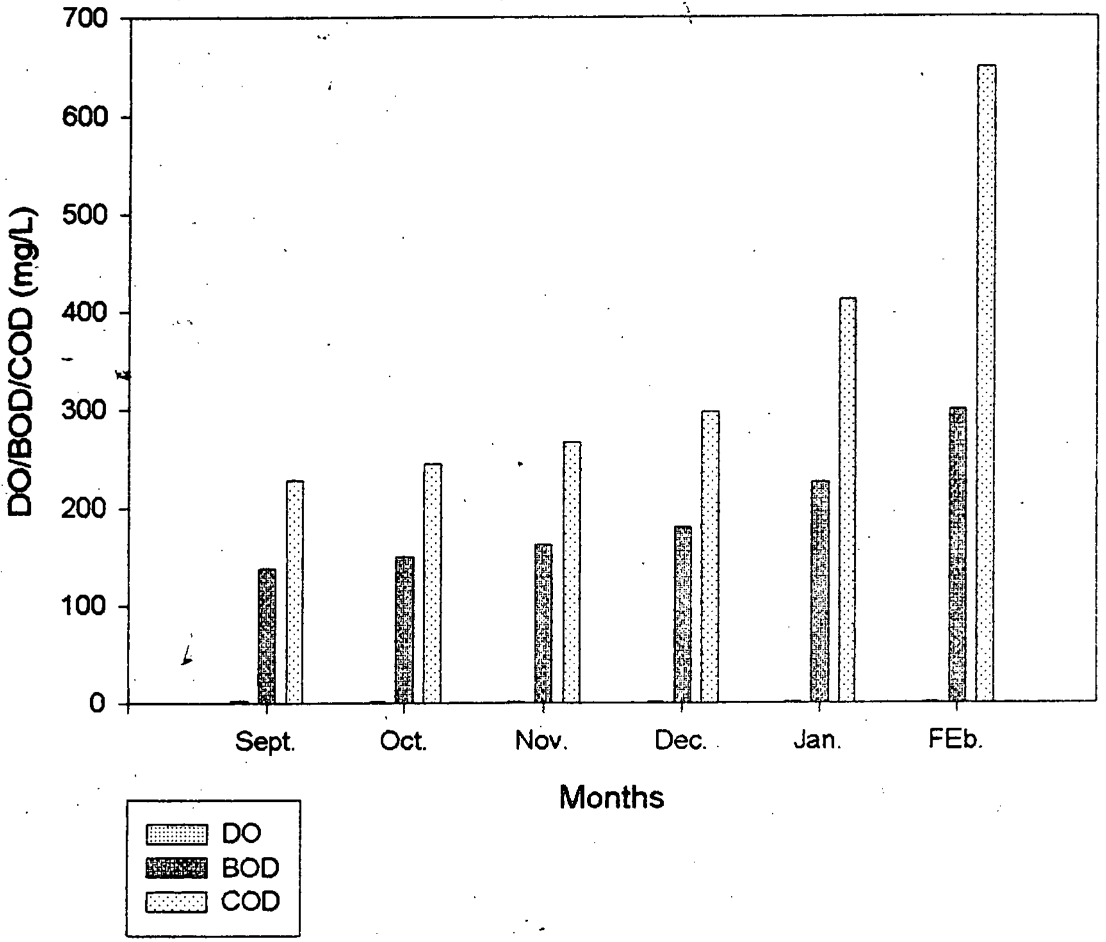

Figure:-5.5, Plot for DO/BOD/COD vs. Sampling Duration of Buriganga river Data (Station Point-5).

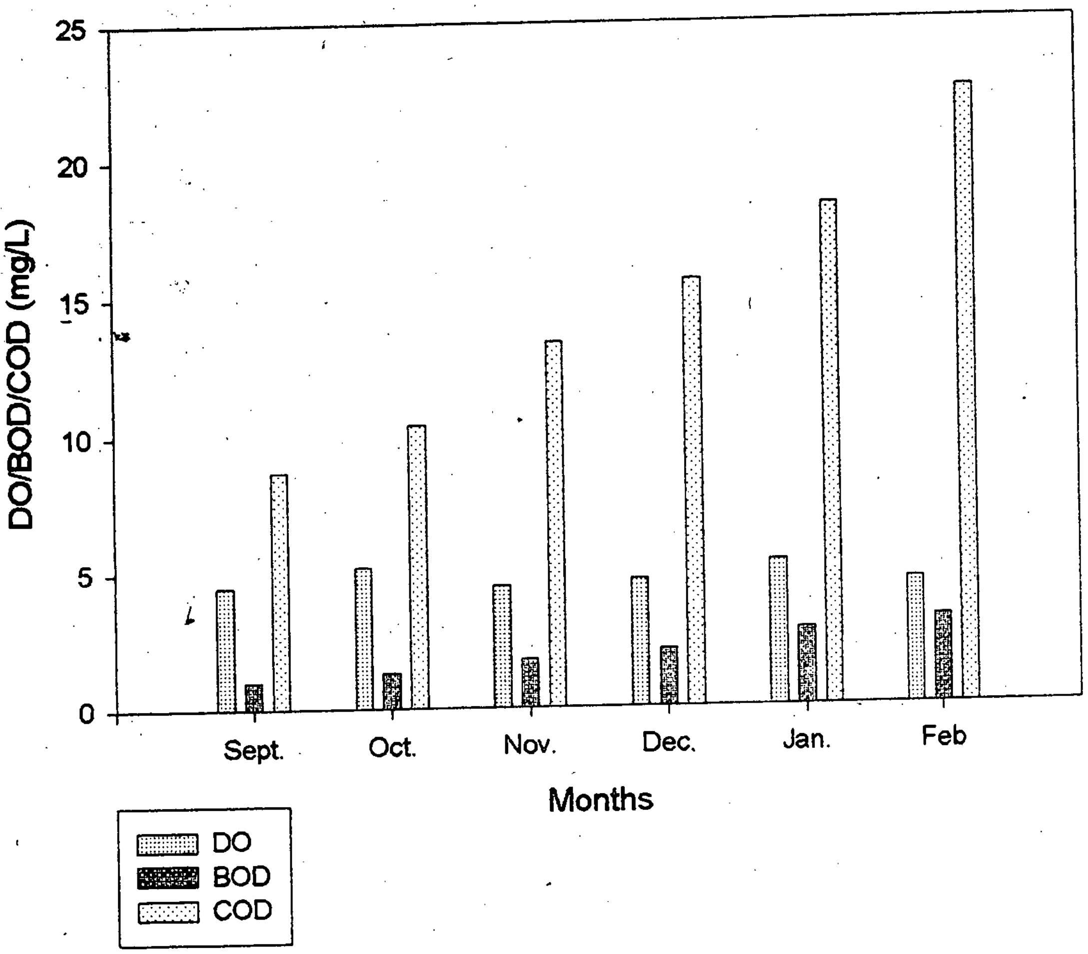

Figure:-5.6, Plot for DO/BOD/COD vs. Sampling Duration of Balu river Data at Demra (Station Point-6).

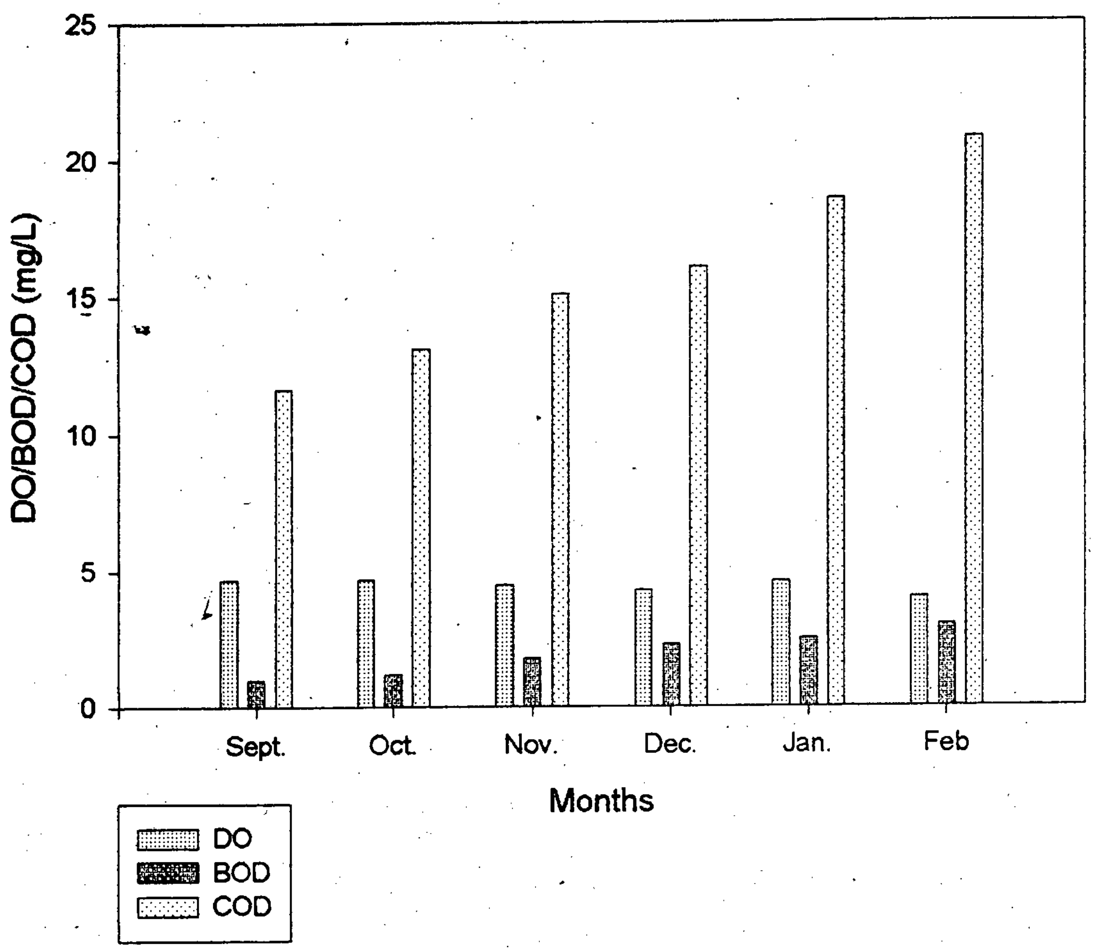

Figure:-5.7, Plot for DO/BOD/COD vs. Sampling Duration of Shitalakhya river Data at Demra (Station Point-7).

