ANALYSIS OF THE DRINKING WATER QUALITY OF IUT BY SCRUTINIZING WATER QUALITY PARAMETERS

A THESIS WORK BY

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A thesis submitted to the Department of Civil and Environmental Engineering,

Islamic University of Technology, Gazipur,

in partial fulfillment of the requirement for the degree

of

BACHELOR OF SCIENCE IN CIVIL AND ENVIRONMENTAL ENGINEERING

2015

CERTIFICATE OF RESEARCH

It is hereby certified that the work presented in this thesis was carried out by the following final year student of session 2014-2015 under the direct supervision of Dr. Md. Rezaul Karim, Professor of Department of Civil and Environmental Engineering (CEE), Islamic University of Technology, Gazipur, Dhaka.

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DECLARATION

We declare that the thesis report entitled "ANALYSIS OF THE DRINKING WATER QUALITY OF IUT BY SCRUTINIZING WATER QUALITY PARAMETERS" is the result of our own research except as cited in references. This particular project has neither been submitted nor being concurrently submitted in candidature for degree in any other university.

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ACKNOWLEDGEMENT

At first this author acknowledges the blessings of The Almighty, The Beneficent, and The Merciful for enabling him to complete the study successfully.

This dissertation would not have been possible without the guidance and help of several individuals who, in one way or another, contributed and extended their valuable assistance in the preparation and completion of this study.

The author owes his deepest and sincerest gratitude to Dr. Md. Rezaul Karim, Professor of Department of Civil and Environmental Engineering, for his continuous encouragement, guidance and heartfelt efforts in explaining things articulately and his inspiration at every stage of this work.

The author expresses his profound gratefulness to Md. Solaiman Hossain and Md. Al-Amin Sheikh, the Technicians of Environmental Laboratory, for their assistance in the use of facilities in the laboratory.

The author finally must express his gratitude to his parents who supported and encouraged him throughout his life and have given him the opportunity of receiving the finest education from one of the most renowned institutions in the country.

ABSTRACT

The tap water of IUT is used for drinking purpose ubiquitously in the university. The water of IUT should therefore be safe and free from health hazards as well as unaesthetic conditions with a view to fulfilling the aim of adequately potable water supply. To ensure that, the quality of drinking water of IUT require to be analyzed with constant vigilance by virtue of scrutinizing the behavior and impact of important water quality parameters.

The focus of this study is to investigate the quality of drinking water of IUT by means of scrutinizing paramount water quality parameters. The assessment of their effectiveness and suitability as viable drinking water option can thus be executed.

Several samples of water from all the buildings of IUT were collected and they underwent relevant experiments each month from February to September, except May. The investigated quality parameters were pH, color, turbidity, electrical conductivity, Iron concentration, Manganese concentration and E. coli concentration.

The tests have shown that the quality of water of IUT changes from season to season and from building to building for certain reasons. From detailed analysis, no health hazard was found but potential for some future aesthetic problems regarding secondary drinking water standards were prominent. pH, turbidity, electrical conductivity exhibited no latent as their values were within standard. Iron and Manganese concentration indicated potential for aesthetic problems since they frequently went across aesthetic standard values. Though the results of E. coli concentration showed severe condition, they were faulty and not perfectly executed. This denotes requirement of further investigation. The value of hardness exhibited that the water of IUT is soft to slightly hard, and didn't insinuate any health hazard either.

The color of IUT water increased in the rainy season (during the months of June and July). This could occur due to increased solubility of metals and geological materials. The absolute reason and possible effects of it need to be further investigated.

Treatment of the water of IUT to gain Iron and Manganese concentration within an aesthetically standard value could be helpful. The water will then be able to be aesthetically pleasant to the consumers.

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Chapter 1
INTRODUCTION

1.1 Background and Present scenario of the proposed topic

Islamic University of Technology at Gazipur, Dhaka, Bangladesh is renowned as one of the top universities of Bangladesh. It is commonly referred as IUT which is the subsidiary organ of the Organization of the Islamic Conference (OIC), representing fifty- seven member countries from Asia, Africa, Europe and South America. A number of students from outside of Bangladesh as well as from various districts within the country get admitted in this institution.

