Study on physico-chemical properties of rain water, ground water and pond water in KUET premises.

By

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Philosophy in Department of Chemistry

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Declaration

This is to certify that the thesis work entitled "Study on Physico-Chemical Properties of rain water, ground water and pond water in KUET premises." has been carried out by Md. Aminur Rahman in the Department of Chemistry, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

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To

My Beloved Parents

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Abstract

Six samples of pond water, four samples of rain water and four samples of ground water were collected from the KUET premises. The sampling of pond water has been made during the period Nobember, 2013 to April 2014, while the rain water samples were collected during the late rainfall in the month of September. The rain samples were mounted 1.5 meters above the ground to avoid rain splash as recommended Pond water samples were collected by grab-sampling method. All samples were filtered and preserved at 20° C. Some water parameters such as Alkalinity, Hardness, TDS, Arsenic, pH, Turbidity, Conductivity & Salinity were measured.

Four tube well water samples were collected from different location of KUET residential area. The pH of tube well water ranged from a minimum of 7.79 to a maximum of 8.2 of TW_3 (Tube well water, collected from building no 12) and TW_1 (Tube well water, School gate KUET) respectively. Similarly the variation of pH of pond water ranged from a minimum of 8.40 to a maximum of 8.87 of PWL1 (Pond water lower Position, Rokaya hall) and in rain water the maximum value was 6.77 of RWJ_1 (Rain water from jessore urban) and the minimum value was 6.34 of RWC (Rain water collected from Chittagong) respectively. The values of conductivity for all tube well water were found to be greater than those of pond water and rain water. In present observations the conductivity for tube well water ranges from 1021 to 1598 μs/cm, for pond water ranges 324 to 732 μs/cm and for rain water ranges from 13 to 80 μs/cm. It indicates that the tube well water contain larger quantity of dissolved mineral salts. In case of pond water the conductivity is also significantly change during winter season and rainy season.

The total dissolved solids (TDS) of tube-well water ranged from a minimum of 551 mg/L to a maximum of 887 mg/L of TW_1 (Tube-well, School gate) and TW_4 (Tube well water, collected from building no 19) respectively. Similarly the variation of total dissolved solids of pond water ranged from a minimum of 175 mg/L to a maximum of 399 mg/L of PWL_1 (Pond water, lower Position Rokaya hall) and PWL_2 (Pond water, lower Position power plant side pond) and for rain water ranged from a minimum of 6 mg/L to a maximum of 40 mg/L of RWC (Rain Water, Collected from Chittagong) and RWK (Rain Water, Collected from Khulna) respectively. This high values of TDS (Total dissolved solids) specially in Tube well water are mainly due to carbonates, bicarbonates, chlorides, phosphates and

nitrates of calcium, magnesium, sodium, potassium and manganese. The variation in total alkalinity of tube-well water ranged from a minimum of 496.66 mg/L to a maximum of 508.33mg/L of TW_2 (Tube well water, collected from building no 5) and TW_3 (Tube well water, collected from building no 12) respectively. Similar variation in total alkalinity of pond water ranged from a minimum of 83.33 mg/L to a maximum of 131.66 mg/L of PWL_1 (Pond water, lower Position Rokaya hall) and PWU_3 (Pond water, collected from upper Position Khan Jahan Ali Hall) respectively.

Tube-well water samples have found the iron content and the results varied from 16.78 – 27.97 ppm. No tube-well was found having the iron content within the maximum permissible limit of 1.0 ppm. Lead and cadmium concentration in the rain water was found below the detectable limit. Arsenic was investigated to all tube well water and found below 0.02 ppm that is within acceptable limit.

Contents

Chapter I	**Introduction**		Page
	1.1	Background	1
	1.2	Water resources in Bangladesh	4
	1.3	Major water Pollutants and It's Impacts	6
	1.4	Causes of Lack of Safe Drinking Water	7
	1.4.1	Lack of aquifer	7
	1.4.2	Cultivation of brackish water shrimp	7
	1.4.3	Reduction in upstream flow	7
	1.4.4	Excessive use of underground water in an unplanned way	8
	1.4.5	Natural disasters	8
	1.5	Effects of Lack of Safe Drinking Water	9
		Aim of Thesis	11
Chapter II	**Literature Review**		
	2.1	Background	12
	2.2	Safe Drinking Water Options	14
	2.3	*Low-Tech/Low-Cost Drinking Water Solutions*	14
	2.3.1	*Rain Water Harvesting*	14
	2.3.2	Excavating or Renovating Ponds	15
	2.3.3	Pond Sand Filter	15
	2.3.4	Rooftop Catchment Areas	15
	2.3.5	Plastic sheets with a hole	15
	2.3.6	Shallow and Deep Tube-wells	15
	2.4.1	Others	16
	2.4.2	Present water management situation in Khulna	16

Chapter III **Experimental**

3.1	Sampling	18
3.2	Determination of pH	18
3.3	Total dissolved solids	19
3.4	Electrical conductivity	20
3.5	Dissolved oxygen	21
3.6	Salinity	21
3.7	Alkalinity	23
3.8	Determination of iron	23
3.9	Turbidity	25
3.10	Total Hardness	26
3.11	Arsenic test	26
3.12	Cadmium (Cd)	27
Summary of Analysis Method (Table)		29

Chapter IV **RESULTS & DISCUSSION**

4.1	pH	30
4.2	Conductance	31
4.3	Total Dissolved Solid (TDS)	33
4.4	Salinity	34
4.5	Alkalinity	34
4.6	Hardness	35
4.7	Dissolved Oxygen (DO)	36
4.8	Iron, Lead and Cadmium	37
4.9	Arsenic	37

Figure1: pH values of various water samples collected in different sources 30

Figure2: Conductance(μs/cm) values of various water samples collected in different sources 32

Figure3: TDS(mg/L) values of various water samples collected in different sources 33

Figure4: Salinity(ppt) values of various water samples collected in different sources 34

Figure5: Alkalinity(mg/L) values of various water samples collected in different sources 35

Figure6: Hardness(mg/L) values of various water samples collected in different sources 36

Figure7: DO(mg/L) values of various water samples collected in different sources 37

Figure8: Iron(mg/L) values of various water samples collected in differen sources 38

Table 1. Physico-chemical properties of pond water 15/11/2013 39

Table 2. Physico-chemical analysis of pond water 29/04/2014 40

Table 3. Physical-chemical analysis of tube-well water 40

Table 4. Physical-chemical analysis of rain water 41

Picture no1: Rokaya Hall Pond(PW1) 42

Picture no2: Plant Side Pond (PW2) 43

Picture no3: Khanjahan Ali Hall pond (PW3) 44

Chapter V Conclusion 45

References **47-49**

Chapter I

Introduction

1.1 Background

Water is essential to life. There are many different types of water depending on its sources and processes. All water is different, meaning water will have different elements in various concentrations.

Qualities of Water:

- Water is vital to all known forms of life, and is essential to living a healthy lifestyle.
- Your body uses water to hydrate, lubricate, and cleanse. The kidney is the body's filter and uses water to rinse and flush the excess minerals and contaminates from the body.
- Although over 70% of the earths surface is covered by water, only 3% of the earths water is fresh water and of that only a marginal percentage is considered fit for drinking

In the water industry, good bottled water is typically water that has been processed and has a TDS (Total Dissolved Solid) content of less than 100 parts per million of TDS. Less than 50 Parts per million is of good quality, between 50ppm and 100ppm the water would be described as becoming thicker. Above 100 parts per million would be leaving the bottle quality boundaries, even though there are no standards in the water industry for bottled water. One can definitely taste the difference.

One common misconception is; What about the minerals? Pure water doesn't have any, or pure water will leech all the minerals from the body. Your body gets over 98% of its minerals from a good healthy diet, that means not eating at fast food restaurants (if that is really what you call a restaurant).

Important factors of healthy Water:

- Nothing should be in water but water, plain & pure H2O!
- No Minerals, No Fluoride!
- Neutral PH
- Lowest TDS (Total Dissolved Solids)

Try placing a bowl of reverse osmosis water down for the dog to drink. Put a bowl of tap water and see which water next to it and see which bowl the animal drinks. It works every time!

Be healthy - drink lots of water. Typically water from the tap does not taste great, so most people drink sodas, juice etc. If you have good tasting water available, you will drink more water and less sodas. As a result you have saved money on unhealthy drinks and became healthier by drinking more water. The average person does not drink enough water throughout the day.

With the right filtration equipment you can have the health benefits of pure water from your kitchen tap. Pure water can be used for drinking, cooking, crystal clear ice cubes and provide good healthy water for your pets. Your house plants will love it, too.

The most economical process for high quality water is reverse osmosis. There are several ways to obtain reverse osmosis water. It has been calculated that with a household of four people or more it is more economical to own or rent a under the sink point of use reverse osmosis drinking system. If less than four people it is more economical to go to the local water store and pre-pay for water discounts and fill your bottles at fill stations provided. Both options are available on the water store.

Distillation is another effective process to produce pure drinking water. Usually distilled water does not taste very good, and is described as dead water due to the fact the oxygen has been remove during the distillation process. At the Water Store 80% of the drinking water we sell is distilled. The distilled water is treated by ozone to disinfect and oxygenate the water and brings back the body and life to the water. The water is then filtered through a coconut carbon filter for great tasting pure water. Distillation is a very hard process to do at home and home distillers are not capable of duplicating the water stores process just described.

Water is one of the most essential natural resources for eco-sustainability and is likely to become critical scarce in the coming decades due to increasing demand, rapid growth of urban populations, development of agriculture and industrial activities especially in low lying area like Khulna, as the water level is within 200ft. Variations in availability of water in time, quantity and quality can cause significant fluctuations in the economy of a country. Hence, the conservation, optimum utilization and management of this resource for the betterment of the economic status of the country become paramount [1]. The definition of water quality is very much depending on the desired use of water. Therefore, different uses require different criteria of water quality as well as standard methods for reporting and comparing results of water analysis [2]

The term 'water quality' is a widely used expression which has an extremely broad spectrum of meanings. Each individual has vested interest in water for his particular use, which may include commercial and industrial uses or recreational pursuits. Since the desired characteristics of water vary with its intended use, there is frequently unsatisfactory communication among the users of water where quality is concerned. Thus in discussing a public water supply, a housewife may declare the water to be of good quality, while a brewer considers the water quality to be poor. All other water uses must be subordinated to man's need for a helpful fluid for his consumption.