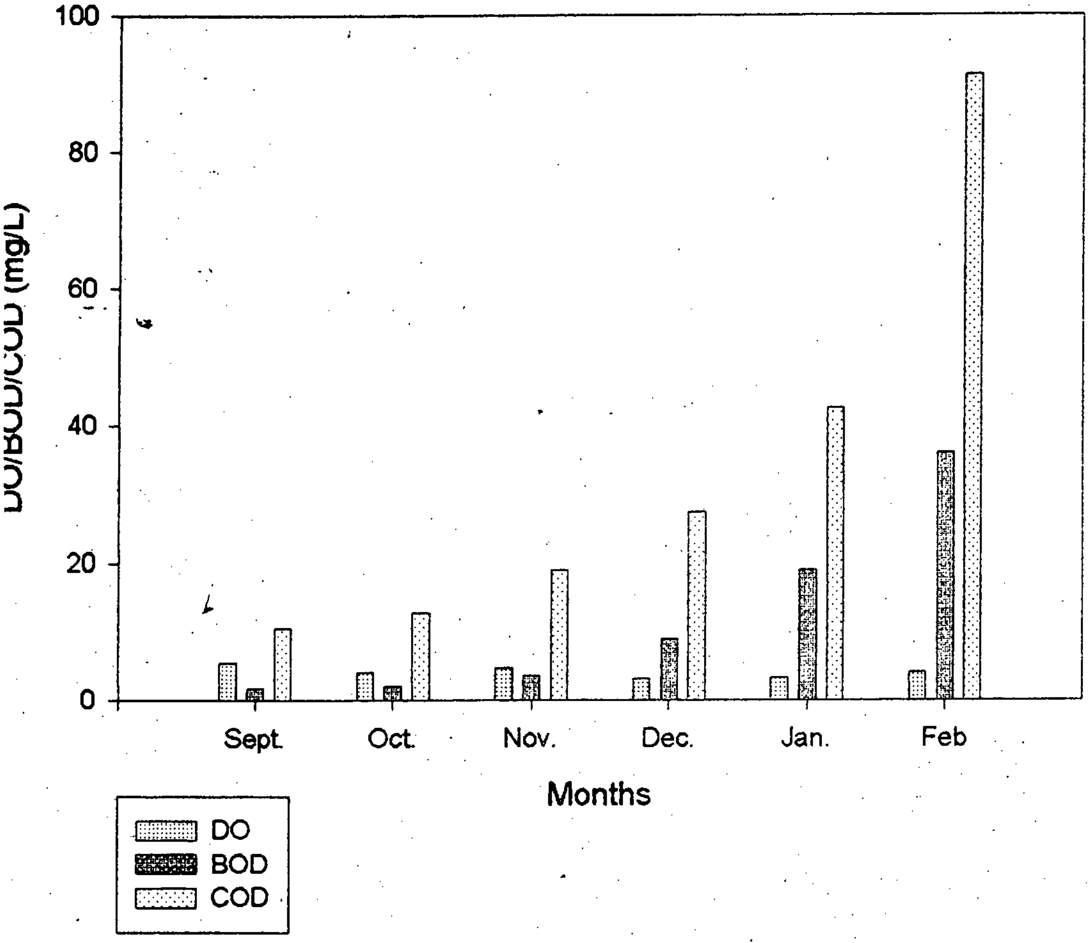

Figure:-5.8, Plot for DO/BOD/COD vs. Sampling Duration of Shitalakhya river Data near Katchpur Bridge (Station Point-8).

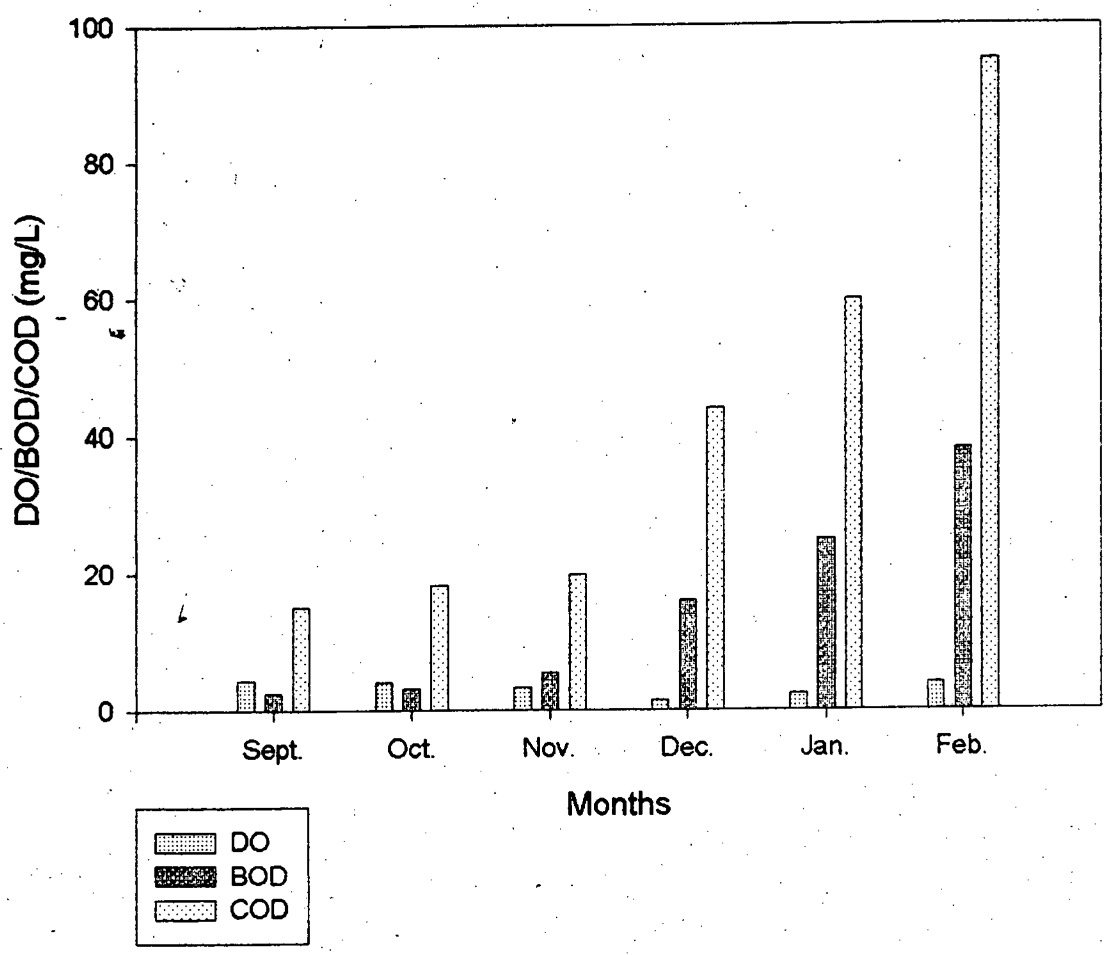

Figure:-5.9, Plot for DO/BOD/COD vs. Sampling Duration of Buriganga river Data at Pagla (Station Point-9).

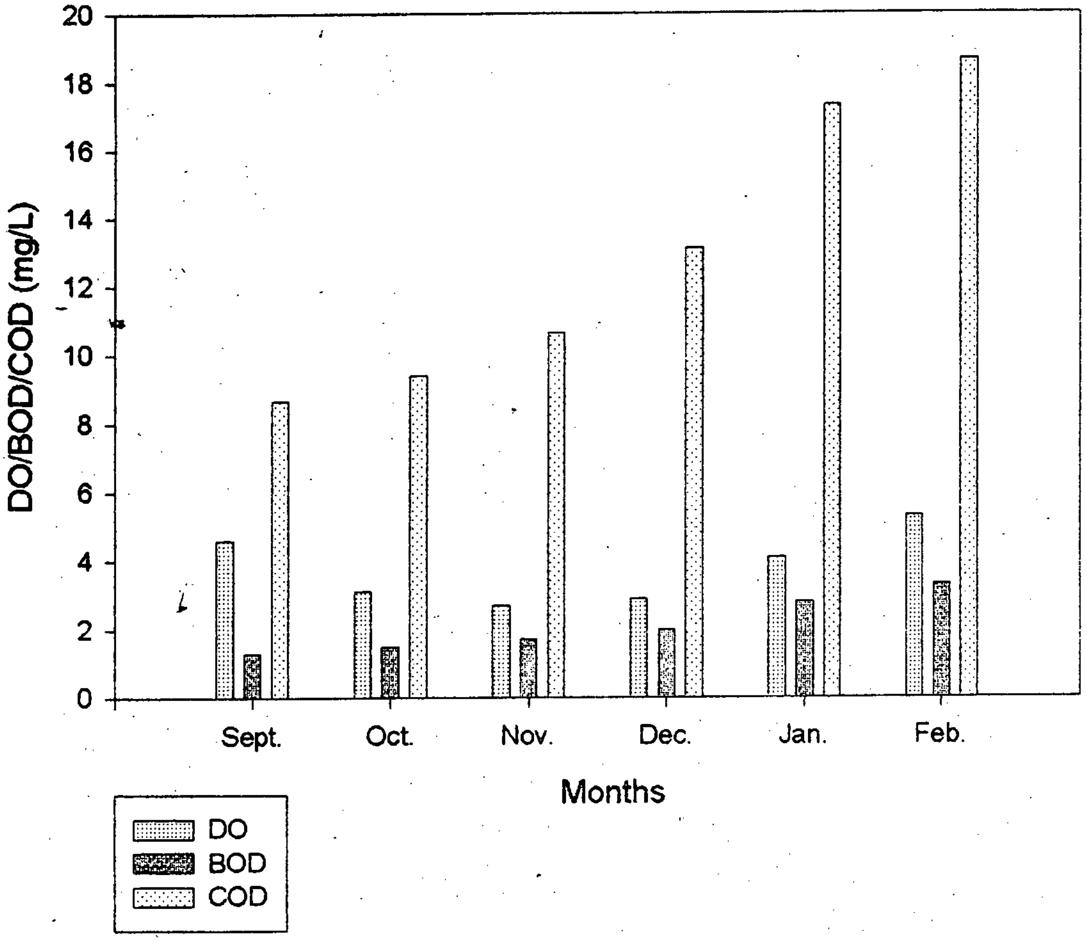

Figure:-5.10, Plot for DO/BOD/COD vs. Sampling Duration of Shitalakhya River Data at Adamji (Station Point-10).