Most of the students of IUT frequently use the water of the campus which hails from the aquifer of Madhupur-Barind tract. The aquifer is susceptible to contamination since a huge number of industries are emerging in the nearby areas. Besides, surface water, which is the main source of groundwater recharge, is not always free from pollution. Therefore, the quality scrutiny of the water of IUT campus is a matter of paramount concern.

The consumption of water of IUT is escalating day by day due to the gradual increase in number of students admitted in IUT. Since water is an inseparable and essential part of our daily lives, the parameters that govern the quality of water require to be selected cautiously and deliberately. Afterwards, the collected water needs to undergo relevant experiments. As the water quality of IUT is supposedly changing from time to time, the experiments have to be conducted each month.

1.2 Objectives of the study

Now-a- days the people of IUT are generally concerned about their drinking water quality and this concern has immensely influenced their regular consumption of water. This fact necessitated the study under discussion and hence stipulated the need of fulfilling the objectives mentioned below –

- To determine the values of certain important water quality parameters and to prepare a comprehensive data set of the values
- To discover the reasons of the seasonal variation of the parameters and also the causes of their variation from building to building.
- To deduce the adversities which are arising or may arise in future from the water by finding out the negative attributes of water.

1.3 Significance of the Study

By drinking enough water one can maintain a good health and reduce the need for medication by preventing and impeding various bodily malfunctions. Water is the most important component for sustenance and proper functioning of the human body as almost 75% of the human body is water. [1]

Every part of the human body is made up of cells, and they are filled with a water solution of proteins, lipids, amino acids and other elements. The reason for the presence of water is that all the reactions that keep the human body functioning and alive are electric in nature and water is the medium in which these physiochemical reactions take place and thereby facilitates the reactions.[1] A cell exchanges elements with the rest of the body by electrolysis and in a normal case, minerals and micro elements pass through the cell membrane to the nucleus by electro-osmosis. Drinking water in adequate quantities is essential, since in the case of water shortage, electrolysis cannot occur and cells dry out and die.[1]

The groundwater that people generally consume is not always safe for human health. In order to ensure the drinkability of this water, checking the values of the water quality parameters and treating them accordingly are essential.

Environmental and human health significance of selected water quality parameters

pH:

A controlled value of pH is desired in water supplies, sewage treatment and chemical process plants. In water supply, pH is important for coagulation, disinfection, water softening and corrosion control.

Color:

Colored water is not always harmful to man, but in most cases it is. Even if the water is not harmful, people for aesthetic reasons do not prefer it. Also, disinfection by chlorination of waters that contain natural organics (which produces color) results in the formation of chloroform, tri-halomethanes and a range of other chlorinated organics, leading to problems which are a major concern in water treatment. Thus it is important to limit the color of water for domestic supplies.

Turbidity:

Turbidity is a useful indicator of groundwater quality changes. Turbidity in groundwater does not indicate pathogen presence but provides information on general water quality and is an indicator of surface influence on groundwater quality.

Turbidity is important for water supply engineers as turbid water is not aesthetically acceptable to people. There is always a fear among people that turbid water may cause diseases. For filtration, turbid water is not suitable as it causes quick clogging of filter bed which means the use of pre-treatment plant is necessary.

Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote growth of pathogens in the distribution system, leading to water borne diseases.

Electrical Conductivity:

Electrical Conductivity (EC) measurements are used routinely in many industrial and environmental applications as a fast, inexpensive and reliable way of measuring the ionic content of a solution. In many cases, it is directly linked to the total dissolved solids (TDS). EC is used to determine mineralization of water and by virtue of it the physiological effect on consumers can be predicted. High TDS imparts "mineral taste". It also denotes possibility of corrosion or encrustation of metallic distribution systems, which affect domestic plumbing, hot water heaters, toilet flushing mechanisms, faucets, washing machines and dishwashers.

Iron and Manganese concentration

As far as is known, humans suffer no harmful effects from drinking water containing iron and manganese.