The water quality in ponds, tube-well and rain may vary depending on the geological morphology, vegetation and land use (modification by human activities such as agriculture, industrialization and urbanization) in the catchment. Industries, agriculture and urban settlements produce nutrients (sewage effluent and fertilizers) and toxic substances, such as organic and inorganic pollutants, and other chemicals including heavy metals. Water pollution occurs when these substances, which degrade the water quality of river, enter the waterway and alter their natural function. Where ponds and lakes have been profoundly altered and have lost much of their value, the scientific understanding of these water bodies is being used in prescribing restoration methods [3]

Water for drinking and food preparation must be free from minerals and organic substances that can produce adverse physiological effects. To encourage man to drink this health-promoting liquid, the water must be aesthetically acceptable. For example, it should be free from apparent turbidity, color and odor and any objectionable taste. Drinking water should also have a reasonable temperature. Such water is termed "potable," meaning that it could be consumed in any desired amount without concern for adverse health effects. Potable water is thus defined as water that is free from disease producing microorganisms and chemical substances deleterious to health [4]. The provision of potable water to the rural and urban population is necessary to prevent health hazards. Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is palatable and safe for drinking [4] .

1.2 Water resources in Bangladesh

Bangladesh is well endowed in water resources. Lying at the confluence of the world's second largest river system formed by three mighty rivers – the Ganges (locally known as Padma), Brahmaputra, and Meghna, the country is the world's largest deltaic plain that comprises an intricate network of over 250 rivers. In an average year, these rivers together pass nearly 1.36 trillion cubic meters of water second on earth only to the Amazon [5]. Besides surface water, ground water is also plentiful in Bangladesh due to the monsoon rains, which exhibit large regional and seasonal variations. Average annual rainfall varies from a high of nearly 5800 mm in the northeastern region to a low of about 1200 mm in the western region. The monsoon period between June and September gets about 85% of the annual rainfall, while the dry period between November and March usually remains rainless [6]. During most monsoon periods, as much as 60% of the country's cultivable area is flooded to some extent through river overflows and accumulation of direct rainfall. Disaster strikes if heavy rainfall is coupled with the peak flows in the major rivers, otherwise it is regular monsoon inundation that the rural farmers eagerly await. The water control problems confronting the Bangladesh agriculture therefore are twofold: smoothing the uneven seasonal distribution of water and containing the seasonal rage of the mighty rivers.

The significance of effective utilization of water resources to the heavily agrarian Bangladesh economy can hardly be over-emphasized. The Bangladesh agricultural sector has been able to achieve steady increases in food grain production in recent years due to a number of factors, such as more intensive use of fertilizers and high-yielding seed varieties, improved distribution of rural credit networks, and, most importantly, improved irrigation and flood control facilities. Reduced flooding and water storage by the flood control projects have generated significant agricultural benefits. Agricultural production, especially of rice, has increased notably due to the availability of more dry land during the monsoon season and irrigation facilities during the dry season, which have made as many as three annual harvests possible. Flood control projects have also protected the rural networks of roads and railways from annual inundation and thus helped sustain the flow of economic and commercial transactions. Improved infrastructure facilities have created year around transportation jobs, while increased agricultural production have created more farming, storage, and transportation activities generating more rural employment. It is estimated that flood control and irrigation facilities have typically led to a 30 to 50% per hectare increase in agricultural employment [5]

Alike all developing countries, safe water is an important national issue for Bangladesh a country with an approximate population density of 900/km^2. Two decades ago, for Bangladesh, surface water was the only freshwater source. However, over this time, in liaison with its development partners, the country became successful in providing groundwater-based, microbial-free water supply through network of shallow and deep tube wells. Bangladesh, with an acre of water body for every eight persons, has one of the highest man–water ratios in the world. Surface water bodies, e.g., ponds and tanks, almost evenly distributed throughout the country, comprise 336,000 acres, which is about 10% of the total inland water area [5]. Even after the remarkable success with hand pumped and piped water, use of unsafe water is still in common parlance as manifested by the fact that water-related diseases remained the major cause of mortality in Bangladesh [7-8].

Bangladesh is largely dependent on groundwater for drinking and irrigation uses, and 90% of drinking water is abstracted from aquifers [9]. Therefore, any contamination (natural or man-made) to this natural resource will bring about a serious disaster to the overall socioeconomic environment of Bangladesh. The salinity problem in southwest Bangladesh and the recently identified arsenic problem in groundwater almost over all of Bangladesh has been a matter of concern to the nation.

The mean annual rainfall (1989–1998) in the Khulna and Mongla port areas is ≈ 1961 mm compared with a potential evaporation rate of 1561 mm. About 87% of the rainfall occurs during the wet period (May to October) and the rest during the dry period (November to April). The mean maximum temperature both at Khulna and Mongla is 35 C whereas the minimum is 11 and 14 C respectively. The surface lithological distribution of the area is deltaic deposits which are comprised of tidal deltaic deposits, deltaic silt deposits and mangrove swamp deposits [10]. The subsurface lithological distribution is characterized by a heterogeneous mixture of sand, silt and clay.

1.3 Major water Pollutants and It's Impacts

(a) Liquid : Oil, Lubricants, grease, TBT,

Harmful effects:

(i) Coating and asphyxiation, (ii) Reduction of light intensity and oil coating inhibits photosynthesis; reduce exchange of oxygen and carbon dioxide, (iii) Damage of bird population, coating the feathers by oil, causes buoyancy and insulation losses. (iv) Acute toxicity: Sometimes spillage may cause wide spread mortality amongst the population of fish, worms, crabs and mollusk.

(b) Metals: Mercury, Copper, Lead, Cd , Fe etc.

Harmful effects:

(i) Mental disorders, Nervous system break down (e.g. Minamata disease, Itai itai disease in Japan), (ii) Anemia, Kidney disorder, sterility & carcinogenic,

(c) Gaseous: CO_2, CO, SO_2 ,Cl_2 ,NH_3 Acid fumes, Isocyanide

Harmful effects:

(i) Increases of toxic gases in air, (ii) Adverse impact on human beings (e.g. Asthma & other respiratory diseases)

(d) Solids: PAHs.,PCBs, PVC, Plastic materials, Glass wool, Asbestos etc

Harmful effects:

(i) PAHs: Cause malignant tumors, interfere with enzymatic breakdown affecting the lungs, stomach, intestines and skin. Highly toxic and bioaccumulate in the environment,

(ii) Dioxins: Carcinogenic, can suppress the immune system. Suspected of prenatal and post natal affects on children's nervous system.

(iii) PCBs: Have been linked to cancer, liver damage, reproductive impairments and system damage. Highly biomagnified & persistent in the higher trophic level of marine food chain,

(e) Harmful Microbes : Pathogenic bacteria and viruses and its adverse impacts on fishery resources and human health.

1.4 Causes of Lack of Safe Drinking Water

1.4.1 Lack of aquifer

Ground water occurs in permeable geological formations known as aquifers. For extraction of groundwater medium clean sand is suitable. This sand has considerable porosity and permeability and can store a huge amount of water. Fine sand also can store a considerable amount of water. However, as the position of the area is in the lower part of Ganges delta the sediments of the region have very low permeability and are not able to store water. As a result, the region lacks aquifer that fresh groundwater can be extracted from.

1.4.2 Cultivation of brackish water shrimp

In the southwest region shrimp cultivation is underway in almost all the wetlands. In most of the cases, salt water from the river is brought into the wetland for shrimp cultivation, which is increasing the salinity of the adjacent fresh water ponds and shallow aquifer through seepage [11]

Thus there is great scarcity of drinking water in areas where shrimp is cultivated and that covers greater portion of southern districts of this region. This shortage of drinking water affects women the most, as it is their responsibility to collect drinking and cooking water for the household. They have to walk several kilometers to obtain drinking water, wasting much of their time that they could have used in productive employment.

1.4.3 Reduction in upstream flow

In the past the southwest coastal region was rich in fresh water as the Ganges had flowed through it. However, the scenario changed following two disastrous events: the change of the course of the river Ganges due to Ganga water distribution Treaty, commonly known as Farakka Treaty due to which only 27500 thousand cusec water becomes available for Bangladesh during the dry period with the remaining amount being diverted by India) and the closing of the face of the origin of the river MathaVanga [12]. This had a serious implication for safe drinking water available from ground water sources. The reduction of upstream flow deteriorates the recharge rate of the ground water table, reduced fresh water bodies and results in over extraction of groundwater for irrigation and use of water from fresh water ponds.

1.4.4 Excessive use of underground water in an unplanned way

Since the 1980s vast land in the southwest coastal region, except the slight saline wetland, has been brought under irrigation for cultivation of Boro rice through extraction of underground water in the dry season [13]. The lack of surface water for irrigation during dry season has compelled the farmers to exploit underground water extensively resulting in a lowering of underground water table beyond the suction limits of shallow tube-well, making millions of shallow tube-wells dysfunctional. This over-extraction of groundwater is one of the possible reasons for the contamination of shallow aquifer by arsenic.

1.4.5 Natural disasters

Due to geographical disadvantage, this southwestern region of Bangladesh regularly experiences natural disasters (e.g. water logging, cyclones, tidal surges, floods, river erosion, etc) which are responsible for the destruction of drinking water sources. In addition, effects of climate change have caused hazards in this region to occur more frequently than before and with greater intensity. During cyclone Sidr in late 2007 the majority of drinking water sources became dysfunctional. Under the Sidr rehabilitation programs water supply and sanitation facilities were restored by various government and non government agencies. However, the majority were again damaged by the recent cyclone Aila [14].

Gabura is one of the victim union of Shyamnagar where most of the drinking water sources damaged during cyclone Aila. The people of the area received the highest amount of sufferings from drinking water shortage. Aila devastated all the drinking water sources (ponds and tube wells). During Aila, high tidal surges contaminated all fresh water sources with polluted saline water. Many people were compelled to drink such polluted water as they do not have any other option and consequently suffer from water borne diseases such as allergy, skin diseases, cholera and diarrhea. The sea level of this region is raising 3-4 ml per year and it creates new salinity affected areas, which creates further scarcity of drinking water [13].

1.5 Effects of Lack of Safe Drinking Water

The effects of scarcity of safe drinking water in south-western region can have health, social and financial implication. People in the region suffer from various diseases caused by drinking an insufficient amount of water and drinking water with high levels of salinity, impurity or arsenic contamination. Various skin diseases, intestinal diseases, dysentery, fever and diarrhea are part of life. Other health concerns linked to a lack of safe drinking water include malnutrition amongst women and children, reproductive problems for pregnant women, skin turning black, physical weakness and anxiety. Women can be particularly susceptible to diseases (e.g. rickets) as they are expected to take less water than men.

Women and girls face a number of rights abuses as a direct result of the lack of safe drinking water. In rural Bangladesh it is the women`s role to collect drinking water. The drinking water can be many kilometers from the home and there are frequent incidents of violence against women and girls for not fetching drinking water on time or not having meals prepared because of the amount of time it takes to fetch water. Fetching water means women do not have time to tend to their homestead garden, which is often their only source of productivity and income.