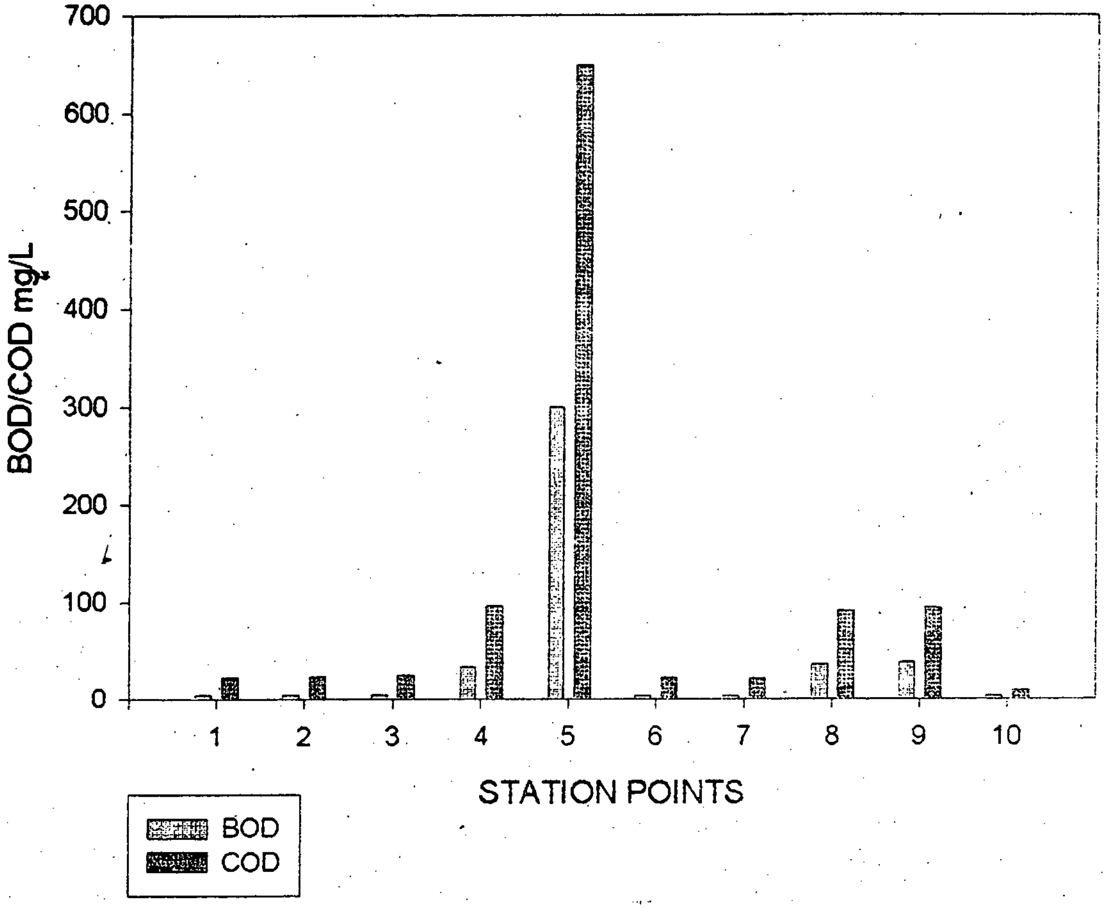

Figure:5.11, Variation of BOD/COD at different station points for the month of February'96.

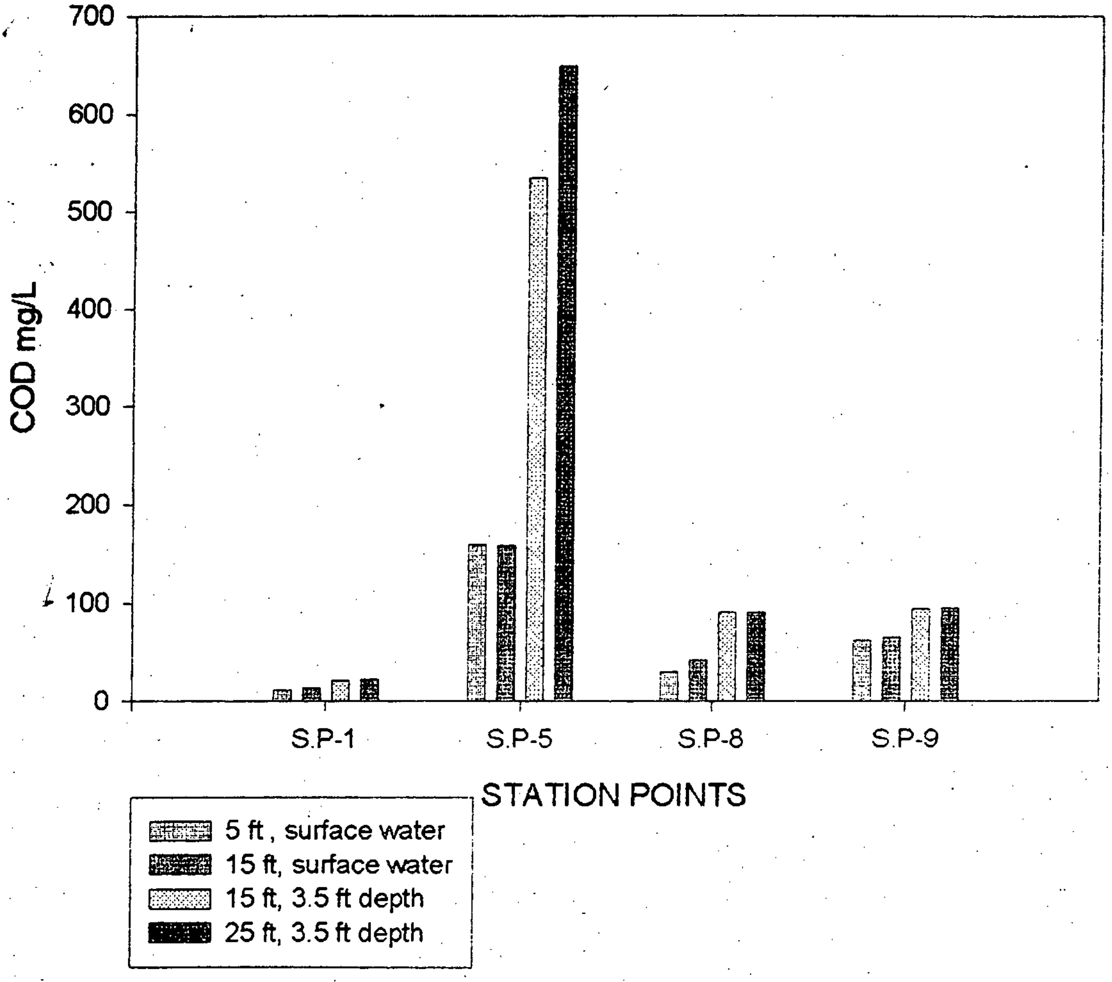

Figure:5.12. Variation of COD at differenrt distances and depth for station point 1, 5, 8 and 9 for February'96.

5.4. Discussions

From the analysis of the samples it was shown that the waters were becoming polluted because of industrial and domestic pollutants. Most of the industries had no effluent treatment plant. Therefore, their wastes were discharged to the rivers in untreated form. Different water quality parameters were investigated from September \`95 to February \`96.

Station point - 1 was selected for Turag river, it was shown from the Table-5.1.1 to Table-5.1.3 and from Table-B-1.1 to Table-B-1.3, in appendix, that the pH level varied from 6.57 to 7.45 which were within the desirable ranges of drinking, fishing, industrial, irrigation and livestock water. The variation of turbidity were from 117 to 131 FTU, which exceeded the standard ranges of drinking and industrial water. The conductivity varied from 117 to 486 µs, which were within the standard values of fishing and irrigation water. The TDS varied from 56 to 245 mg/L, which were within the standard values of drinking, industrial, irrigation, and livestock water. The values of TDS were increased due to decrease in water level of the river. The variation of TSS was from 19 to 80 mg/L, which exceeded the drinking water standard and sometimes the fishing water standard, but within the industrial water standard. Sulfate varied from 5 to 21 mg/L, that was within the desired levels of drinking and irrigation water. Phosphate varied from 0.052 to 0.645 mg/L, which were within the standard values of drinking, fishing, and irrigation water. Chloride varied from 3.057 to 4.553 mg/L, that was within the desired levels of drinking, fishing, industrial and irrigation water. The values of nitrate varied from 1.586 to 12.16 mg/L, which were within the desired levels of drinking and livestock water upto January \`96, but from February \`96 it exceeded the drinking water standard. The variation of chromium was from 0.005

to 0.073 mg/L, which were within desired standard of drinking and fishing water upto December `95, but after that it exceeded the standard levels of drinking and fishing water. The values of iron was from 0.379 to 0.464 mg/L, which were within the standard values of drinking and industrial water. Lead varied from 1.447 to 9.605 mg/L, which exceeded the standard levels of drinking, fishing, industrial, irrigation, and livestock water. Ammonium ion varied from 0.248 to 3.825 mg/L, which exceed the drinking and fishing water standard, but within the irrigation water standard upto January′ 96.

Dissolved oxygen (DO) of the water was from 4.0 to 6.5 mg/L, which were within the standard levels for drinking, fishing, industrial, irrigation and livestock water. BOD varied from 1.6 to 4.7 mg/L, which were beyond the drinking water standard, but within the fishing, industrial and irrigation water standard. COD varied from 2.46 to 22.27 mg/L, which exceeded the drinking and industrial water standard. The differences in the values of BOD and COD indicated the presence of non-biodegradable organic matter. The comparison for DO, BOD and COD with time are presented in Figure-5.1 by bar graph.