However, both iron and manganese interfere with laundering operations, impart objectionable stains to plumbing fixtures and cause difficulties in distribution systems by supporting growths of iron bacteria. Iron also imparts a taste to water, which is detectable at very low concentrations.

Hardness:

Magnesium hardness, particularly associated with the sulfate ion, has a laxative effect on people unaccustomed to it. Magnesium concentrations of less than 50 mg/L are desirable in potable waters, although many public water supplies exceed the amount.
Calcium hardness presents no public health problem. In fact, this hardness is apparently beneficial to the human cardiovascular system.

E.coli Concentration:

E.coli can cause several intestinal and extra-intestinal infections such as urinary tract infection and mastitis. However, it is not always harmful to human bodies. Yet, E.coli concentration should be controlled in water because many types of them cause diseases like bloody diarrhoea, anaemia and so on.

1.4 Limitations

The experiments to determine the E.coli concentrations were faulty. The values of E.coli concentration in February, March and April were not flawless since there was a lack of precautions. There was a chance of intrusion of germs in the media from outside source; for instance, open hands of laboratory technicians, surrounding air etc. This may result in higher values than the exact ones. Furthermore, the measurements of E.coli concentration were not absolutely correct since we took the value for 10 millilitre of water sample and transformed it into that for 1 Litre by multiplying it with 100. It is very natural and expectable to get 1 E.coli germ in a random 10 mL sample. But if this value is transformed into 100 per Litre, the value surmounts the standard range. Therefore, it was an irrational approach of measurement. But preparing media with 1 Litre sample was very expensive, so the experiment had to be conducted in the aforementioned way.

The values for June, July, August and September could not be measured due to the dearth of expensive reagents and other materials.

Chapter 2
LITERATURE REVIEW

2.1 Importance of Drinking Water

Water is very essential for life; without water life cannot sustain. Inadequate intake of water can result in dehydration, and dehydration can result in impaired work performance and morbidity. On the other hand, health benefits can be derived from the liberal intake of fluids of appropriate composition. The importance of drinking water becomes obvious when we consider the role of water as a constituent of the human body. Almost 75% of the human body is water.[1]

The various physiological functions that keep the human body alive and active are the results of the many physiochemical reactions that take place within the body. The nature of these reactions and electric, i.e. ion based. These reactions are facilitated by water which acts as the medium. Hence, the importance of water in the human body is paramount.

A cell in the body exchanges elements with the rest of the body by electrolysis. In a normal case, minerals and micro elements pass through the cell membrane to the nucleus by electro-osmosis. It is a common observation that one of the foremost protocols for a patient upon hospitalization is the intravenous saline solution. Extreme cases of dehydration can be the cause of death. Minor dehydration – not enough to kill – is both the result and hidden cause of many illnesses. The inverse is also true. Good hydration is at the foundation of good health.

Adequate water intake in the right amount of minerals therefore is essential and a wise practice, because administrating an intravenous saline water solution in the hospital is expensive.

In extreme case of severe dehydration, protoplasm of any living cells dries out, and the result is the end of life. This phenomenon is at the base of premature aging -- inadequate drinking of water (for a long period of time) causes the basic metabolic, physical and chemical activities to diminish, depriving the human body of the vital elements it needs. One of the first symptoms of dehydration is the degradation of the skin, which is the most exposed organ of the body.[1]

There are, of course, many more benefits of drinking water. For instance:

- Water makes it possible for the electric reactions to take place within the cells, as shown above, and keeps the pH body balance.
- Water dissolves toxins and helps body to flush them away.

- Water physically and chemically breaks down the food we eat, assisting the metabolic system.
- Water transports all the nutrients to different parts of the body.
- Water in the blood also transports the oxygen we breathe to all organs.
- Water lubricates cartilages that buffer all joints.

Proper intake of water can also eliminate unnecessary drug or medication intake along with dehydration. Dehydration also causes many sorts of discomforts and can hinder proper physiological functions for which the body automatically takes water from less demanding organs to cover the needs of the main important ones.[1] The affected parts of the body start to alert in different ways, causing pain and other complications leading people towards medication. Drinking water or remineralized water can help keep the body vitalized and fit.