There are other social crises associated with poor access to safe drinking water: the education of children is hampered; young children are often left unattended when their mother goes to fetch water; they are frequent incidents of child labour; the household has less time to socialise and develop social networks; women are teased and harassed on their way to fetch water social stigma prevents girls getting married and leads to an increased rate of divorce; population migration; and local contentions and litigations related to water use have become a regular phenomena.

Gathering drinking water means a significant amount of productive hours is consumed. Household expenditure increases to purchase fresh water to enable cultivation of crops. Cost of buying vegetables increases whilst the durability of houses is reduced and scarcity of food occurs. Maintaining livestock and poultry become difficult. Scarcity of organic fertilizer makes carrying out agricultural activities difficult. All these factors together constitute a major economic problem for the poor people.

Pollutants such as nutrients and pesticides may bind with suspended solids and settle in bottom sediments where they may become concentrated. Suspended sediments can also smother aquatic plants as they settle out in low flows, and clog mouthparts and gills of fish and aquatic macroinvertebrates. High turbidity affects submerged plants by preventing sufficient light from reaching them for photosynthesis. High turbidity also has the capacity to significantly increase water temperature. Water temperature needs to remain fairly constant so aquatic fauna can survive.

Usually lead in drinking water originated between the water main in the street and the household faucet. Most lead in drinking water comes from lead lined pipes, lead solder and brass plumbing fixtures inside the apartment. The EPA estimates that 98% of all homes have pipes, fixtures or solder joints in the household plumbing that can contribute some level of lead to the tap water (National Research Council Staff). Exposure to lead is very dangerous for young children compared to an adult. This is because young children's growing rate is much higher than an adult. Lead can accumulate in human body over some time and cause serious damage to brain, kidney, nervous and red blood cells. For infants, large amount of lead can cause delays in physical and mental development like nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure in short period of time. In a lifetime exposure to cadmium at levels exceed 0.005 mg/L can cause kidney, liver, bone and blood damage

Lead is determined by atomic absorption spectrophotometry in conjunction with a graphite furnace containing a graphite platform. A sample is placed on the graphite platform, and a matrix modifier is added. The sample then is evaporated to dryness, charred, and atomized using high-temperature ramping. The absorption signal produced during atomization is recorded and compared with standards.

Aim of the Thesis

The objective of the present work is to utilize the collected rain water as drinking water. Pollution is occurred due to presence of oxides of Sulpuer, oxides of Nitrogen, Oxides of Carbon which are present in the atmosphere and other gases. As the concentration of these gases in the atmosphere increases the PH of rain water decreanes which indicates pollution of the area. Therefore the specific aim of the project are-

i) To design a pilot plant for effulent treatment.

ii) To reduce the contamination.

iii) To reduce the physic-chemical phenomenon from the rain water.

iv) To collect the rain water from different places and different pots.

v) To investigate physic-ckemical properties of collected water.

Chapter II

Literature Review

2.1 Background

The quality of water in south-west coastal regions of Bangladesh have been experiencing acute shortage of safe drinking water and increase in salinity intrusion in surface and ground water over the past few years. Khulna, the third largest city, with a population of about 1.5 million is also located in this region. The city has been identified as one of the 15 most climate change vulnerable cities of the world [15]. Cyclone, storm surge induced flooding, riverine coastal flooding, water logging, salinity intrusion and coastal erosion are the main climate and hydrologic hazards in the area. The cyclones "Sidr" in 2007 and "Aila" in 2009 caused widespread damage to property and havoc to people's livelihood. Commissioning of the Farakka Barrage on the Ganges River in India in 1975 has reduced the fresh water inflows to the region. Furthermore, construction of the coastal polders has gradually reduced the flood-plain storage areas for tidal waters from the Bay of Bengal.People have started migrating to the peri-urban and urban areas of Khulna as the opportunity for livelihood in rural areas have decreased due to climatic and hydrologic hazards.

Sea level is projected to rise between the present (1980-1999) and the end of this century (2090-2099) by 35 cm (23 - 47 cm) in the A1B scenario [16]. However, the distribution will not be uniform due to ocean density and circulation changes. The rise along the Bangladesh coast could be 0 - 5 cm more than the global average. Existing literature indicate that the spatial coverage and temporal duration of salinity would increase due to this sea level rise. The 5 ppt isohaline could move about 9 km farther inland during the dry season due to a sea level rise of 32 cm [17]. The inundated area could also increase by about 11% due to the rise of sea level by 88 cm. About 84% of the Sundarbans could be deeply flooded under such scenario and the mere sustenance of the Sundarbans could be at risk. Thus, any change in climate induced by global warming and dimming could further aggravate the already fragile agro-ecosystem of the region and worsen the poverty situation.

In addition, the added effects of climate change have caused hazards in this region to occur more frequently than before and with greater magnitude. The scientific evidence indicates that increased sea surface temperature with climate change will intensify cyclone activity and heighten storm surges. Surges will be further elevated by rising sea level as thermal expansion and ice caps continue to melt. Hence, the effects of climate change, increase in sea surface temperature and sea-level rise, are likely to exacerbate Bangladesh`s vulnerability to cyclones. Larger storm surges threaten greater future destruction, because they will increase the depth of inundation and will move further inland - threatening larger areas than in the past [18].

Levels of water salinity have a clear seasonal pattern [19] due to rainfall patterns and upstream withdrawal of freshwater (owing to the operation of the Farakka Barrage, which the Indian government uses to regulate flow on the Ganges) during the drier months. Since 1948, river salinity in the southern districts of Patuakhali, Pirojpur, Barguna, Satkhira, Bagerhat, and Khulna has risen by 45% [20]. Salinity intrusion is likely to increase in the future because of further reduced river flows, increased upstream withdrawal, and longer term climate change–induced decreases in dry season rainfall and sea-level rise.

The coastal population of Bangladesh relies heavily on rivers, tube wells (groundwater), and ponds for washing, bathing, and obtaining drinking water. Domestic ponds, which take up 10% of the total land area (excluding rice paddies), are primarily rain fed but can also, mix with saline water from rivers, soil runoff, and shallow groundwater [19]. Approximately 20 million people living along the coast are affected by varying degrees of salinity in drinking water obtained from various natural sources. Salinity has gradually increased due to the capillary action resulting in reduced fertility of agricultural land and drying of rivers due to the increasing levels of silt on their beds. The presence of salt water in the rivers upstream of the estuaries makes the use of groundwater near the river problematic, as there is a risk that salt water will be drawn into the aquifer. The sea level of this region is raising 3-4 ml per year and it creates new salinity affected areas, which creates further scarcity of drinking, water [18]. Moreover, the conversion into unsustainable livelihood of shrimp cultivation is another driving factor to increasing salinity levels. Shrimps are farmed using saline water piped from rivers which not only increases salinity of local water bodies such as ponds and wetlands but can also seep and contaminate drinking water.

The frequent disasters bring saline water inland polluting surface and fresh water points. During cyclone Aila, for instance, the people in Khulna suffered greatly due to drinking water shortage. All drinking water sources such as ponds and tube wells were flooded with high tidal surge. With most tube-wells flooded, many were forced to drink polluted water since they did not have other options and consequently suffered from water borne diseases such as allergy, skin diseases, cholera and diarrhoea.

2.2 Safe Drinking Water Options

According to the paper "Solution Exchange for the Climate and Disaster Risk Reduction Community Consolidated Reply Query: Safe Water for the South West – Experiences; Advice Compiled by Dilruba Haider, Community Facilitator and Shibaab Rahman", which seeked inputs as a part of CDRR Community from officials of various NGOs such as SPS Khulna, ActionAid, UNICEF and DPHE and Government such as CDMP to receive their experiences and lessons learnt on supplying drinking water and sweet water for irrigation in the region, provided insights on existing technologies. These technologies which include both low-tech/low cost and high-tech/high cost drinking water solutions have been implemented by governmental and various non governmental institutions in the coastal areas of the country.[19]

2.3 Low-Tech/Low-Cost Drinking Water Solutions

2.3.1 Rain Water Harvesting

The most common low-tech and low cost technique used by communities is rainwater harvesting (RWH). Rain water harvesting has been modified through different non governmental organizations to provide the needy at affordable costs so as to harvest rain water for drinking purpose. According to the paper, SPS Khulna, for instance, set up concrete tanks which is used as the RWH, costing Tk 15,000 per family while some local earthen containers (namely motka) that cost individual families Tk 1,000. Action Aid installed a RWH system in Khulna, while UNDP's Disaster Response Facility set up rainwater harvesters in areas affected by cyclones AILA and SIDR. According to the paper, the RWH was intervened in western Indian state of Guujrat that helped improve the ground water table. [19]

2.3.2 Excavating or Renovating Ponds

Excavating or renovating ponds on higher ground is another means of producing an access to sweet water for drinking purpose through building strong and high embankments. The Bangladesh Disaster Preparedness Center (BDPC) used this solution in Morrelganj of Bagerhat district, where they re-excavating some derelict ponds.