Three station points (station point-2, 3, and 6) were selected for the Balu river water quality analysis. Table-5.2.1 to Table-5.2.3, Table-5.3.1 to Table-5.3.3 and Table-5.6.1 to Table-5.6.3, and Table-B-2.1 to Table-B-2.3, Table-B-3.1 to Table-B-3.3 and Table-B-6.1 to Table-B-6.3 in appendix, showed that the pH level varied from 6.68 to 7.80 which were within the desirable ranges of drinking, fishing, industrial, irrigation and livestock water. The variation of turbidity were from 7 to 140 FTU, which exceeded the standard ranges of drinking water and sometims industrial water. The conductivity varied from 62.10 to 523 μs, which were within the standard values of fishing and irrigation water. The values of TSS varied from 11.0 to 65 mg/L, which exceeded the drinking water standard and sometimes the fishing water standard, but within the industrial water levels. The TDS varied from 38.60 to 261.0 mg/L, which were within the standard values of drinking, industrial, irrigation and livestock water. The values of TDS were increased due to decrease in water level of the river. Sulfate varied from 5 to 18 mg/L, that was within the desired levels of drinking and irrigation water. Phosphate varied from 0.026 to 1.375 mg/L, which were within the standard values of drinking, fishing and irrigation water. Chloride varied from 1.901 to 5.531 mg/L, that were within the desired levels of drinking, fishing, industrial and irrigation water. The values of nitrate varied from 0.978 to 9.825 mg/L, which were within the desired levels of drinking and livestock water standard. The variation of chromium was from 0.003 to 0.062 mg/L, which were within desired standard of drinking and fishing water, but within the industrial water levels. The values of iron was from 0.239 to 0.862 mg/L, which were within the standard values for drinking water, but sometimes beyond the industrial water standard. Lead varied from 1.364 to 2.323 mg/L, which exceeded the standard levels of drinking, fishing, industrial, irrigation and livestock water. Ammonium ion varied from 0.266 to 6.435 mg/L, which exceed the drinking, and fishing water standard but sometimes beyond the irrigation water standard. Dissolved oxygen (DO) of the water was from 4.0 to 7.2 mg/L, which were within the standard levels for drinking, fishing, industrial, irrigation and livestock water. BOD varied from 1.0 to 4.7 mg/L, which were beyond the drinking water standard, but within the fishing, industrial and irrigation water standard. COD varied from 2.4 to 23.83 mg/L, which exceeded the drinking and industrial water standard for most of the times. The differences in the values of BOD and COD indicated that the presence of non-biodegradable organic matter. The comparison for DO, BOD and COD with time are presented in Figure-5.2, 5.3 and 5.6 by bar graph.

Three station points (station point-4, 5, and 9) were selected for the Buriganga river water quality analysis. Table- 5.4.1 to Table- 5.4.3, Table-5.5.1 to Table-5.5.3 and Table-5.9.1 to Table-5.9.3 and Table-B-4.1 to Table-B-4.3, Table-B-5.1 to Table-B-5.3 and Table-B-9.1 to Table-B-9.3 in appendix, showed that the pH level varied from 6.78 to 8.04 which were within the desirable ranges of drinking, fishing, industrial, irrigation and livestock water. The variation of turbidity were from 15 to 189 FTU, which exceeded the standard ranges of drinking water, and for most of the time the industrial water standard. The conductivity varied from 120.30 to 3200 µs, which were beyond the standard values of fishing and irrigation water for most of the times. The values of TSS varied from 13.0 to 162 mg/L, which exceeded the drinking and fishing water standard, and sometimes the industrial water levels. The TDS varied from 60.20 to 1630.0 mg/L, which were beyond the standard values of drinking, and sometimes the industrial water but within the irrigation and livestock water. The values of TDS were increased due to decrease in water level of the river. Sulfate varied from 10.0 to 359.90 mg/L, that was within the desired levels of drinking and irrigation water. Phosphate varied from 0.053 to 24.37 mg/L, which were within the standard values of drinking, fishing and irrigation water for station point-4, and 9, but for station point-5, the values exceeded the standard levels of drinking, fishing and irrigation water for most of the times. Chloride varied from 2.170 to 307.75 mg/L, which were within the desired levels of drinking, fishing, industrial and irrigation water. The values of nitrate varied from 0.794 to

10.292 mg/L, which were within the desired levels of drinking and livestock water standard. The variation of chromium was from 0.0195 to 0.836 mg/L, which were beyond standard for drinking and fishing water for most of the time, but sometimes within the industrial water levels. The values of iron was from 0.106 to 2.660 mg/L, which were within the desired standard for drinking and industrial at station point-4, but for station point-5, it exceede the desired drinking and industrial water standard. Lead varied from 1.599 to 17.215 mg/L, which exceeded the standard levels of drinking, fishing, industrial, irrigation and livestock water. Ammonium ion varied from 0.462 to 89.85 mg/L, which exceed the drinking, fishing and irrigation water standard. Dissolved oxygen (DO) of the water was from 4.3 to 5.8 mg/L, for station point-4, and 1.5 to 4.6 mg/L for station point-9 which were within the standard levels for drinking, fishing, industrial, irrigation and livestock water, but for station point-5, the DO was almost nil, which indicated septic water. BOD varied from 1.5 to 34.0 mg/L, for station point-4, 2.5 to 37.0 mg/L for station point-9, and 144 to 300 mg/L for station point-5, which indicated that waters were beyond the drinking fishing, industrial and irrigation water levels for most of the times. COD varied from 5.20 to 107.08 mg/L, for station point-4, 9.29 to 94.94 mg/L for station point-9, and 151.84 to 649.32 mg/L for station point-5, which exceeded the drinking and industrial water standard, for most of the times. The differences in the values of BOD and COD indicated that the presence of non-biodegradable organic matter. The comparison for DO, BOD and COD with time are presented in Figure-5.4, 5.5, and 5.9 by bar graph.

Three station points (station point-7, 8, and 10) were selected for the Shitalakhya river water quality analysis. Table-5.7.1 to Table-5.7.3, Table-5.8.1 to Table-5.8.3 and Table-5.10.1 to Table-5.10.3 and Table-B-7.1 to Table-B-7.3, Table-B-8.1 to Table-B-8.3 and Table-B-10.1 to Table-B-10.3 in appendix, showed that the pH level varied from 6.70 to 7.81 which were within the desirable ranges of drinking, fishing, industrial, irrigation and livestock water. The variation of turbidity were from 7 to 86 FTU, which Sometimes exceeded the standard ranges of drinking and industrial water. The conductivity varied from 86.30 to 434 µs, which were within the standard values of fishing and irrigation water. The values of TSS varied from 10.0 to 72 mg/L, which exceeded the drinking water standard and sometimes the fishing water standard, but within the industrial water levels. The TDS varied from 50.60 to 217.0 mg/L, which were within the standard values of drinking, industrial, irrigation and livestock water. The values of TDS were increased due to decrease in water level of the river. Sulfate varied from 5 to 15 mg/L, which were within the desired levels of drinking and irrigation water. Phosphate varied from 0.055 to 0.529 mg/L, which were within the standard values of drinking, fishing and irrigation water. Chloride varied from 1.214 to 6.643 mg/L, that were within the desired levels of drinking, fishing, industrial and irrigation water. The values of nitrate varied from 3.619 to 133.275 mg/L, which exceeded the desired levels of drinking water for most of the times, but within the livestock water standard. The variation of chromium was from 0.010 to 0.096 mg/L, which were within desired standard for industrial water but sometimes exceeded the drinking, and fishing water standard. The values of iron was from 0.098 to 0.436 mg/L, which were within the standard values for drinking and the industrial water. Lead varied from 1.030 to 3.827 mg/L, which exceeded the standard levels of drinking, fishing, industrial, irrigation and livestock water. Ammonium ion varied from 0.319 to 3.525 mg/L, which exceed the drinking, fishing water standard and sometimes the irrigation water standard. Dissolved oxygen (DO) of the water was from 2.8 to 5.3 mg/L, which were within the standard levels for drinking, fishing, industrial, irrigation and livestock water, but sometimes it went beolw the standard levels of different water characteristics. BOD varied from 1.0 to 36.0 mg/L, which were beyond the drinking water standard, but sometimes within the fishing, industrial and irrigation water standard. COD varied from 2.73 to 91.26 mg/L, which exceeded the drinking and industrial water standard, for most of the times. The differences in the values of BOD and COD indicated that the presence of non-biodegradable organic matter. The values of BOD and COD at station point-8, exceeded the standard levels of drinking, fishing and industrial water standard for most of the times. The graph for DO, BOD and COD with time are presented in Figure-5.7, 5.8 and 5.10 by bar graph. BOD and COD values at the sampling stations have been illustrated in Figure 5.11. Samples were taken 25 ft away from the river bank and at a depth of 3.5 ft. The COD values were always greater than

BOD values in every cases as depicted in Figure 5.11. At station point-5 the BOD and COD were unusually greater than those at any other station points. It may be happened that, the effluent that discharged to river were not diluted properly by the river water at that point. Station point 4, 8, and 9 showed the almost similar values of BOD and COD. The BOD and COD values of station point 1, 2, 3, 6, and 7 were same. The values were less than 30 mg/L which indicate that river water at that locations is not polluted. It showed from station point 4, 5, 8 and 9 that there were some potential sources of pollutants.

Figure 5.12 showed the variation of COD at different distances and depth of sampling positions of the station point 1, 5, 8 and 9. The values of COD at position 1 and 2, and 3 and 4 were almost same. But at station point-5 it showed that the values of COD at sampling positions 3 and 4 differed very significantly. It can be deduced from this figure that pollution load in river water is higher at a depth of 3.5 ft than the surface and from river bank. From the analysis of the data it is showed that the concentration of metalic ions increases very rapidly at winter season. Specially for the month of February' 96 the concentration was very high. The concentration of lead ion for all the rivers exceeded the standard values for drinking, fishing, industrial, irrigation and livestock water. So the waters from different rivers around Dhaka City can not be used without treatment of lead for any purpose. In Buriganga river at Chandighat, there is a water treatment plant for Dhaka City. The plant has no treatment system for the removal of lead, therefore, the users of the water could be affected to serious illness or death by brain damage, taking water with high concentration of lead (1.599 to 17.215 mg/L). The concentration of chromium for all the rivers around Dhaka City exceeded the drinking and fishing water standard, but at Hazaribugh it also exceeded the industrial standard. If these waters are taken without treatment or removal of chromium people can be affected by cancer.

Therefore, water available in the rivers around Dhaka city provides a means for transportation, a source for domestic and industrial water supplies and recharging of aquifers, a medium for natural treatment of wastes and dilution of various non-degradable pollutants. The self-purification capacity of water bodies has been misused and overloaded by indiscriminate discharge of untreated or partially treated domestic and industrial wastes. The river water available in monsoon is considered enough to dilute the polluting loads discharged in waters for natural degradation but in winter season, specially for the month of February the dilution factor and the reoxygenation characteristics are reduced tremendously.