Drinking adequate amount of water is perceivably important and necessary for every organ and bodily functions. Starting from the nervous system to the urinary system and all the organs therein, water nourishes and enables uninterrupted functions up to the cellular level, given that the organs are receiving other nourishments and minerals properly. Kidneys are the vital organs of the human body which are directly related to water intake and regulate mineral accumulation within the body. They are powerful chemical factories that perform the following functions[2]:

- remove waste products from the body, including inorganic minerals
- remove drugs from the body
- balance the fluids of the body
- release hormones that regulate blood pressure
- produce an active form of vitamin D that promotes strong, healthy bones
- control the production of red blood cells

In order to maintain health, the kidneys must excrete a minimum of 2 liters of urine per day. [3] When water is not available, there is nothing present in which to dissolve the body's waste products (uric acid and urea) for expulsion. As a result, they build up within the body, leading to kidney stones and putting additional strain on the kidneys to find adequate liquid with which to expel the toxins.

2.2 Water Hardness (Calcium and/or Magnesium content of water) and Health Effects

More than 80 observational and epidemiological studies were collected from the worldwide literature, published in 1957, which relates water hardness and cardiovascular disease risks. These studies were conducted in more than 17 countries, primarily in North America, Europe and Japan (WHO, 2005).

Most, but not all, of the studies found an inverse (protective) association between cardiovascular disease mortality and increased water hardness (measured by Calcium Carbonate or another hardness parameter and/or the calcium and magnesium content of water). The associations were reported in numerous countries, and by many different investigators, with different study designs. Both population and individual-based studies have observed benefits. The most frequently reported benefit was a reduction in ischemic heart disease mortality. The strongest epidemiologic evidence for beneficial effects was of drinking water magnesium concentrations; there was also evidence - but not as strong – of drinking water calcium concentrations. In addition, there is supporting evidence from experimental and clinical investigations suggesting a plausible mechanism of action for calcium and magnesium. The potential significance of the epidemiological findings is that beneficial health effects may possibly be extended to large population groups on a long-term basis by simple adjustments of the water quality (WHO, 2005).

Hard water is a dietary source of calcium and sometimes magnesium, although the absolute relative concentrations will vary greatly by source and the water consumption level. Consumption of moderately hard water containing typical amounts of calcium and magnesium may provide an important incremental percentage of the daily dietary requirement. Inadequate total dietary intakes of calcium and magnesium are common worldwide, therefore, an incremental contribution from drinking water can be an important supplement to approach more ideal total daily intakes (WHO, 2005).

There are no known harmful human health effects in the general public associated with the consumption of calcium and magnesium within a large range, and the nutritional essentiality of calcium and magnesium is well known. In addition, limited but suggestive evidence exists for benefits associated with other diseases (stroke, renal stone formation, cognitive impairment in elderly, very low birth weight bone fractures among children, pregnancy complications, hypertension and possibly some cancers). The suggestion is that reintroduction of magnesium and calcium into demineralized water in the remineralizaion process would likely provide health benefits in consumer populations. Adding calcium and magnesium carbonates (as lime or limestone) to the demineralized water is a common water stabilization practice and is relatively inexpensive (WHO, 2005).

2.3 Definition of Nutritional Requirements and recommendations

Experts from many countries and international organizations have defined nutritional needs and recommendations. The requirement of a nutrient, as defined by the World Health Organization, the Food and Agriculture Organization of the United Nations and the International Atomic Energy Agency (WHO/FAO/IAEA) Expert Consultation on Trace Elements in Human Nutrition and Health, is "the lowest continuing level of nutrient intake that, at a specified efficiency of utilization, will maintain the defined level of nutrition in the individual" (WHO/FAO/IAEA, 1996).

Basal requirement is the "intake needed to prevent pathologically relevant and clinical signs of impaired function attributable to inadequacy of the nutrient". However, the basal requirement does not account for the needs to maintain nutrient reserves in the body, or consider the amount sufficient to ensure that absorption and retention were not operating at maximum capacity. Therefore, the value needed to fulfill the basal requirement plus the additional needs to maintain a level of tissue storage or other reserves constitutes the normative requirement (WHO/FAO/IAEA, 1996).