2.3.3 Pond Sand Filter

This is an alternative and popular option of potable water supply through treatment of surface water in coastal belt and arsenic prone areas for providing domestic water supply. Intervention of PSF by UNICEF and the DPHE was carried out along the coastal belt; however, lack of maintenance caused them to be abandoned. According to the paper, PSF could offer a good solution, if maintained properly. [19]

2.3.4 Rooftop Catchment Areas

"Rooftop catchment areas are set up in roves of homestead and were intervened by Comprehensive Disaster Management Program (CDMP) with DPHE, some of which were implemented in Satkhira", the paper explains. [20]

2.3.5 Plastic sheets with a hole

During disasters, many NGOs provide plastic sheet with a hole to collect rain water when scarcity of water is high. The plastic sheet with a hole in the middle is set by spreading it on four bamboo poles or on thatched roof to collect rainwater. [20]

2.3.6 Shallow and Deep Tube-wells

As per the document, shallow and deep tube-wells generally extract ground water from aquifers with depth of 300ft and 1000 ft respectively. Various NGOs and Government of Bangladesh have implemented such tube-wells in different regions of coastal areas mostly as temporary solutions. [20]

2.4.1 Others

Some other very expensive options like "sky water harvesting" air to water technology (collecting water from vapor), membrane-based water technology, and piping water in from areas that have sweet water sources. All of these options have very high installation costs, but because of the long term usage without any further investment, makes these options worth considering. In Shyamnagar of Satkhira district, Shushilan along with Dhaka University are piloting an initiative that drives rainwater to shallow pockets of aquifer to recharge ground water, which is then drawn through a tube-well. [19]

2.4.2 Present water management situation in Khulna

Local sources said although the government and non-government organizations (NGOs) have already taken a number of measures to address the water crisis, these are still not enough to meet the demand of a large population in the Aila-hit areas. Most of the rivers, canals, ponds and wetlands in the coastal belts particularly Mongla in Bagerhat, Dakope and Koiraupazilas in Khulna, and Shyamnagarupazila in Satkhira district are heavily affected by salinity intrusion. Locals said only very few people have the ability to buy purified water from different water treatment plants or shops, but most of the people could not afford to buy safe drinking water due to financial crisis. Most of the villagers in remote areas have to collect drinking water from distant places. Villagers used to collect drinking water from nearby water ponds as was the case in the village of Tolma under Dumuriaupazila in Khulna. Most of the villagers now depend on tube-wells as the ponds have been contaminated due to salinity intrusion that however is not adequate for them. Surface water as pond water is put in use as drinking water option in many other areas. A water treatment plant has been set up by Prodipan, a local NGO, at Mongla Upazila Parishad Jame Mosque in Bagerhat district in Khulna division. At present, the plant purifies 3,000-4,000 liters of salt water taken from a nearby pond. Government took limited steps with food aid and to pump out saline water from ponds at least one or two from each village with a plan to harvest rain water for domestic use. Embankments were not fully repaired due to inundation of saline water in vast land areas, so pumping out of saline water could not reach every village. People of AILA affected areas used to drink and cook with surface water from pond and Pond Sand Filters (PSF) constructed by the Department of Public Health Engineering (DPHE) of the Government. [20]

Khulna University of Engineering and technology have been constructed numerous dip tubewell in its area. About 50 to 60 households on the average, have been using water from this tubewell. The use of water from this tubewell has the potential to revolutionize the drinking water systems in its areas. The groundwater samples were collected from shallow and deep tubewells that ranged in depth from 20 to 294 m below the ground surface. Pond water samples were collected from the water surface. The water samples were collected after rinsing the bottles with the samples and the bottles were securely sealed and labelled. Aeration during sampling was avoided as far as possible. Electrical conductivity (EC) and pH were determined in the field using portable EC- and pH-meters. [20]

Chapter III

Experimental

3.1 Sampling

Six samples of pond water were collected from the KUET premises. The sampling of pond water has been made during the period November, 2013 to April 2014, while the rain water samples were collected during the late rainfall in the month of September. The rain samplers were mounted 1.5 meters above the ground to avoid rain splash as recommended

Pond water samples were collected by grab-sampling method. All samples were filtered and preserved at 20° C until all chemical parameters were measured and ionic components determined. Four tube well water samples were collected from different location of KUET residential area.

3.2 Determination of pH

A measure of hydrogen ion activity in water, or, in general terms, the acidity of water. pH is measured on a logarithmic scale of 0 to 14, with 7 being neutral. A high pH indicates alkaline (or basic) conditions and a low pH indicates acidic conditions. pH is influenced by geology and soils, organic acids (decaying leaves and other matter), and human-induced acids from acid rain (which typically has a pH of 3.5 to 5.5).

Procedure

i) I have stired the water sample vigorously using a clean glass stirring rod and have Poured a 40mL ±5mL sample into the glass beaker using the watch glass for a cover.

ii) The sample has been let to stand for a minimum of one hour to allow the temperature to stabilize, stirring it occasionally while waiting and have Measured the temperature of the sample and have adjusted the temperature controller of the pH meter to that of the sample temperature. This adjustment should be done just prior to testing. On meters with an automatic temperature control,I have also followed the manufacturer's instructions.

iii) The pH meter has been standardized by means of the standard solutions provided. Temperature and adjustments must be performed.

iv) I have immersed the electrode(s) of the pH meter into the water sample and have turned the beaker slightly to obtain good contact between the water and the electrode(s).

v) The electrode(s) require immersion 30 seconds or longer in the sample before reading to allow the meter to stabilize. If the meter has an auto read system, it will automatically signal when stabilized.

vi) The pH value has been read and recorded to the nearest tenth of a whole number. If the pH meter reads to the hundredth place, a round off rule will apply as follows: If the hundredth place digit is less than 5, leave the tenth place digit as is. If it is greater than 5, round the tenth place digit up one unit. If the hun-dredth place digit equals 5, round the tenth place digit to the nearest even number.

vii) I have rinsed the electrode(s) well with distilled water, then have dabed lightly with tissues to remove any film formed on the electrode(s). I also have not wiped the electrodes, as this may result in polarization of the electrode and consequent slow response.

3.3 Total dissolved solids

Total dissolved solids (TDS) are a measure, in milligrams per liter (mg/L), of the amount of dissolved materials in the water. Ions such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium all contribute to the dissolved solids in the water. In many instances resource agencies use the terms TDS and salinity interchangeably, since these ions are typically in the form of salts [21]. Measuring total dissolved solids is a way to estimate the suitability of water for irrigation and drinking. This is an important parameter for drinking water because high TDS values may result in a 'salty' taste to the water.

To obtain valid measurements, we need to follow proper procedures in calibrating, rinsing, and measuring. Here is a step-by-step procedure for two HACH model meters, along with instructions for converting the meter reading of each meterto TDS (ppm). Depending on which meter we have, the actual meter reading will be different, but EC or TDS results are the same.

Measuring TDS of water sample

1. After calibrating meter, I have rinsed meter tip and small container with distilled water, then have placed meter tip into water sample and also have taken meter reading. I have remembered to allow meter to stabilize prior to taking reading.
2. I have calculated TDS in (mg/L)unit.

3.4 Electrical conductivity

Calibration of conductivity meter:

I have taken 0.1M Potassium Chloride in a beaker than have switched on the magnetic stirrer and have also placed the beaker on the stirrer . Have inserted the magnetic bead in the beaker. Than also have placed the electrode inside the solution. I have selected the calibration button and using up and down key adjusts the conductivity of the 0.1N potassium chloride solution to 14.12millisiemens / cm at 30°c. Now the meter is ready for the measurement of samples.

TESTING OF WATER SAMPLE

The electrode has been rinsed thoroughly with deionised water and carefully and have wiped with a tissue paper Than I have measured 200 mL of water sample and have transfered it to a beaker and placed it on the magnetic stirrer. I have dippen the electrode into the sample solution taken in a beaker and have waited for a steady reading.

I have made sure that the instrument is giving stable reading Than I have Noted down the reading in the display directly, which is expressed in millisiemens. Electrical conductivityis the ability of a substance to conduct an electrical current, measured in microsiemensper centimeter (mS/cm). Ions such as sodium, potassium, and chloride give water its ability to conduct electricity. Conductivity is an indicator of the amount of dissolved salts in a stream. Conductivity often is used to estimate the amount of total dissolved solids (TDS) rather than measuring each dissolved constituent separately.

Solids can be found in nature in a dissolved form. Salts that dissolve in water break into positively and negatively charged ions. Conductivity is the ability of water to conduct an electrical current, and the dissolved ions are the conductors. The major positively charged ions are sodium, (Na^{+}) calcium (Ca^{+2}), potassium (K^{+}) and magnesium (Mg^{+2}). The major negatively charged ions are chloride (Cl^{-}), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}), and bicarbonate (HCO_3^{-}). Nitrates (NO_3^{-2}) and phosphates (PO_4^{-3}) are minor contributors to conductivity, although they are very important biologically.

3.5 Dissolved oxygen

Dissolved oxygen (DO) is needed by fish and other stream organisms. In unaltered streams, dissolved oxygen levels usually determine the ability for the stream to support aquatic oxygen-dependent life, as defined by temperature and elevation. As plant and animal material decays, it consumes dissolved oxygen. Turbulence, interaction with the air, and photosynthesis replenish oxygen in the water. Cold water can hold more dissolved oxygen than warmer water. Dissolved oxygen measurements can be expressed as a concentration, milligramsper liter (mg/L), or as percent saturation (the amount of oxygen the water holds compared to what it could absorb at that temperature).

3.6 Salinity:

Salinity is a measure of the dissolved salts in the water. Salinity is usually highest during periods of low flows and increases as water levels decrease. Salinity is measured as either TDS (Total Dissolved Solids), which measures the amount of dissolved salts in the water, or as EC

(Electrical Conductivity), which is the property of a substance which enables it to serve as a channel or medium for electricity. Salty water conducts electricity more readily than purer water. A sample's EC can be converted to TDS and vice versa. High levels of salinity in water may have adverse impacts upon fresh water flora and fauna, which are not salt tolerant. High levels of salinity also have implications when using water for stock watering.

Salinity is a measure of the amount of salts in the water. Because dissolved ions increase salinity as well as conductivity, the two measures are related. The salts in sea water are primarily sodium chloride (NaCl). However, other saline waters, such as Mono Lake, owe their high salinity to a combination of dissolved ions including sodium, chloride, carbonate and sulfate.

Salts and other substances affect the quality of water used for irrigation or drinking. They also have a critical influence on aquatic biota, and every kind of organism has a typical salinity range that it can tolerate. Moreover, the ionic composition of the water can be critical. For example, cladocerans (water fleas) are far more sensitive to potassium chloride than sodium chloride at the same concentration.

How to collect and test water samples

1. Thoroughly I have mixed the water. I want to test before taking a sample.

2. Have dippen a water sampling container into the water being tested and have rinsed thoroughly.

3. The jar has been allowed to half fill with water.

4. I have removed the protective cap from salinity meter and turn the unit on.

5. I also have immersed the salinity meter into the sample up to the raised mark (about 25mm), and slowly swirl the meter. The two electrodes of the meter must be covered. (If testing free water in the paddock don't rest the end ofthe meter in sediment on the bottom).

6. The displayed value has been allowed to stabilize (it takes several seconds to compensate for the temperature of the sample).

7. I have read the number on the meter, then have converted it to the desired units and record the reading.

8. Lower part of the meter has been washed off with freshwater (especially the electrodes)

3.7 Alkalinity:

I have rinsed the burette with 0.02MSulphuric acid and discard the solution.
The burette has been filled with 0.02Msulphuric acid and adjust it to zero.
I have fixed the burette in the stand.

I also have used a measuring cylinder exactly measure 100 mL of sample and have poured it into a 250 mL of conical flask.I have added few drops of phenolphthalein indicator to the contents of conical flask. The colour of the solution will turn to pink. This colour change is due to alkalinity of hydroxyl ions in the water sample. I have titrated it against 0.02N sulphuric acid till the pink color disappears. This indicates that all the hydroxyl ions are removed from the water sample. The titter value has been noted down. The value of titration is 0.5mL.This value is used in calculating the phenolphthalein alkalinity.