CHAPTER-6

CONCLUSIONS AND RECOMMENDATION

6.1. CONCLUSIONS

Analysis of the data indicated that based on proximity to industrial areas and dense population, Buriganga river is the most polluted river. Pollution load is mainly from sewage and human excreta. Industrial pollution load is much less in quantity, but in localized areas concentration of different constituents are alarmingly high. Localized polluted areas are Turag river at Tongi, Buriganga river at Hazaribug and Pagla, and Shitalakhya river at Demra and Adamji.

In terms of water quality parameters that have been considered in this study, the overall ambient water quality in all the rivers monitored is not good. The general characteristics are in the following ranges. p^H- 6.5 to 8.04; turbidity-12 to 189 FTU; total dissolved solid(TDS)-38mg/L to 1.63g/L; conductivity-62μs to 3.27ms; total suspended solids(TSS)-12 to 162mg/L; sulfates-5 to 359mg/L; phosphates-0.03 to 24.37mg/L; nitrates-0.978 to 14.50 mg/L; chlorides-2.361 to 307.75mg/L; chromium-0.003 to 0.836mg/L; iron-0.335 to 2.66mg/L; lead-1.364 to 17.215mg/L; ammonium-0.248 to 89.85mg/L; Dissolved Oxygen-1.0 to 6.5mg/L; BOD-0.9 to 300mg/L; and COD-1.5 to 649.32mg/L.

The TDS values varied over a wide range with high values obtained in Buriganga at Hazaribugh (station point-9) which exceeded the drinking water level by 1.63 times for the month of February'96.

For the month of February' 96 the values of different constituent exceeded the drinking water level. The level of increase are as follows: total chromium 1.46 times, lead 19.21 times, ammonium 7.65 times, BOD 21 times and COD 5.56 times in Turag river (SP-1), total chromium 1.24 times, lead 3.88 times, ammonium 14.75 times, BOD 23.5 times and COD 5.95 times in Balu river (SP-3) at Tongi near Moinerteak; total chromium 1.26 times, lead 7.45 times, ammonium 7.05 times, BOD 15 times and COD 5.19 times in Shitalakhya river near Demra bazar (SP-5) at Dkaka; and total chromium 16.70 times, lead 34.43 times, ammonium 179.70 times, BOD 1500 times and COD 162.66 times in Buriganga river near Hazaribagh (SP-9) at Dhaka.

Pollutional level was worst during the month of February'96. By comparing the results of previous work, it appears that pollution level has increased for all the points.

RECOMMENDATION

1. In this study analysis were carried out in the laboratory with 24 hours storage time. Spot analysis (analysis at the sampling stations) is needed, after collecting the samples for more accurate result. This can be performed by using portable instrument at the place of sampling.
2. Atomic absorption spectrophotometer may be used for more precise result of anion, instead of UV-spectrophotometer.
3. Study may be carried out in the complete dry season(October to April) in order to get the actual pollution effect of the river water. In this study water quality was investigated from

September to February.

4. Analysis of the water samples may be done during wet season for comparison of pollutional level of river water.

The investigation into the multinatural aspect of water quality around Dhaka City is no doubt a painstaking job. Sixth month duration study is definitely insufficient to look into the physical and chemical characteristics of water. There are number of agents for contamination, the details of which can only be detected through physical, chemical, and bacteriological tests for individual elements including poisonous chemicals such as cyanide, cadmium, barium, arsenic, chloroform extract, phenols etc., and some disease causing bacteria, such as bacillus streptococci etc. More extensive study by taking more sampling point is also required to know the actual characteristics of the water.

Tests for residues of pesticides or heavy metals are required to ascertain fully the quality of water. Tests for river water should be complimented by testing for heavy metals and pesticide residues in water and in the bottom sediment, as many metals absorb into particulate matter and cannot be accurately detected from water samples alone.

Above all, for effective treatment of water it is necessary to detect all the pollutional constituents into water. As there is a tendency of increase in the water pollution by various human activities, more elaborate study will be required from time to time is recommended.

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APPENDIX–A

CALIBRATION DATA

Table–A1.

Data for the COD calibration curve.

COD (mg/L)	Absorbance
10	0.013
20	0.031
30	0.041
50	0.078
100	0.132
200	0.266
300	0.396

Table–A2

Data for the calibration curve of PO_4^{-3}

PO_4^{-3} concentration (mg/L)	Absorbance
0.20	0.21
0.40	0.42
0.60	0.63
0.80	0.84

Table-A3

Data for the p^H adjustment

Sample Concentration C_1(mg/L)	Sample Volume (ml)	H_2SO_4 Added (ml)	Water Added (ml)	Final Volume (ml)	Final Concentration C (mg/L)
10	1	2	97	100	0.1
20	1	2	97	100	0.2
30	1	2	97	100	0.3
40	1	2	97	100	0.4
50	1	2	97	100	0.5

Table-A4

Data for Cr calibration curve

Concentration of Cr Solution (mg/L)	Absorbance
0.10	0.10
0.20	0.21
0.30	0.33
0.40	0.44
0.50	0.55