However, how important reserves are is an open question. The criterion utilized to define nutrient inadequacy may differ for individuals at different life stages. On the other hand, the knowledge of the criteria used to define nutrient inadequacy is important to integrate and/or compare requirements obtained from different sources of evidence.

2.4 Various modes of drinking water

Water pollution and scarcity of safe drinking water has become a major global concern of the present times. This situation is very pronounced in Bangladesh. Declining groundwater levels (> 1 m /yr) are detected in the urban and sub-urban areas around Dhaka, as well as in north-central, north-western and south-western parts of the country (0.1 – 0.5 m/yr), and this condition is getting worse day by day (Shamsuddoha et.al., 2009).

The major sources of water, whether for drinking, industrial or agricultural use, are surface water (30%) and ground water (69%). Very little recycling/reuse of water is taking place. The usage pattern of water can be broadly divided into the following: 96% for agricultural use, 3% for domestic case and 1 % for industrial use (Ministry of Foreign Affairs, Denmark. 2010).

Availability of clean water is one of the major challenges faced by Bangladesh along with an ongoing energy crisis and the poverty situation. High economic and population growth has lead to an extensive over-usage of ground water. Arsenic in the ground water is another major issue for concern. More than half of the 160 million people living in Bangladesh are exposed to arsenic and 20 million people are said to be exposed to excessive levels of arsenic pollution (Ministry of Foreign Affairs, Denmark, 2010).

Flood, a common phenomenon in Bangladesh, also has an impact on drinking water: it contaminates water and creates a shortage of safe drinking water. As a result, water borne diseases break out and spread rapidly through out localities, adding more to the suffering of the people.

In light of the following circumstances, it can be seen that various options of water supply, especially for drinking water, should be available. People should also have the awareness of and accessibility to those options. The various modes of drinking water can be enumerated as tap water, spring water, bottled water, alkaline water, harvested rain water, ground water, etc.

2.4.1 Tap water

Tap water quality varies from country to country or from region to region. It can come from the surface (lakes) or underground (wells). Tap waters are usually treated by chlorination to remove bacterial contamination. Previously treated water may still contain harmful substances. Tap water can have following impurities:

1. Chlorine: Chlorine in drinking water is a potential cancer generator. It also sometimes crosses the taste and odor threshold.
2. Lead: Lead in drinking water can also cause a variety of adverse health effects.
3. Heavy metals: Toxic metals and heavy metals can be introduced in water from faulty, aging pipes and from ground through leakage of pipes.
4. Organic chemical compounds: There can be chemical contaminants and bacteria in drinking water due to inadequate treatment.

Clean, healthful drinking water is essential to physical well-being. It can be arranged by using filters that are appropriate for waters with specific contents found upon testing.

2.4.2 Harvested Rain Water

It can be a viable source of drinking water. The rain water after sometime the shower had gun is pure enough for drinking. However, harvesting rain water and using it have not yet attained an effective implementation. Not to mention that this mode is also largely dependent on time/season and regions (of heavy rainfall to no rainfall), and is hence a very unreliable source of water supply.

2.4.3 Bottled Water

Bottled water can be distilled water, mineral water or carbonated water.

Distilled water is completely devoid of any minerals. Drinking distilled water therefore cannot contribute to supplying dietary minerals to health.

As for mineral water, the U.S. Food and Drug Administration classifies mineral water as water containing at least 250 parts per million total dissolved solids (TDS), originating from a geologically and physically protected underground water source. No minerals may be added to this water (FDA,2010).[4] In Europe, the European Economic Community Mineral Water Regulations prohibit the processing and treatment of any bottled water from the source (von Wiesenberger, 1991).

Water collected directly from springs is also available in many countries. Spring water can be very healthful as it contains useful minerals. Athletes often drink alkaline, carbonated water as it is known to reduce fatigue on a short-term basis. This sort of bottled water contains high amounts of bicarbonates and gives an immediate energy boost for a temporary period of time.[5] Two of the imported labels of this study, i.e. Perrier[6] and Evian[7] (French products), are natural spring waters and the spring from which water for Perrier is collected is carbonated. However, they both contain significant amounts of bicarbonate.