To the same solution in the conical flask add few drops of mixed indicator. The colour of the solution turns to blue.This colour change is due to CO_3^{-2}& HCO_3^-ions in water sample. Continue the titration from the point where stopped for the phenolphthalein alkalinity.I have titrated till the solution becomes red. The entire volume of sulphuric acidicsnoted down and it is accountable in calculating the total alkalinity. Repeat the titration for concordant values.

3.8 Determination of iron

Preparation of a Standard Potassium Dichromate Solution

I have transfered approximately 2.45g of reagent-grade potassium dichromate to a clean, dry weighing bottle and have used a beaker and have watched glass arrangement, the solid has been dried in an oven at $110^{O}C$ for one hour Than I have also Cooled the potassium dichromate in its weighing bottle for at least 30 minutes in a desicator.I have Obtained the weight of the weighing bottle and its contents to the nearest milligram, have transfered the potassium dichromate to a clean beaker, and have reweighed the empty weighing bottle to the nearest milligram in order to determine the weight of the potassium dichromate by difference. I have dissolved the potassium dichromate by adding a small volume of distilled water to the beaker. The solution has been transfered quantitatively, with the aid of a glass funnel and stirring rod, to a clean 500-mL volumetric flask.I have added distilled water to the volumetric flask to bring the solution up to the calibration mark, stopper the flask, and I have mixed the solution thoroughly. From the weight of potassium dichromate used, calculate the concentration of the solution.I also been sure to label the volumetric flask containing your standard solution.

Preparation of the Sample Solution

I have transfered approximately 50 mL water sample to a clean, dry weighing bottle. Dry the sample in an oven at 100^{O}C for one hour.I also have weighted accurately, to the nearest tenth milligram, portions of the dried sample into each of the three 500 mL Erlenmeyer flasks; each sample should contain enough iron to require approximately 30 to 35 mL of the potassium dichromate titrant (approximately 0.25 g). Have Aadded 10mL of distilled water and 10mL of concentrated (12 M) hydrochloric acid to each flask and heat each mixture gently over a burner in a ventilation hood to dissolve the sample. A residue of white or gray-white silica can be ignored.

Adjustment of the Oxidation State of Iron

The sample solution has been heated to boiling over a burner in a ventilation hood and add 0.5 M$SnCl_2$ solution drop by drop, while swirling the flask, until the yellow color of iron (III) just disappears. Then ass one or two drops more of the $SnCl_2$solution. I have cooled the solution to a temperature below 25°C and have added all at once 10 mL of 0.18 M mercuric chloride solution. A silky white precipitate should form. If it is gray or black or if no precipitate forms, an incorrect amount $SnCl_2$ solution was used and the sample must discarded. After two or three minutes, but notlonger, add 150 mL of distilled water and proceed immediately to the addition of special reagents and the titration.

Addition of Special Reagents; Titration

I have added 10 mL of the sulfuric acid-phosphoric acid solution and 8 drops of barium diphenylamine sulfonate indicator solution.I also have titrated the solution with standard0.0167 M potassium dichromate to an endpoint marked by the sudden appearance of a deep violet color throughout the solution.

Completion of Analysis

With the second and third sample solutions, in turn, repeat the steps of the procedure involving oxidation-state adjustment, addition of special reagents, and final titration. From the experimental data, calculate the percentage of iron in each of the original samples. If the results differ significantly, repeat the analysis with additional samples of the unknown.

3.9 Turbidity

Measurements of the amount of suspended material in the water sample represent turbidity. This material, which is comprised of particles such as clay, silt, algae, suspended sediment, and decaying plant material, causes light to be scattered and absorbed, rather than transmitted in straight lines through the water. Turbidity is measured in Fermazin Turbity Unit (FTU) or Nephelometric Turbidity Units (NTU's).

Suspended Solids usually enter the water as a result of soil erosion from disturbed land or can be traced to the inflow of effluent from sewage plants or industry. Suspended solids also occur naturally in the water from bank and channel erosion; however, this process has been accelerated by human use of waterways. Turbidity measurements also take into account algae and plankton present in the water.

Though high turbidity is often a sign of poor water quality and land management, crystal clear water does not always guarantee healthy water. Extremely clear water can signify very acidic conditions or high levels of salinity.

3.10 Total Hardness:

One of the factors that establish the quality of a water supply is its degree of hardness. Hardness is defined as calcium and magnesium ion content. Since most analyses do not distinguish between $Ca^{2+}$and $Mg^{2+,}$ and since most hardness is caused by carbonate mineral deposits, hardness is usually reported as parts per million (ppm) of calcium carbonate (by weight). A water supply with a hardness of 100 ppm contains the equivalent of 100 g of $CaCO_3$in 1 million g of water or 0.1 g in 1 L of water (or 1000 g of water since the density of water is about 1 g/mL).

Apparatus: Conical flask, Burette, Pipette, Beaker, Measuring flask

Reagents: 0.1M EDTA solution, Eriochrome Black-T indicator, Basic buffer solution (NH_4OH and NH_4Cl), Standard hard water, Given water sample

Procedure:

(a) Standardisation of EDTA solution with standard hard water

I have Pipetted out 10 ml of standard hard water in a washed conical flask. Have add 5ml basic buffer solution and 2-3 drops of Eriochrome Black-T indicator, the colour of the solution turns wine red. Then have titrated this solution against EDTA solution taken in the burette until the colour changes from wine red to clear blue at the end. The final reading of the burette is noted and the titration is repeated to get concordant value.

(b) Estimation of Total Hardness of given water sample

I have pipetted out 10 ml of given hard water in a washed conical flask.Have added 5ml basic buffer solution and 2-3 drops of Eriochrome Black-T indicator, the colour of the solution turns wine red.Then have titrated this solution against EDTA solution taken in the burette until the colour changes from wine red to clear blue at the end. The final reading of the burette is noted and the titration is repeated to get concordant value.

3.11 Arsenic test:

Studies of human exposure to arsenic and its consequences for human health require two different kinds of arsenic analyses depending on whether quantitative or qualitative results are required. Several methods have been developed and improved for the measurement of total arsenic, and have been widely used for the evaluation of drinking-water contamination and the resulting concentrations of arsenic in humans. The most commonly used methods for the analysis of arsenic and arsenic compounds in water and biological samples are described below.

Merck test:

This is done in a controlled reaction between an acidified water sample and zinc powder. A volume-specific reaction vessel, usually a plastic bottle supplied in the test kit, is used for this reaction. At first, fill the reaction bottle to the mark. Tow drops As-1 reagent add and swirl. Then one level red dosing spoon As-2 reagent I have added and have swirled until the reagent is completely dissolved. After that one level green dosing spoon reagent As-3has been added and immediately I have reclused the reaction bottle with the screw cap. I also have filled up the black test strip holder integrated in the screw cap, with the white dot facing outside. Immediately I have inserted the test strip into the opening reaction zone first, as far as the mark and have fliped the test strip holder down completely . I have Leaved to stand for twenty minutes, swirling tow or three times during this period. Any contact has been avoided between the test strip and the sample solution. As the arsenic converts to arsine gas and comes in contact with the test strip, the mercuric bromide indicator on the test strip changes in color from white to shades of yellow and brown. This chemical reaction varies in time between test kits from 10 to 30 minutes. After 30 minutes remove the strip, briefly dip into the water, shake off excess liquid and determine with color comparator chart to obtain a quantitative measure for arsenic in the tested sample. I have read off the corresponding result in mg/L As or if necessary and have estimated an intermediate value. But kit test is available with varying levels of complexity. Testing for arsenic may not be as easy as testing for many other ions.

3.12 Cadmium (Cd)

Generally, cadmium is found naturally in small quantities in water.Cadmium can be released to drinking water from the corrosion of some galvanized plumbing and water main water piping materials. Higher levels of cadmium may be found in water near industrial areas or hazardous waste sites. In this case, the concentration of cadmium in tap water is low. The concentration of dissolved metal is higher than the suspended ones. The highest concentration was detected in sample 2, while the lowest concentration was detected in sample 1. The EPA standard level for cadmium is 0.003 ppm[22]. The EPA has discovered that cadmium has high potential to cause health effect

Cadmium standard solutions (5 –50 μg L^{-1}) were prepared by stepwise dilution from a 1000 mg L^{-1}stock solution (Merck Titrisol) with Milli-Q treated water, acidified with nitric acid top H 2.

Apparatus

A SHIMADZU Model AA-6800 atomic absorption spectrometer equipped with a hollow cadmium cathode lamp and a deuterium lamp for background correction was used. The spectrometer's monochromator was adjusted to 228.8 nm (the resonance line corresponding to a highly cadmium-sensitive wavelength). Several selections were made to adjust the spectrometer, including: slit width, 0.5 nm; burner height, 8mm; sample uptake rate, 1 mL min^{-1}; air flow rate, 2.2 L min^{-1}; and acetylene flow rate, 0.9 L min^{-1}. The atomic signal was measured in peak height mode. The on-line pre-concentration system was equipped with an Ismatec Model IPC-8 peristaltic pump furnished with Tygonpumping tubes (i.d. 0.5 mm) and a homemade Perspex injector-commutator.

Calibration of Atomic Absorption Spectrometry (AAS)

The characteristic concentration check value is the concentration of element (in mg/L) that will produce a signal of approximately 0.2 absorbance units under optimum conditions at the wavelength listed. By using the characteristic concentration check, the operator can determine whether instrumental parameters are optimized and whether the instrument is performing up to specifications. Calibration of AAS was carried out by using an external calibration curve. The external calibration curve was prepared from solution of known concentrations of the sample element, which was also known as stock solution. High purity metal salts dissolved in high purity acids were used to make the stock solution. Working standards were diluted from the stock standard

Table 1 Summary of Analysis Methods

Sl. No.	Parameters	Method of Analysis	Instruments/Reagents Required
1	Alkalinity/Acidity	Tritimetric analysis	Sulphuric acid: 0.02N; Phenolphthelein Indicator (1%); Methyl orange (1%)
2	Hardness	EDTA complexometric method	Buffer solution (8–10pH); Inhibitor; Eriochrome black-T (EBT) 1%; EDTA (0.1N)
3	TDS	Ion electrode	Sention conductivity electrode Model: P/n: 51975-00
4	Arsenic,As	Kit Test	Merck test
5	Heavy metals (Pb&Cd)	Spectrophotometric analysis	SHIMADZU Model AA-6800
6	pH	Potentiometric	Sention conductivity electrode Model: P/n: 51975-00
7	Turbidity	Turbidity meter	EI instruments-345
8	Color	Color observation	Nesslers tube
9	Conductivity	Ion electrode	Sension conductivity electrode Model: P/n: 51975-00
10	Salinity	Ion electrode	Sension conductivity electrode Model: P/n: 51975-00

Chapter IV

RESULTS & DISCUSSION

The variation in physico-chemical characteristics of the tube well water, pond water and rain water in KUET premises have been summarized in the table 1, Table 2, Table 3 and Table 4.