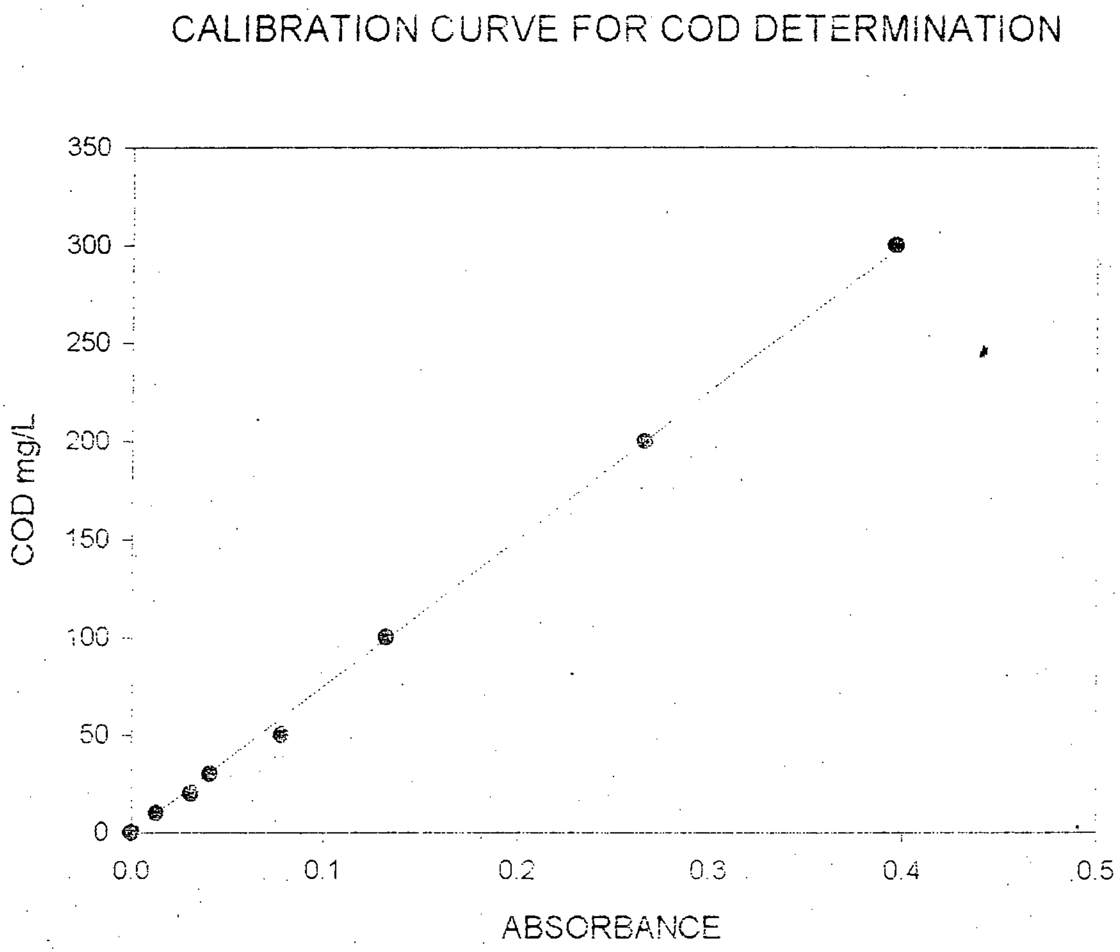

Figure-A1: Plot for COD vs. Absorbance

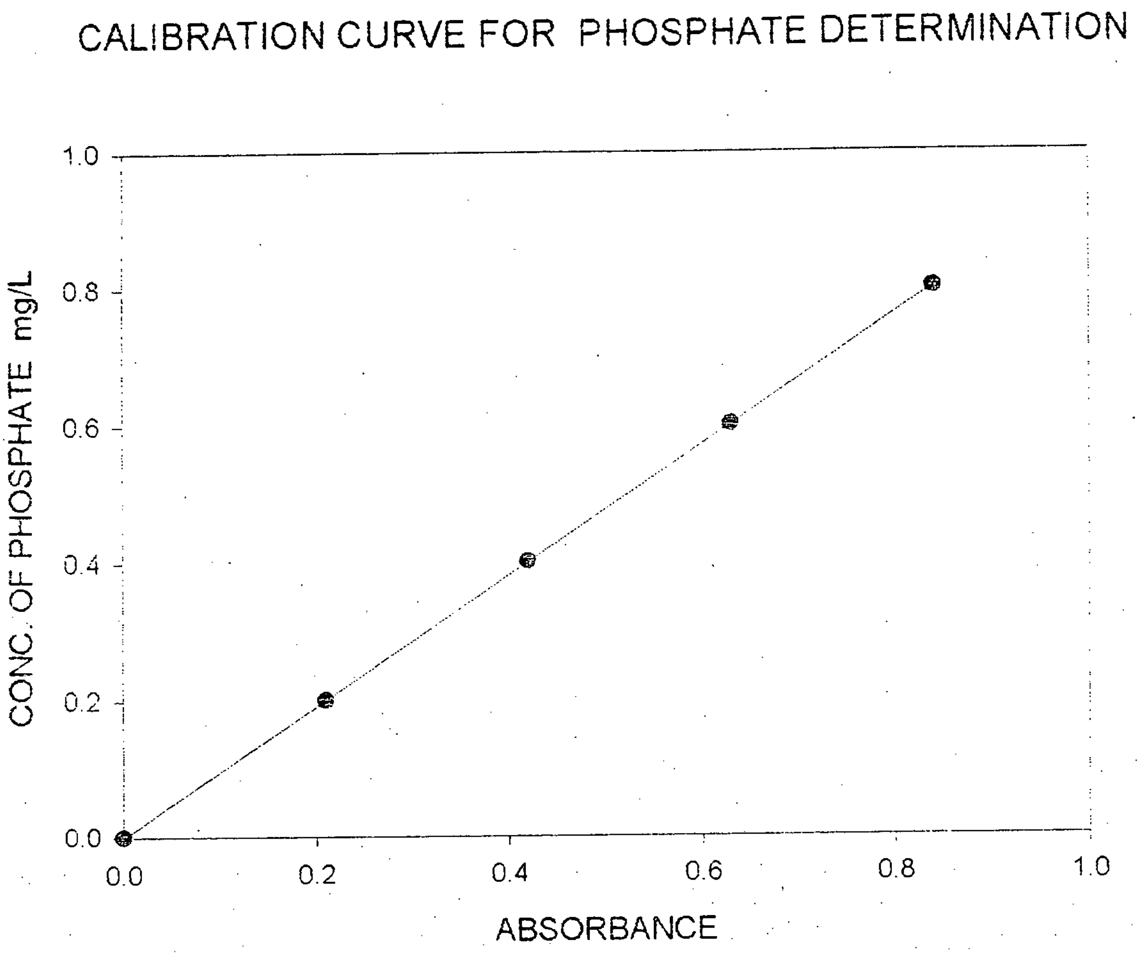

Figure-A2: Plot for Concenteration of Phosphate vs. Absorbance

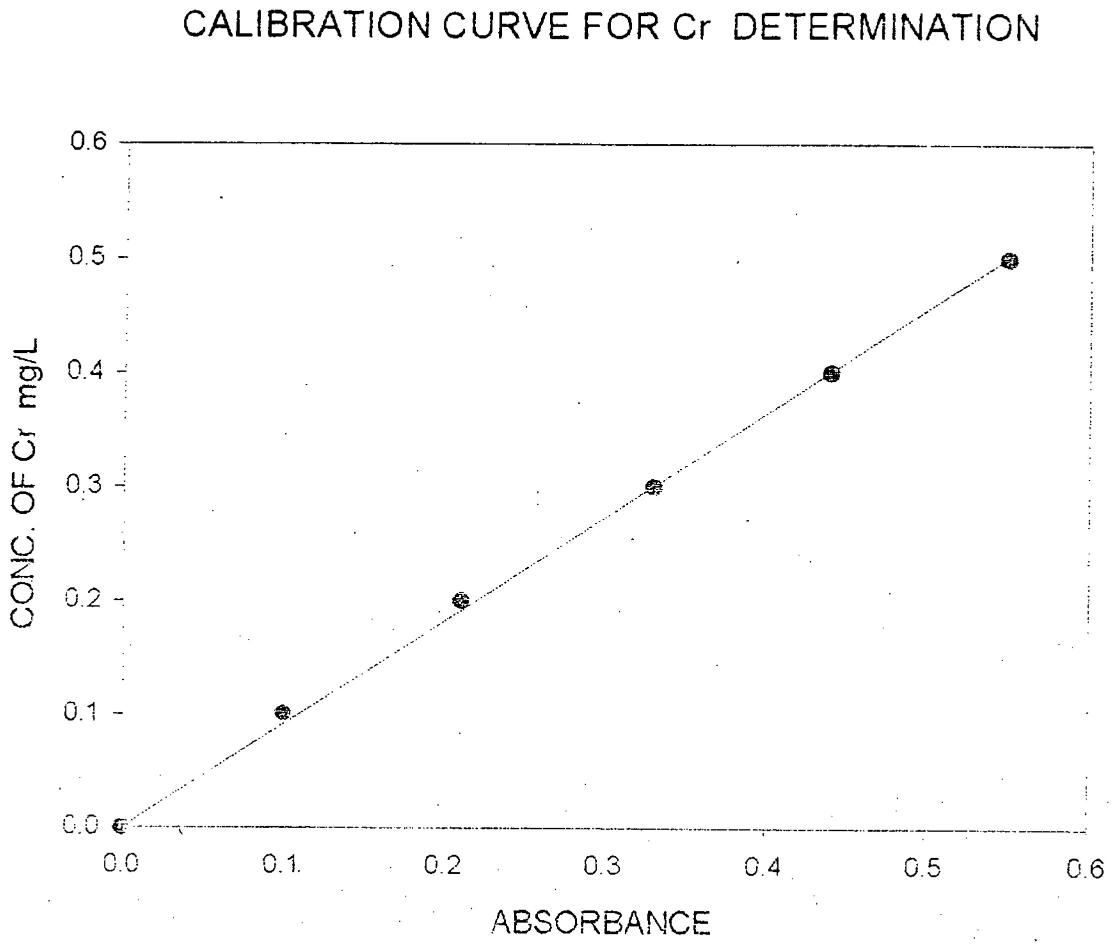

Figure-A3: Plot for Concenteration of Chromium vs. Absorbance

APPENDIX-B

EXPERIMENTAL RESULTS AND DATA

Table-B-1.1.

Experimental Data at station point-1, of Turag river for September'95 near Moinertaek at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	19. 9. 95	117.0	30.0	6.97	22	56.0	-	-
Horizontally 15′ from the River bank (Surface water)	19. 9. 95	118.0	29.0	6.98	23	55.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	19. 9. 95	119.6	31.0	7.08	23	57.9	5	0.055
Horizontally 25′ from the River bank (3.5 ft depth)	19. 9. 95	118.6	30.0	7.11	25	58.0	5	0.052

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	1.50
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	2.24
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.005	-	-	-	-	4.2	1.0	2.46
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.007	-	-	-	-	4.3	0.9	3.20

Table-B-1.2.

Experimental Data for station point-1, of Turag river for October'95 near Moinerteak at Tongi

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	PH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	22. 10. 95	118.2	24.0	6.72	20	59.0	-	-
Horizontally 15′ from the River bank (Surface water)	22. 10. 95	117.8	27.0	6.72	19	60.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	22. 10. 95	119.6	29.0	6.75	22	61.4	7	0.068
Horizontally 25′ from the River bank (3.5 ft depth)	22. 10. 95	119.3	33.0	6.77	22	63.6	6	0.070

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	3.72
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	5.20
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.013	-	-	-	-	4.2	1.4	9.66
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.014	-	-	-	-	4.4	1.4	9.66

Table-B-1.3.

Experimental Data for station point-1 of Turag river for November'95 near Moinerteak at Tongi

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	21. 11. 95	157.4	75.0	6.76	45	78.7	-	-
Horizontally 15′ from the River bank (Surface water)	21. 11. 95	156.3	80.0	6.77	49	77.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	21. 11. 95	155.8	82.0	6.95	52	78.0	11	0.079
Horizontally 25′ from the River bank (3.5 ft depth)	21. 11. 95	159.1	86.0	6.96	53	78.8	12	0.079

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.7	-	10.40
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.8	-	8.92
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.020	-	-	-	-	4.2	1.8	8.92
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.021	-	-	-	-	4.3	1.9	9.66

Table-B-2.1.

Experimental Data at station point-2, of Balu river for September'95 near Moinertaek at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	19. 9. 95	62.1	15	6.85	12	38.6	-	-
Horizontally 15′ from the River bank (Surface water)	19. 9. 95	63.2	16	6.86	13	38.7	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	19. 9. 95	64.0	17	6.87	14	39.5	5	0.030
Horizontally 25′ from the River bank (3.5 ft depth)	19. 9. 95	65.0	17	6.87	14	40.0	6	0.032

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	2.4
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	2.75
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.003	-	-	-	-	4.5	1.1	5.43
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.004	-	-	-	-	4.4	1.0	5.95

Table-B-2.1-

Experimental Data for station point-2 of Balu river for October'95 near Moinerteak at Tongi

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	22. 10. 95	75.0	21	6.97	16	40.5	-	-
Horizontally 15′ from the River bank (Surface water)	22. 10. 95	74.5	22	6.98	16	40.1	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	22. 10. 95	74.9	23	6.97	18	40.2	7	0.036
Horizontally 25′ from the River bank (3.5 ft depth)	22. 10. 95	75.2	25	6.97	19	40.3	8	0.037

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	4.98
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	5.95
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.003	-	-	-	-	4.3	1.4	10.62
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.000	-	-	-	-	4.2	1.5	12.85

Table-B-2.2.

Experimental Data for station point-2 of Balu river for November'95 near Moinerteak at Tongi

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	21. 11. 95	80.5	52	7.03	24	50.6	-	-
Horizontally 15′ from the River bank (Surface water)	21. 11. 95	80.4	52	7.04	24	51.1	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	21. 11. 95	81.0	54	7.05	25	52.2	9	0.042
Horizontally 25′ from the River bank (3.5 ft depth)	21. 11. 95	81.9	56	7.06	25	52.7	10	0.047

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	6.69
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	7.20
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.007	-	-	-	-	4.1	1.9	12.62
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.006	-	-	-	-	3.9	2.0	14.33

Table-B-3.1.

Experimental Data for station point-3, of Balu river for September'95 near Moinertaek at Tongi.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	19. 9. 95	91.3	25.0	6.95	21.0	44.1	-	-
Horizontally 15′ from the River bank (Surface water)	19. 9. 95	92.1	26.0	6.98	22.0	44.5	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	19. 9. 95	92.5	29.0	7.00	25.0	45.9	-	-
Horizontally 25′ from the River bank (3.5 ft depth)	19. 9. 95	92.9	32.0	7.05	26.0	48.3	-	-

Sample Location/Station	NO_3^- mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	2.76
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	4.24
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.5	1.6	9.66
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.6	1.6	11.14

Table-B-3.2.

Experimental Data for station point-3 of Balu river for October'95 near Moinerteak at Tongi

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	22. 10. 95	99.7	28.0	7.11	25.0	44.3	-	-
Horizontally 15′ from the River bank (Surface water)	22. 10. 95	102.1	30.0	7.12	26.0	44.7	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	22. 10. 95	105.0	33.0	7.19	27.0	45.1	9.0	0.036
Horizontally 25′ from the River bank (3.5 ft depth)	22. 10. 95	105.3	34.0	7.27	27.0	46.2	10.0	0.039

Sample Location/Station	NO_3^- mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	4.24
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	5.95
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.3	1.7	12.10
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	4.2	1.8	13.37

Table-B-3.3.