Chapter 3
METHODOLOGY

3.1 Sample Collection

This study consists of 12 samples collected from all the buildings of IUT. These buildings are named as -- --

1. The Mosque
2. South Cafeteria
3. Medical Centre
4. North Hall
5. South Hall
6. South Student Centre
7. Administrative building
8. Old Academic Building
9. New Academic Building
10. Library
11. Mechanical Workshop
12. Electrical Workshop

All these samples are tap waters. They come from the main pump located beside the North Hall. The submersible pump has a depth of 500 ft. The water collected by the pump from ground water aquifer is directly distributed through MS pipes, which encompasses the whole area of IUT. The aquifer is in the Pleistocene terrace of the Madhupur-Barind tract that is semi-confined in nature. It is very deep since it is of Pleistocene age.

3.2 Test procedures and Test standards

The water quality parameters that have been measured are –

a. pH

b. Color

c. Turbidity

d. Electrical Conductivity (EC)

e. Iron Concentration

f. Manganese Concentration

g. Hardness

h. E.coli Concentration

The test procedures and calculations of them are described consecutively below:

3.2.1 pH:

Reagent:

Standard solutions for calibration of pH meter

Apparatus:

pH meter

Procedure:

1. Calibration of the pH meter using a standard pH solution was performed.

2. 100 ml of the sample was taken in beaker. It was reassured that the sample was not agitated in order to avoid exchange of gases between sample and atmosphere.

3. The pH meter was inserted in the sample. After allowing some time for attainment of equilibrium, the pH meter was turned on and a reading was taken.

3.2.2 Color:

Apparatus:

Spectrophotometer

Procedure:

1. The cell containing the distilled water was placed in the sample compartment with the transparent sides facing the light source. Then the compartment lid was closed.

2. “AUTO ZERO” key was pressed to set the zero.

3. The distilled water was discarded and the sample was placed in the measuring position. Afterwards, the compartment lid was closed again.

4. The “START” key was pressed to measure the color.

5. The concentration (Conc.) was recorded as color units for the sample.

3.2.3 Turbidity:

Apparatus:

Portable Turbidimeter

Procedure:

1. Firstly, the sample cell was filled with the sample up to the line (approximately 30 mL). The cell was capped carefully.

2. The sample was held by the cap and was wiped to remove water spots and finger prints.

3. A thin bed of silicone oil was applied from the top to the bottom of the cell, just enough to coat the cell with a thin layer of the oil. Using the oiling cloth provided, the oil was spread uniformly. The excess was wiped off. The cell had to appear nearly dry with little or no visible oil.

4. After ensuring that the filter was in place. The sample cell was placed in the instrument cell compartment and the lid was closed.

5. Then the "RANGE" key was pressed and the range was collected.

6. The appropriate signal averaging setting (on or off) was selected by pressing the "SIGNAL AVG" key.

7. The appropriate Ratio setting (on or off) was selected by pressing the "RATIO" key. By pressing the "UNITS" key the appropriate was selected.

8. Eventually, the results were read and recorded.

3.2.4 Electrical Conductivity:

Apparatus :

Portable Conductivity Meter

Procedure :

1. Firstly, 200 mL of sample was taken into a receptacle.
2. The probe of apparatus was inserted
3. In water the unit was set by appropriate button.
4. The "DISPLAY" button was pressed and the value was obtained from the screen.

3.2.5 Iron Concentration:

Reagent:

1. Hydrochloric Acid
2. Potassium permanganate solution
3. Potassium thiocyanate solution
4. Standard iron solution

Apparatus :

1. Nessler tube
2. Measuring cylinder
3. Dropper

Procedure:

1. 100 mL of sample was placed in a Nessler.
2. 5 mL of dilute HCL was added.
3. 2 drops of KM_nO_4 solution was added.
4. 5 mL of KCNS solutions was added. The solution turned brown due to the dissolved Iron.
5. The color was compared with the standard prepared as follows:
    a. The foretold procedure was repeated for distilled water.
    b. Gradually more and more standard iron solution was being added (0.2 mL at a time) until the color of the standard and the sample matched.
6. The amount of iron solution added was recorded and the unit was converted to mg/L to attain the concentration.