4.1 pH

The pH of tube well water ranged from a minimum of 7.79 to a maximum of 8.2 of TW3 and TW1 respectively (Figure 1). Similarly the variation of pH of pond water ranged from a minimum of 8.36 of PWL3 to a maximum of 8.87 of PWL2 and in rain water the maximum value was 6.77 of RWJ1 and the minimum value was 6.34 of RWC respectively (Figure 1). In case of rainwater, pH values were found lower compare to all other investigated places.

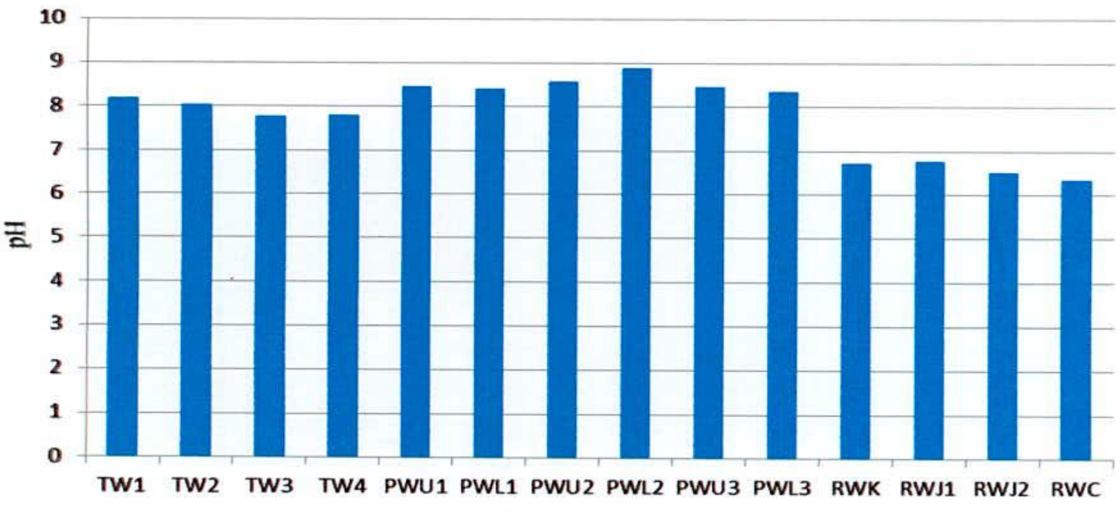

Figure 1: pH values of various water samples collected in different sources.

*TW1-Tube-well, School gate KUET, TW_2-Tube-well water, Building no-5, **TW3**-Tube-well Building no 12, TW-4 Tube-well Building no 19, PWU1-Pond water, Rokaya Hall upper , PWL1-Pond water lower, Rokaya Hall, PWU2-Pond water power plant upper, PWL2-Pond water power plant lower, PWU3-Pond water upper Khanjahan ali hall , PWL3-pond water lower Khanjahan ali hall, RWK-Rain water KUET, RWJ1-Rain water jessore urban , RWJ2-Rain water jessore Rural , RWC-Rain water collected from Chittagong.*

During the present investigation a pattern of pH change was noticed. In case of pond water the maximum value of pH, which indicates the alkaline nature of water might be due to high temperature that reduces the solubility of CO_2. In all the ponds, pH is always alkaline. In table 1 and Table 2 shows the variation of pH in winter and summer season. In summer the pH value is more alkaline than winter season. It is reasonable because in the increase of temperature in summer, water is evaporated from surface and decreases the volume of water. Hence alkalinity is increases. The tube well water pH is slightly alkaline and within the acceptable range. Significantly lower pH value is found for rainwater. This is due to acidic gases such as H_2S, SO_2, N_2O, CO_2 etc are absorbed by rain water and hence decreases the pH.

4.2 Conductance

The electrical conductance of water measure of the ability of the water to conduct electricity. It is also an indirect measure of the presence of ions, such as nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron. These substances conduct electricity because they are negatively or positively charged when dissolved in water. The concentration of dissolved solids, or the conductivity, is affected by the bedrock and soil in the watershed. It is also affected by human influences. For example, agricultural runoff can raise conductivity because of the presence of phosphate and nitrate. It is important to measure the conductivity of water because aquatic organisms require a relatively constant concentration of the major dissolved ions in the water. Levels too high or too low may limit survival, growth or reproduction.

Electrical conductivity is affected by temperature, it is thus important to report temperature data along with conductivity values. In unpolluted waters, conductance increases by 2 to 3% per °C. The international standard temperature to which conductivity measurements are corrected is

25°C. This measurement is expressed in microsiemens per centimeter (µS/cm) at 25 degrees Celsius. Conductivity values can be used to estimate the total concentration of dissolved solids (commonly referred to as total dissolved solids, or TDS). The desired level of conductivity in drinking water according to the WHO is 1,000 µS/cm and most drinking water sources of Bangladesh 750 to 1500 µS/cm.

The electrical conductivity has a direct relation with the total solids. The values for all tube well water were found to be greater than those of pond water and rain water. In present observations the electrical conductivity for tube well water ranges from 1021 to 1598 µs/cm, for pond water ranges 324 to 732 µs/cm and for rain water ranges from 13 to 80 µs/cm are showed in figure 2. The tube well water is found high conductivity. It indicates that the water contain larger quantity of dissolved various mineral salts. In case of pond water the conductivity is also significantly change during winter season and rainy season. It showed in Table 1 and Table 2. The reason for such significant change may attribute to concentrate the dissolved ions in winter season due to layer of pond water decreases compare to rainy season.

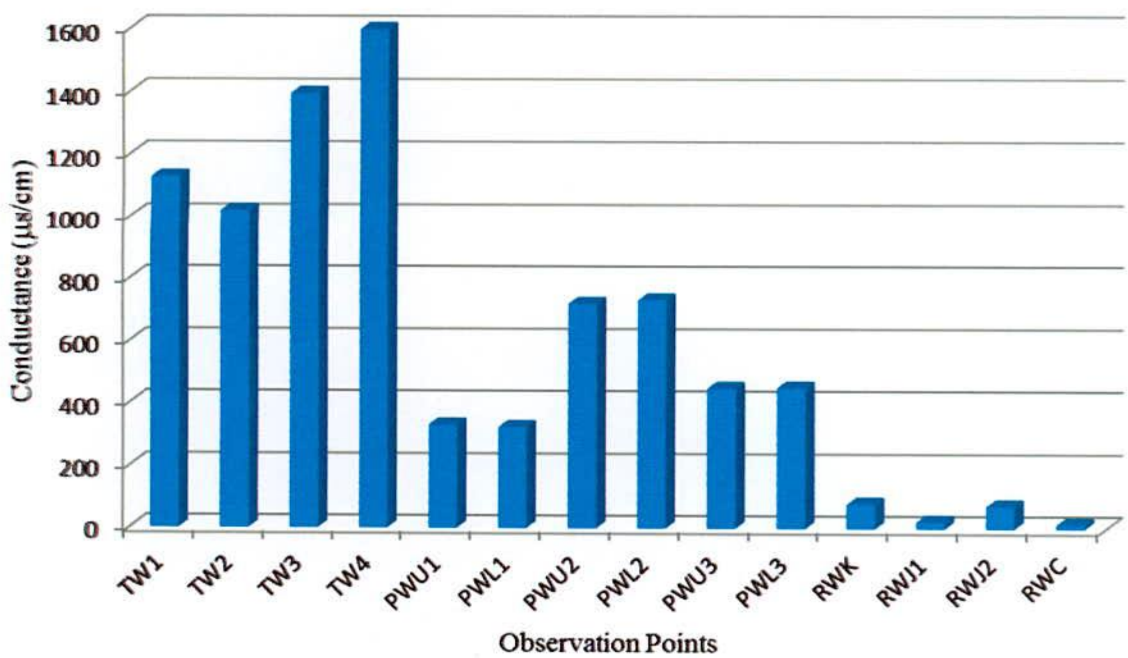

Figure 2: Conductance (µs/cm) values of various water samples collected in different sources.

4.3 Total Dissolved Solid

The total dissolved solids of tube-well water ranged from a minimum of 551 mg/L to a maximum of 887mg/L of TW_1 and TW_4 respectively (Figure 3). Similarly the variation of total dissolved solids of pond water ranged from a minimum of 175 mg/L to a maximum of 399 mg/L of PWL_1 and PWL_2 and for rainwater ranged from a minimum of 6 mg/L to a maximum of 40 mg/L of RWC and RWK respectively.

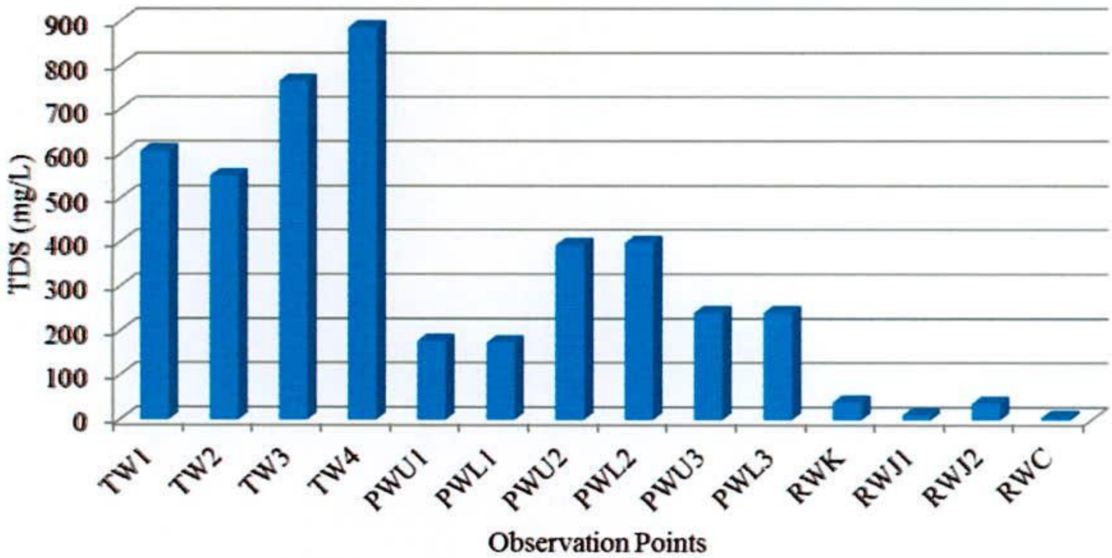

Figure 3 : TDS (mg/L) values of various water samples collected in different sources.