Experimental Data for station point-3 of Balu river for November'95 near Moinerteak at Tongi

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	21. 11. 95	110.0	53.0	7.15	25.0	50.0	-	-
Horizontally 15′ from the River bank (Surface water)	21. 11. 95	111.0	54.0	7.17	26.0	51.1	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	21. 11. 95	114.0	55.0	7.18	26.0	52.1	10.0	0.040
Horizontally 25′ from the River bank (3.5 ft depth)	21. 11. 95	115.0	58.0	7.18	29.0	53.0	11.0	0.045

Sample Location/Station	NO_3^- mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	6.69
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.0	-	8.17
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.020	-	-	-	-	4.5	2.1	15.07
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.022	-	-	-	-	4.4	2.0	16.83

Table-B-4.1.

Experimental Data for station point-4, of Balu river for September'95 near Demra bazar at Dhaka.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5' from the River bank (Surface water)	04. 09. 95	111.0	18.0	6.68	11.0	56.6	-	-
Horizontally 15' from the River bank (Surface water)	04. 09. 95	112.0	19.0	6.71	13.0	56.8	-	-
Horizontally 15' from the River bank (3.5 ft depth)	04. 09. 95	113.0	20.0	6.75	15.0	56.9	8.0	0.026
Horizontally 25' from the River bank (3.5 ft depth)	04.09. 95	117.6	21.0	6.76	16.0	56.9	8.0	0.027

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5' from the River bank (Surface water)	-	-	-	-	-	-	-	5.2	-	2.00
Horizontally 15' from the River bank (Surface water)	-	-	-	-	-	-	-	4.6	-	2.50
Horizontally 15' from the River bank (3.5 ft depth)	-	-	0.003	-	-	-	-	4.4	1.0	8.17
Horizontally 25' from the River bank (3.5 ft depth)	-	-	0.000	-	-	-	-	4.5	1.0	8.67

Table-B-4.2.

Experimental Data for station point-4, of Balu river for October'95 near Demra bazar at Dhaka

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	10. 10. 95	118.1	27.0	6.89	21.0	58.5	-	-
Horizontally 15′ from the River bank (Surface water)	10. 10. 95	118.5	28.0	6.90	21.0	58.7	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	10. 10. 95	119.1	31.0	6.92	24.0	58.9	9.0	0.035
Horizontally 25′ from the River bank (3.5 ft depth)	10. 10. 95	120.0	32.0	6.93	24.0	59.1	9.0	0.037

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.7	-	4.71
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.6	-	5.70
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.003	-	-	-	-	4.8	1.2	8.92
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.003	-	-	-	-	5.2	1.3	10.40

Table-B-4.3.

Experimental Data for station point-4, of Balu river for November'95 near Demra bazar at Dhaka

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	08. 11. 95	155.4	32.0	6.90	23.0	75.4	-	-
Horizontally 15′ from the River bank (Surface water)	08. 11. 95	155.9	34.0	6.92	25.0	77.7	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	08. 11. 95	157.0	34.0	6.99	26.0	78.4	10.0	0.114
Horizontally 25′ from the River bank (3.5 ft depth)	08.11. 95	157.7	35.0	7.04	28.0	78.7	10.0	0.115

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	6.20
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	7.43
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.000	-	-	-	-	4.5	1.9	10.90
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.004	-	-	-	-	4.5	1.8	13.37

Table-B-5.1.

Experimental Data for station point-5, of Shitalakhya river for September´95 near Demra Ferry Ghat at Dhaka.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	04. 09. 95	93.0	51.0	7.03	45.0	52.6	-	-
Horizontally 15′ from the River bank (Surface water)	04. 09. 95	94.2	51.0	7.06	47.0	52.7	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	04. 09. 95	95.4	53.0	7.06	48.0	53.4	5.0	0.055
Horizontally 25′ from the River bank (3.5 ft depth)	04. 09. 95	96.1	58.0	7.07	48.0	54.2	5.0	0.056

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.8	-	2.73
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.7	-	3.48
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.010	-	-	-	-	4.7	1.0	9.90
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.011	-	-	-	-	4.7	1.0	11.64

Table-B-5.2.

Experimental Data for station point- 5, of Shitalakhya river for October'95 near Demra Ferry Ghat at Dhaka

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	10. 10. 95	97.6	71.0	7.09	40.0	48.8	-	-
Horizontally 15′ from the River bank (Surface water)	10. 10. 95	97.7	72.0	7.25	41.0	48.8	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	10. 10. 95	98.0	83.0	7.28	45.0	48.9	7.0	0.064
Horizontally 25′ from the River bank (3.5 ft depth)	10. 10. 95	98.4	86.0	7.30	52.0	49.0	7.0	0.065

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	6.20
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.5	-	6.20
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.007	-	-	-	-	4.7	1.2	13.12
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.008	-	-	-	-	4.7	1.2	13.12

Table-B-5.3.

Experimental Data for station point- 5 of Shitalakhya river for November'95 near Demra Ferry Ghat at Dhaka

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	08. 11. 95	158.3	29.0	7.14	21.0	79.1	-	-
Horizontally 15′ from the River bank (Surface water)	08. 11. 95	158.8	30.0	7.18	22.0	79.5	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	08. 11. 95	160.6	31.0	7.19	22.0	80.3	8.0	0.125
Horizontally 25′ from the River bank (3.5 ft depth)	08. 11. 95	160.8	31.0	7.21	23.0	80.5	8.0	0.127

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.0	-	6.44
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	7.18
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.031	-	-	-	-	4.3	1.7	13.86
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.028	-	-	-	-	4.5	1.8	15.10

Table-B-6.1.

Experimental Data for station point- 6, of Shitalakhya river for September'95 near Katchpur bridge at Narayangonj.

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	04. 09. 95	86.3	59.0	6.70	36.0	51.9	-	-
Horizontally 15′ from the River bank (Surface water)	04. 09. 95	86.9	59.0	6.70	37.0	52.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	04. 09. 95	87.5	61.0	6.78	42.0	52.0	7.0	0.068
Horizontally 25′ from the River bank (3.5 ft depth)	04. 09. 95	88.1	62.0	6.79	43.0	52.5	7.0	0.069

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.6	-	3.50
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	5.2	-	4.00
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.029	-	-	-	-	5.2	1.7	8.42
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.029	-	-	-	-	5.5	1.8	10.65

Table-B-6.2.

Experimental Data for station point- 6 of Shitalakhya river for October'95 near Katchpur bridge at Dhaka

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	10. 10. 95	100.7	67.0	6.83	46.0	61.7	-	-
Horizontally 15′ from the River bank (Surface water)	10. 10. 95	100.9	67.0	6.85	46.0	61.9	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	10. 10. 95	102.8	76.0	6.86	47.0	63.5	8.0	0.080
Horizontally 25′ from the River bank (3.5 ft depth)	10. 10. 95	103.2	76.0	6.89	47.0	64.1	9.0	0.083

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	7.18
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	7.93
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.035	-	-	-	-	4.3	2.1	10.15
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.034	-	-	-	-	4.1	2.0	12.87

Table-B-6.3.

Experimental Data for station point- 6, of Shitalakhya river for November'95 near Katchpur bridge at Dhaka

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	08. 11. 95	170.8	31.0	6.95	23.0	86.1	-	-
Horizontally 15′ from the River bank (Surface water)	08. 11. 95	171.0	32.0	6.95	23.0	86.3	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	08. 11. 95	172.1	32.0	6.98	23.0	85.3	10.0	0.112
Horizontally 25′ from the River bank (3.5 ft depth)	08. 11. 95	172.7	33.0	6.98	27.0	85.4	10.0	0.111

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.0	-	14.85
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.7	-	16.09
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.054	-	-	-	-	4.6	3.6	18.31
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.057	-	-	-	-	4.7	3.7	19.05

Table-B-7.1.

Experimental Data for station point- 7, of Shitalakhya River for September'95 near Adamji at Narayangonj.

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	12. 09. 95	112.9	31.0	7.14	39.0	50.6	-	-
Horizontally 15′ from the River bank (Surface water)	12. 09. 95	113.3	32.0	7.18	40.0	56.4	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	12. 09. 95	113.5	54.0	7.28	65.0	57.2	5.0	0.086
Horizontally 25′ from the River bank (3.5 ft depth)	12. 09. 95	114.4	55.0	7.28	72.0	57.3	6.0	0.091

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.9	-	3.72
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	4.96
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.014	-	-	-	-	4.5	1.3	7.93
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.017	-	-	-	-	4.6	1.3	8.67

Table-B-7.2.

Experimental Data for station point- 7, of Shitalakhya river for October'95 near Adamji at Narayangonj

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	PH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	15. 10. 95	106.2	28.0	6.78	21.0	53.1	-	-
Horizontally 15′ from the River bank (Surface water)	15. 10. 95	108.3	41.0	6.82	31.0	54.1	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	15. 10. 95	113.1	41.0	6.95	33.0	56.4	8.0	0.128
Horizontally 25′ from the River bank (3.5 ft depth)	15. 10. 95	117.9	54.0	7.00	35.0	56.7	9.0	0.134

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.4	-	5.45
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.3	-	6.20
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.025	-	-	-	-	2.9	1.5	9.16
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.030	-	-	-	-	3.1	1.5	9.40

Table-B-7.3.

Experimental Data for station point- 7, of Shitalakhya river for November'95 near Adamji at Narayangonj

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	19. 11. 95	170.3	43.0	7.15	27.0	85.0	-	-
Horizontally 15′ from the River bank (Surface water)	19. 11. 95	171.2	45.0	7.16	29.0	85.7	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	19. 11. 95	171.9	47.0	7.17	30.0	85.8	10.0	0.224
Horizontally 25′ from the River bank (3.5 ft depth)	19. 11. 95	172.4	47.0	7.19	30.0	86.2	10.0	0.226

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	3.4	-	6.70
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	2.9	-	8.42
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.027	-	-	-	-	2.9	1.7	10.40
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.032	-	-	-	-	2.7	1.7	10.65

Table-B-8.1.

Experimental Data for station point-8, of Buriganga river for September'95 near Hazaribug at Dhaka.