3.2.6 Manganese Concentration:

Reagent:

1. Alkaline Cyanide
2. Ascorbic acid powder pillows
3. PAN indicator solution, 0.1%
4. De-ionized water

Apparatus:

Spectrophotometer

Procedure:

1. The test was first selected on the screen of the apparatus.

2. The Multi-cell Adapter was inserted with the 1-inch square cell holder facing the user.

3. 10 mL of de-ionized water was poured into a square sample cell (blank prepared).

4. 10 mL of sample was poured in another square sample cell (sample prepared).

5. The contents of one Ascorbic acid Powder Pillow were added to each cell and the cells were dissolved in water by swirling.

6. 12 drops of Alkaline Cyanide solution were added to each cell and the cells were swirled gently to mix.

7. 12 drops of 0.1% PAN indicator solution were added to each cell and the cells were again swirled gently.

8. The timer was pressed that initiated a two-minute reaction period.

9. After the timer had expired, the blank was wiped and inserted into the cell holder with the fill line.

10. ZERO was pressed. The display exhibited 0.000 mg/L Mn.

11. The sample cell was wiped and inserted into the cell holder with the fill line.

12. Finally, the results were recorded.

3.2.7 Hardness:

Reagent:

1. Buffer solution
2. Eriochrome Black T dye
3. Standard EDTA solution

Apparatus:

1. Beaker
2. Measuring Cylinder
3. Dropper
4. Stirrer

Procedure:

1. 100 mL of sample was taken in a clean beaker.

2. 2 mL of buffer solution was added to sample so that the pH was maintained between

9 and 10.

3. Few drops of EBT indicator were added to the sample and it turned to wine-red color.

4. Burette was rinsed with few mL of EDTA solution. Then the burette was filled with standard EDTA solution.

5. The sample was titrated against the EDTA solution, till all the Calcium and Magnesium ions present reacted with EDTA. Appearance of blue color indicated that all these ions were complexed with EDTA and thereby the point was confronted.

6. The burette reading was noted down.

Calculations:

Total Hardness (mg/L as $CaCO_3$) = Vol. Of EDTA x Normality of EDTA x Equivalent weight of $CaCO_3$ x 1000/vol of sample taken

3.2.8 E.coli Concentration:

E.coli Concentration was determined by preparing “Media” comprising necessary environment for E.coli to grow up adequately and be visible. The process of preparing this media is described below:

Apparatus:

1. Petri dish
2. Filter paper
3. Vacuum pump
4. Incubator

Ingredients:

1. 1L distilled water
2. 48 g m Endo Broth powder
3. 15.5 g Bacto Agar powder
4. 20 mL Ethanol

Procedure:

1. The ingredients were mixed together in the foretold amount and then boiled.
2. 20mL of the mixture was taken into Petri dish and it was frozen for 4-5 minutes.
3. After preparation of the media, the filter paper was taken on filtering flux. By means of a vacuum pump, the 10 mL sample water was made to pass through the filter paper. The germs got collected on the filter paper.
4. The filter paper was placed in the media and along with it was kept in incubator for 24 hours. After that, the inflated visible E.coli germs were counted and the concentration was amplified to get the concentration of 1 Litre sample.

Table 3.2

Chart of standard values of Water Quality Parameters

Parameter	Standard Value	Unit
pH	6.5 – 8.5	-
Color	<15	pt-Co
Turbidity	<5	NTU
Electrical Conductivity	0.1 - 50	mS/ cm
Iron Concentration	0.3 – 1.0	mg/ L
Manganese Concentration	<0.4	mg/ L
Hardness	no specific value	mg/ L
E.coli Concentration	20 - 80	No. / L

Chapter 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter deals with the results obtained from the testing and data analysis of the selected water quality parameters. The causes of their mutual differences and seasonal variation will be discussed here. Along with it, the major findings will be delineated in subsequent portion.