In water, total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles. These ions are also the cause for specific conductance. Therefore, it always gives a correlation with specific conductance. We found a good linear relationship,

$$\text{TDS (mg/L)} = 0.5509(\text{Sp. Conductance, } \mu\text{s/cm}) - 4.0194 \qquad R = 0.999$$

by using this equation one can estimate the TDS with the known specific conductance.

4.4 Salinity

Salinity is defined as the total concentration of electrically charged ions (cations – Ca^{2+}, Mg^{2+}, K^{+}, Na^{+} ; anions – CO_3^{2-}, HCO_3^{-}, SO_4^{2-}, Cl^{-} and other components such as NO_3^{-}, $NH_4^{+}$and PO_4^{3-}) Salinity is a major driving factor that affects the density and growth of aquatic organism's population. Fish are sensitive to the salt concentration of their waters and have evolved a system that maintains a constant salt ionic balance in its bloodstream through the movement of salts and water across their gill membranes. It showed in Figure 4 that the salinity is larger in case of tube well water and smaller in pond water. This result is consistent with the previous result obtained from pH and conductance measurement.

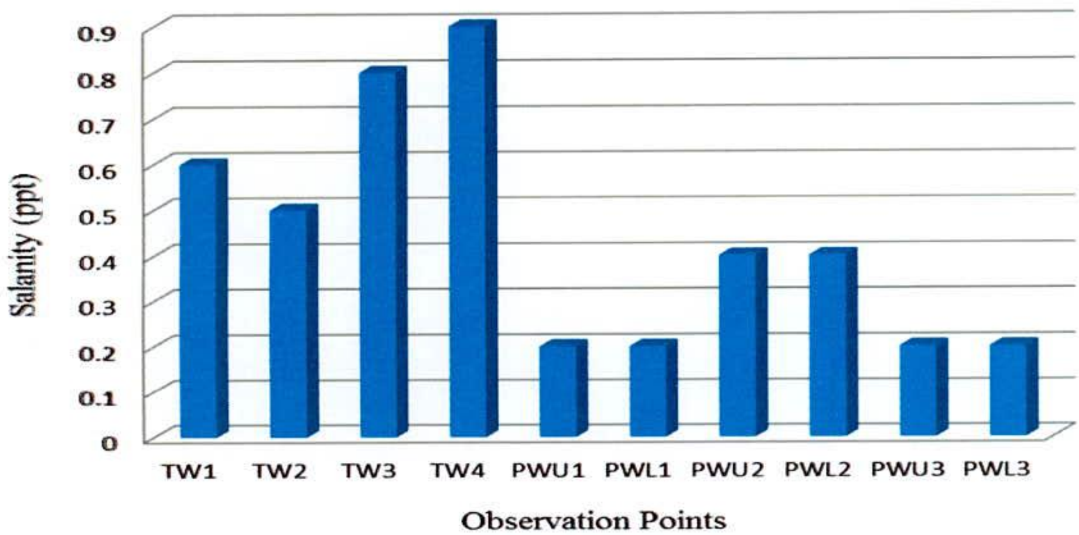

Figure 4 : Salinity (ppt) values of various water samples collected in different sources.

4.5 Alkalinity

The variation in total alkalinity of tube-well water ranged from a minimum of 496.66 mg/L to a maximum of 508.33mg/L of TW_2 and TW_3 respectively. Similar variation in total alkalinity of pond water ranged from a minimum of 83.33 mg/L to a maximum of 131.66 mg/L of PWL_1 and PWU_3 respectively (Figure 5). The alkalinity of water is caused mainly due to OH^{-}, CO_3^{2-} HCO_3^{-} ions. Alkalinity is an estimate of the ability of water to resist change in pH upon addition of acid.

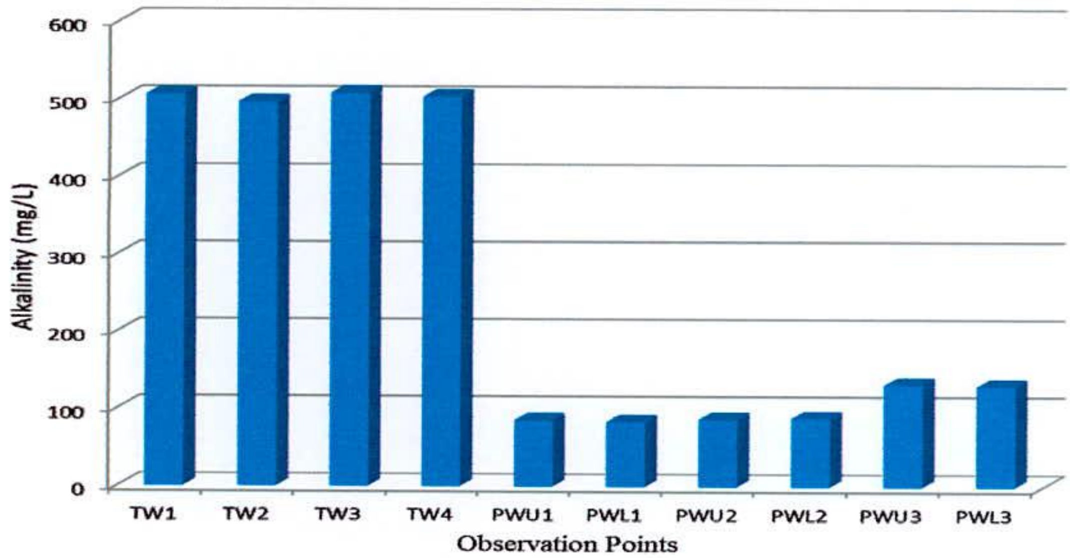

Figure 5: Alkalinity (mg/L) values of various water samples collected in different sources.

The alkalinity of PWU3 is higher than the other two ponds that exceed the highest desirable limit but within maximum permissible limit as per ICMR specification, so from alkalinities point of view, a quality of water is poor. A pH test by itself is not an indication of alkalinity. Water with high alkalinity (i.e., high levels of bicarbonates or carbonates) always has a pH value ~7 or above, but water with high pH doesn't always have high alkalinity. This is important because high alkalinity exerts the most significant effects on growing medium fertility and plant nutrition.

4.6 Hardness

Hardness is caused by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations, although other cations e.g. barium, iron, manganese, strontium and zinc, also contribute. Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per liter or ppm, water containing less than 60 ppm generally being considered as soft, 61-120 ppm being considered as moderately hard, 121-180 ppm being considered as hard and more than 180 ppm are considered as very hard water. The taste threshold for the calcium ion is in the range 100-300ppm, depending on the associated anion, but higher concentrations are acceptable to consumers. Hardness levels above 500ppm are generally considered to be aesthetically unacceptable, although this level is tolerated in some communities [23]. In drinking water hardness is in the range 10-500 mg of calcium carbonate per liter [24].

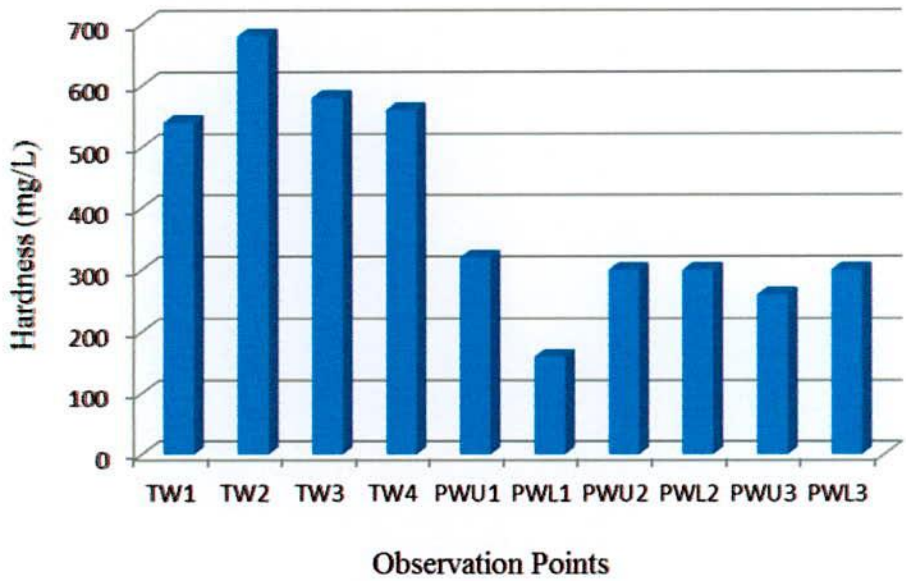

Figure 6 : Hardness (mg/L) values of various water samples collected in different sources.

These do not appear to be any convincing evidence that water hardness causes adverse health effects in humans. In contrast, the results of a number of epidemiological studies have suggested that water hardness may protect against disease. However, the available data are in adequate to prove any causal association. No health-based guideline value for water hardness is proposed. The hardness of tube-well water ranged from a minimum of 540 mg/L to a maximum of 680 mg/L of TW_1 and TW_2 respectively are showed in figure 6. Similarly the hardness of pond water ranged from a minimum of 160 mg/L to a maximum of 320 mg/L of PWL1 and PWU1 respectively. The increase in hardness of pond water during summer season may due to evaporation of surface water and lowering down the hardness water due to heavy rain in monsoon.

4.7 Dissolved Oxygen

The dissolved oxygen of pond water ranged from a minimum of 4.60 mg/L to a maximum of 5.61mg/L of PWL3 and PWL1 respectively are shown in Figure 7. The minimum value of DO was recorded in PWL3 is might be due to the high rate of oxygen consumption by oxidizable mater.

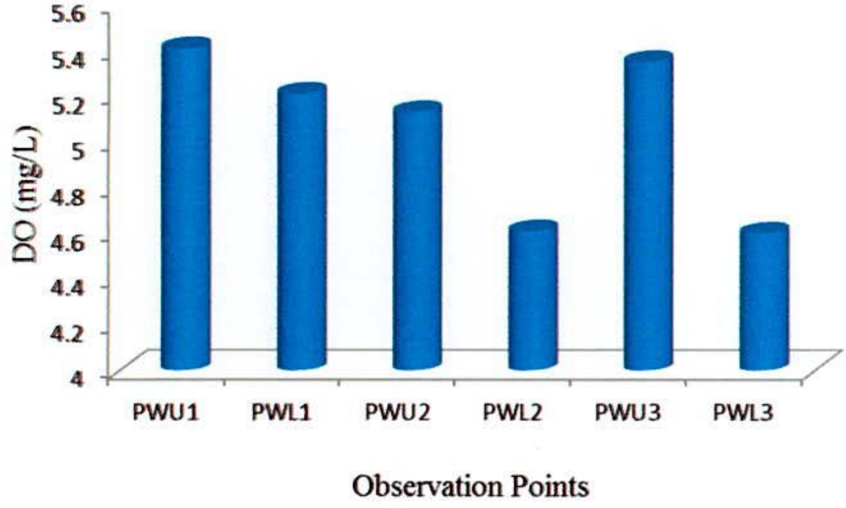

Figure 7: DO mg/L) values of various water samples collected in different sources.