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	PH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	25. 09. 95	132.3	70.0	7.03	71.0	62.5	-	-
Horizontally 15′ from the River bank (Surface water)	25. 09. 95	132.5	71.0	7.04	71.0	62.6	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	25. 09. 95	133.2	72.0	7.06	74.0	62.7	18.0	0.076
Horizontally 25′ from the River bank (3.5 ft depth)	25. 09. 95	133.6	72.0	7.02	75.0	63.3	18.0	0.084

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4,9	-	5.20
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	7.65
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.020	-	-	-	-	4.5	1.5	12.38
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.0195	-	-	-	-	4.5	1.5	14.11

Table-B-8.2.

Experimental Data for station point-8 of Buriganga river for October'95 near Hazaribug at Dhaka

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	30. 10. 95	164.3	46.0	7.06	47.0	84.6	-	-
Horizontally 15′ from the River bank (Surface water)	30. 10. 95	165.6	45.0	7.07	43.0	82.8	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	30. 10. 95	165.9	52.0	7.07	52.0	82.5	18.0	0.093
Horizontally 25′ from the River bank (3.5 ft depth)	30. 10. 95	165.4	65.0	7.10	67.0	83.1	19.0	0.090

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	9.90
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	9.90
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.020	-	-	-	-	4.5	1.8	12.38
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.0195	-	-	-	-	4.5	1.9	13.86

Table-B-8.3.

Experimental Data for station point-8, of Buriganga river for November'95 near Hazaribug at Dhaka

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	27. 11. 95	242.0	84.0	7.11	29.0	124.0	-	-
Horizontally 15′ from the River bank (Surface water)	27. 11. 95	244.0	84.0	7.12	29.0	123.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	27. 11. 95	244.0	88.0	7.12	33.0	122.0	21.0	0.104
Horizontally 25′ from the River bank (3.5 ft depth)	27. 11. 95	246.0	96.0	7.13	46.0	122.0	21.0	0.114

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	12.38
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.4	-	12.87
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.018	-	-	-	-	4.8	2.5	15.59
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.019	-	-	-	-	4.9	2.5	17.00

Table-B-9.1.

Experimental Data for station point-9, of Buriganga river for September,95 near Hazaribug at Dhaka.

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	25. 09. 95	120.3	51.0	7.15	49.0	60.2	-	-
Horizontally 15′ from the River bank (Surface water)	25. 09. 95	120.7	51.0	7.19	50.0	60.3	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	25. 09. 95	121.0	54.0	7.21	49.0	60.4	22.0	0.053
Horizontally 25′ from the River bank (3.5 ft depth)	25. 09. 95	127.8	65.0	7.23	53.0	60.4	23.0	0.055

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	2.5	-	151.84
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	2.3	-	152.82
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	1.9	144.0	230.00
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	-	-	-	-	-	1.7	138.0	227.75

Table-B-9.2.

Experimental Data for station point-9, of Buriganga river for October'95 near Hazaribug at Dhaka

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	30. 10. 95	860.0	144.0	7.40	175.0	215.0	-	-
Horizontally 15′ from the River bank (Surface water)	30. 10. 95	857.0	118.0	7.41	180.0	217.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	30. 10. 95	863.0	128.0	7.43	187.0	220.0	55.0	0.158
Horizontally 25′ from the River bank (3.5 ft depth)	30. 10. 95	867.0	128.0	7.44	192.0	225.0	57.0	0.159

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.4	-	160.50
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.4	-	163.21
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.103	-	-	-	-	1.5	150.0	239.37
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.104	-	-	-	-	1.5	150.0	244.07

Table-B-9.3.

Experimental Data for station point-9, of Buriganga river for November'95 near Hazaribug at Dhaka

Sample Location/Station	Date	Conductivity (ms)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	27. 11. 95	1.34	157.0	7.58	190.0	470.0	-	-
Horizontally 15′ from the River bank (Surface water)	27. 11. 95	1.35	158.0	7.60	191.0	472.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	27. 11. 95	1.36	159.0	7.61	194.0	489.0	85.0	0.259
Horizontally 25′ from the River bank (3.5 ft depth)	27. 11. 95	1.36	160.0	7.62	195.0	528.0	90.0	0.260

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.3	-	183.60
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.3	-	197.00
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.196	-	-	-	-	1.1	162.0	265.05
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.197	-	-	-	-	1.1	162.0	266.08

Table-B-10.1.

Experimental Data for station point-10, of Buriganga river for September'95 near Pagla bazar at Narayangonj.

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	P^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	12. 09. 95	152.9	17.0	7.10	18.0	76.5	-	-
Horizontally 15′ from the River bank (Surface water)	12. 09. 95	152.8	18.0	7.11	21.0	76.6	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	12. 09. 95	152.9	27.0	7.11	34.0	76.6	10.0	0.176
Horizontally 25′ from the River bank (3.5 ft depth)	12. 09. 95	153.1	28.0	7.12	43.0	76.7	10.0	0.182

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	9.29
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.1	-	6.26
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.037	-	-	-	-	4.6	2.5	14.60
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.035	-	-	-	-	4.5	2.4	15.10

Table-B-10.2.

Experimental Data for station point-10, of Buriganga river for October'95 near Pagla bazar at Narayangonj

Sample Location/Station	Date	Conductivity (µs)	Turdidity (FTU)	pH	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	15. 10. 95	135.1	17.0	7.12	12.0	67.5	-	-
Horizontally 15′ from the River bank (Surface water)	15. 10. 95	135.3	18.0	7.12	12.0	67.7	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	15. 10. 95	135.4	22.0	7.19	17.0	67.8	9.0	0.185
Horizontally 25′ from the River bank (3.5 ft depth)	15. 10. 95	135.6	22.0	7.20	18.0	71.4	11.0	0.186

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.2	-	10.90
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	4.3	-	9.40
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.034	-	-	-	-	4.4	3.2	17.60
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.033	-	-	-	-	4.2	3.2	18.31

Table-B-10.3.

Experimental Data for station point-10, of Buriganga river for November'95 near Pagla bazar at Narayangonj

Sample Location/Station	Date	Conductivity (μs)	Turdidity (FTU)	p^H	TSS (mg/L)	TDS (mg/L)	SO_4^{-2} (mg/L)	PO_4^{-3} (mg/L)
Horizontally 5′ from the River bank (Surface water)	19. 11. 95	217.0	30.0	7.01	21.0	108.0	-	-
Horizontally 15′ from the River bank (Surface water)	19. 11. 95	217.0	32.0	7.03	21.0	108.0	-	-
Horizontally 15′ from the River bank (3.5 ft depth)	19. 11. 95	218.0	37.0	6.99	25.0	111.0	14.0	0.203
Horizontally 25′ from the River bank (3.5 ft depth)	19. 11. 95	230.0	40.0	7.05	26.0	121.0	13.0	0.209

Sample Location/Station	NO_3^- (mg/L)	Cl^- (mg/L)	Cr^{+6} (mg/L)	Cr^T (mg/L)	Fe^T (mg/L)	Pb (mg/L)	NH_4^+ (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Horizontally 5′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.5	-	17.82
Horizontally 15′ from the River bank (Surface water)	-	-	-	-	-	-	-	1.8	-	17.32
Horizontally 15′ from the River bank (3.5 ft depth)	-	-	0.043	-	-	-	-	3.9	5.0	18.80
Horizontally 25′ from the River bank (3.5 ft depth)	-	-	0.046	-	-	-	-	3.4	5.5	19.80

APPENDIX-C

SPECTROPHOTOMETRY

Colorimetric and spectrophotometric methods are the most frequently used and important methods of quantitative analysis. They are based on the absorption of visible light or other radient energy by a solution. The amount of radient energy absorbed is depended the amount of material present in the solution. By measuring the absorption of light or other radient energy it is possible to determine quantitatively the amount of absorbing substance present.[18]

Usually these methods are used to determine quantitatively small amounts of a substance. Methods based on the absorption of light are well suited to the determination of sample constituents from traces up to amounts of one or two percent, but they are not as frequently used for the analysis of larger quantities of substance.[18]

Spectrophotometric methods are not limited to the use of visible light but include those that employ radient energy in other portions of the electromagnetic spectrum, such as the UV or infrared. colorimetry is a fairly general term that is frequently used to include spectrophotometric procedures carried out with visible light.[18]

There are two major ways of analyzing spectrophotometrically. One is to make use of the natural color of an ion or compound. The other is to make use of the ultraviolet and infrared rediation for the spectrophotometric determination of substances (especially organic substances) that are not visibly colored (and therefore do not appreciably absorb visible light) but do absorb strongly in the UV or infrared spectral regions. Ions or molecules that have little or no natural color can be determined spectrophotometrically after reaction with a suitable reagent that converts them to a highly colored product.[18]

QUANTITATIVE CALCULATIONS BY BEER'S LAW[17]

The fundamental law on which spectrophotometric methods are based on the Bouguer-Beer or Beer-Lambert law, which is often referred to simply as *Beer's law*. Consider the absorption of monochromatic light as in the following figure:

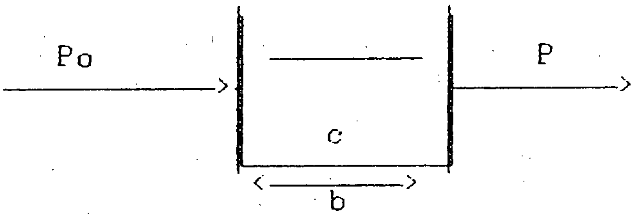

Fig: Absorption of light

Incident light of radient energy P_o passes through a solution of an absorbing species at concentration c and path length b and the emergent light has radiant energy P. This radient energy is the quantity measured by spectrophotometric detectors. Bouguer in 1729 and Lambert in 1760 recognized that when light is absorbed, the energy of the transmitted light decreases exponentially, which can be written as:

$$T = P/Po = 10^{-kb}$$

where k is constant and T is called the *transmittance*, the fraction of light transmitted. This can be put in logarithmic terms:

$$\log T = \log P/P_o = -kb$$

In 1852, Beer and Bernard each stated that a similar law holds for the dependence of T on the concentration:

$$T = \log P/P_o = 10^{-k'c},$$

where k′ is a new constant, or

$$\log T = \log P/P_o = -k'c.$$

Combining these two laws, we have "Beer's" law, which describes the dependence of T on both the path length and concentration,

$$T = P/P_o = 10^{-abc},$$

where a is a combined constant of k and k′ and

$$\log T = \log P/P_o = -abc.$$

It is more convenient to omit the negative sign on the right-hand side of the equation and to define a new term, *absorbance:*

$$A = -\log T = \log 1/T = \log P_o/P = abc,$$

where A is the absorbance. This is the form of Beer's law.