The maximum values were recorded in PWL1 can be explained on the basis of the capacity of water to hold oxygen.

4.8 Iron, Lead and Cadmium

Iron is the second most abundant metal in the earth's crust, of which it accounts for about 5%. Elemental iron is rarely found in nature, as the iron ions Fe^{2+} and Fe^{3+} readily combine with oxygen- and sulfur-containing compounds to form oxides, hydroxides, carbonates, and sulfides. Iron is most commonly found in nature in the form of its oxides [26,27]

Iron is mainly present in water in two forms: either the soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air in the pressure tank or atmosphere, the water turns cloudy and a reddish brown substance begins to form. This sediment is the oxidized or ferric form of iron that will not dissolve in water. Iron can be a troublesome chemical in drinking water. Although present in drinking water, iron is seldom found at concentrations greater than 10 milligrams per liter (mg/L) or 10 ppm. However, as little as 0.3 mg/l can cause water to turn a reddish brown color is the maximum permissible limit of iron for drinking purpose [28]

Four tube-well water samples have been investigated for the iron content and the results varied from 16.78 – 27.97 ppm are shown in figure 8. No tube-well was found having the iron content within the maximum permissible limit of 0.3 ppm. This high concentration of iron content may have health risk if someone uses this drinking water for a long time.

Because of many industries nearby Khulna University of Engineering and Technology including battery industry discharges lot of heavy metals such as lead, cadmium, zinc etc. in the environment without any treatment. So we examined the lead and cadmium concentration in the rain water. It was found that both heavy metals are below the detectable limit measured by AAS.

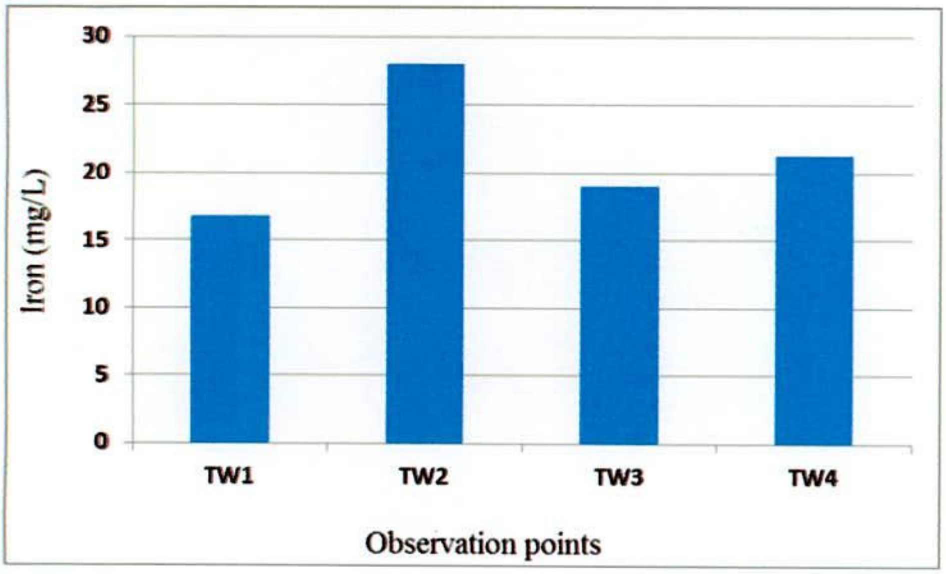

Figure 8: Iron (mg/L) values of various water samples collected in different sources.

4.9 Arsenic

Arsenic occurs naturally in sulphide minerals such as pyrite. It is found in many countries but especially those located south of the Himalayas, such as Bangladesh, India (West Bengal), and China. The main challenge in tackling arsenic in ground water is that it does not follow a specific pattern. For example, it can occur in one tube well and not in another one located less than 100 meters away. Furthermore, a tube well that was previously tested to show an acceptable amount of arsenic might test non-acceptable at a later date. It is therefore vital to test and monitor on a continual basis, with blanket coverage of all tube wells in those countries affected. It is equally important to ensure that people are made aware of the arsenic content in tube well water and promote arsenic mitigation activities. In our present studies, all tube well water showed the arsenic level below 0.02 ppm.

Table1: Physico-Chemical Analysis of Pond water at 15/11/2013

Parameters	Bangladesh Standard	Result					
		PWU1	PWL1	PWU2	PWL2	PWU3	PWL3
pH	(6.5-8.5)	8.44	8.4	8.58	8.87	8.44	8.36
Odor	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless
Conductivity (μS/cm)	250(μS/cm	331	324	720	732	448	450
Salinity(ppt)	-	0.2	0.2	0.4	0.4	0.2	0.2
TDS (mg/L)	1000mg/L	178.9	175.1	394	399	242	242
Dissolved Oxygen (mg/L)	6mg/L	4.33	3.79	3.81	3.79	3.61	3.33
Total Alkalinity (mg/L)	-	85.00	83.33	86.66	88.33	131.66	130
Total Hardness (mg/L)	(200—500)mg/L	320.28	160.14	300.27	300.27	260.23	300.27

Table 2: Physico-Chemical Analysis of Pond water at 29/04/2014

Parameters	Bangladesh Standard	Result					
		PWU1	PWL1	PWU2	PWL2	PWU3	PWL3
pH	(6.5-8.5)	8.23	9.05	9.18	9.14	8.71	8.77
Odor	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless
Conductivity (μS/cm)	250(μS/cm	454	449	1097	1089	633	634
Salinity(ppt)	-	0.1	0.1	0.4	0.4	0.2	0.2
TDS (mg/L)	-	192.8	195.4	481	487	276	280
Dissolved Oxygen (mg/L)	6mg/L	5.21	5.41	5.13	4.61	5.35	4.60
Total Alkalinity (mg/L)	-	98.33	86.66	93.33	93.33	120	121.66
Total Hardness (mg/L)	(200—500)mg/L	360.32	320.28	340.30	240.21	240.21	300.27

Table 3 : Physico-Chemical Analysis of tube well water

Parameters	**Bangladesh Standard**	**Result**			
		TW1	**TW2**	**TW3**	**TW4**
Color	Colorless	Colorless	Colorless	Colorless	Colorless
pH	6-8	8.20	8.05	7.79	7.80
Odor	Odorless	Odorless	Odorless	Odorless	Odorless
Conductivity(μS/cm)		1128	1021	1395	1598
Salinity(ppt)	-	0.6	0.5	0.8	0.9
TDS (mg/L)	-	607	551	766	887
Total Alkalinity (mg/L)	-	506.66	496.66	508.33	503.33
Total Hardness (mg/L)	200-500	540.48	680.61	580.52	560.5
Iron (mg/L)	0.3-1.0	16.78	27.97	19.02	21.26

Table 4: Physico-Chemical Analysis of Rain Water

Parameters	**WHO Standard**	**Result**			
		KUET premises	**Jessore Urban**	**Jessore Rural**	**Chittagong city area**
Color	Colorless	Colorless	Colorless	Colorless	Colorless
pH	6.5-8.5	6.74	6.77	6.52	6.34
Odor	Odorless	Odorless	Odorless	Odorless	Odorless
Turbidity(FTU)	10	Clear	Clear	Clear	Clear
Conductivity(μS/cm)	250	80	22	74	13
Total Dissolved Solids(mg/L)	-	40	11	37	6
Iron,(mg/L)	0.3-1.0	BDL	BDL	BDL	BDL
Lead, (mg/L)	0.05mg/L	BDL	BDL	BDL	BDL
Cadmium,(mg/L)	0.005mg/L	BDL	BDL	BDL	BDL

BDL=Bellow Detective Level

Taste of Water with Different TDS Concentrations

Level of TDS (milligrams per litre)	Rating
Less than 300	Excellent
300 - 600	Good
600 - 900	Fair
900 - 1,200	Poor
Above 1,200	Unacceptable

Picture 2:Rokaya Hall Pond(PW1)

Picture No1:Plant Side Pond (PW2)

Picture3: Khanjahan Ali Hall Pond(PW3)

Chapter V

Conclusion

The evolution of water quality in ground water, pond water and rain water of KUET premises has assessed by the study. We have carried out a physic-chemical study of ground water, pond water and rain water by taking certain important parameters like temperature, pH, odor total dissolved solid, alkalinity, hardness, turbidity, dissolved oxygen, iron, arsenic, lead, cadmium. We have found that the pH of tube-well water ranged from a minimum of 7.79 to a maximum of 8.2 of TW_3 (Tube-well water building 12)and TW_1 (Tube-well school gate)respectively in this present investigation. At the same way, the variation of pH of pond water ranged from a minimum of 8.40toa maximum value was 6.77of RWJ_1 and the minimum value was 6.34 of RWC respectively. This values are within the acceptable limit. We found the values of conductivity for all tube-well water to be greater than those of pond water as well as rain water. In present observations, the conductivity for tube-well water ranges from 1021 to1598µs/cm, for pond water ranges 324 to 732 µs/cm and for rain water ranges from 13 to 80 µs/cm. I found the tube well water high conductivity. It indicates that larger quantity of dissolved mineral salts is contained in the water. In case of pond water the conductivity also changes significantly during winter season and rainy season. The total dissolved solids of tube-well water ranged from a minimum of 551 mg/L to a maximum of 887 mg/L of TW_1 and TW_4 respectively. At the same way the variation of total dissolved solids of pond water ranged from a minimum of 175 mg/L to a maximum of 399 mg/L of PWL_1 and PWL_2 and for rain water ranged from a minimum of 6 mg/L to a maximum of 40 mg/L of RWC and RWK respectively. This high values of TDS specially in Tube well water are mainly due to carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles. The variation in total alkalinity of tube-well water ranged from a minimum of 496.66 mg/L to a maximum of 508.33mg/L of TW_2 and TW_3 respectively. Similar variation in total alkalinity of pond water ranged from a minimum of 83.33 mg/L to a maximum of 131.66 mg/L of PWL_1 and PWU_3 respectively.

The iron content and the results varied from 16.78 to 27.97 ppm have been found by the tube well water samples. We have found no tube well having the iron content within the maximum permissible limit of 1.0ppm. Lead and cadmium concentration in the rain water was below the detectable limit. We have investigated to all tube well water and have found arsenic below 0.02ppm that is within acceptable limit.

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