4.1.1 pH:

pH is the measure of the acidic or alkaline condition of water. It is a way of expressing the hydrogen ion concentration or more precisely, the hydrogen ion activity of water. pH is defined as follows :

$$pH = -\log\{H^+\}$$

, where $\{H^+\}$ is the concentration of hydrogen ion (or proton) in moles per litre (M)

The pH is usually represented by a scale ranging from 0 to 14, with 7 being the neutral. A pH less than 7 implies basic condition. Groundwater is found often to be slightly acidic on account of presence of excessive carbon-di-oxide. Groundwater sometimes can also be found to be alkaline due to the presence of bicarbonate and, less often, carbonate.
Water with pH outside the desirable neutral range may exhibit sour taste and accelerate the corrosion of metallic plumbing fittings and hot water services.

Table 4.1
The Result Chart: Parameter: pH
Standard Value in Drinking Water: **6.5 – 8.5**

Month	Feb	Mar	Apr
Building			
Mosque	7.12	6.85	6.79
South Cafeteria	7.31	6.80	6.76
Medical Centre	7.19	6.85	6.81
North Hall	7.37	6.84	6.79
South Hall	7.33	6.81	6.77
South Student Centre	7.27	6.80	6.75
Administrative Building	7.21	6.84	6.80
Old Academic Building	7.25	6.82	6.77
New Academic Building	7.29	6.87	6.85
Library	7.28	6.86	6.81
Mechanical Workshop	7.26	6.81	6.78

Month	Jun	Jul	Aug	Sept
Building				
Mosque	7.13	6.83	6.90	6.91
South Cafeteria	7.11	6.82	6.91	6.95
Medical Centre	7.07	6.82	6.96	6.91
North Hall	7.29	6.87	6.95	6.99
South Hall	7.09	6.86	6.93	6.95
South Student Centre	7.01	6.88	6.98	7.02
Administrative Building	7.05	6.81	6.91	6.93
Old Academics Building	7.18	6.84	6.90	6.89
New Academic Building	7.04	6.85	6.97	6.95
Library	7.07	6.87	6.99	7.00
Mechanical workshop	7.12	6.86	6.92	6.90
Electrical Workshop	7.10	6.85	6.91	6.87

4.1.2 Color:

Most water available to us is colored to some extent due to the presence of various impurities like iron and manganese, in association with organic matter from decaying vegetation.

Table 4.2
The Result Chart: Parameter: Color
Standard Value in Drinking Water : **<15 pt-Co**

Month	February	March	April
Building			
Mosque	1	2	4
South Cafeteria	5	6	7
Medical Centre	6	4	2
North Hall	2	3	5
South Hall	5	7	8
South Student Centre	2	2	4
Administrative Building	2	5	8
Old Academic Building	3	5	5
New Academic Building	2	4	6
Library	6	6	7
Mechanical Workshop	3	5	6

Month	Jun	Jul	Aug	Sept
Building				
Mosque	13	15	3	2
South Cafeteria	18	22	17	12
Medical Centre	11	27	13	37
North Hall	17	21	5	2
South Hall	20	23	9	1
South Student Centre	19	23	4	3
Administrative Building	10	12	8	2
Old Academics Building	12	11	8	7
New Academic Building	31	33	7	6
Library	15	17	7	6
Mechanical workshop	15	16	5	1
Electrical Workshop	13	15	4	1

4.1.3 Turbidity:

The term "turbid" is applied to water containing suspended matter that interferes with the passage of light through water. Turbidity is a measurement of water clarity. In groundwater, it is associated with inorganic metal oxides, geological materials (e.g. clay particles) and macromolecular components of dissolved organic carbon (e.g. humic acids). Turbidity is a useful indicator of groundwater quality changes.

Table 4.3
The Result Chart: Parameter: Turbidity
Standard Value in Drinking Water : **<5 NTU**

Month	February	March	April
Building			
Mosque	0.5	0.44	0.4
South Cafeteria	0.41	0.63	0.79
Medical Centre	0.49	0.46	0.45
North Hall	0.52	0.44	0.39
South Hall	1.01	1.01	1.02
South Student Centre	0.54	0.61	0.69
Administrative Building	0.7	0.71	0.72
Old Academic Building	0.45	0.47	0.5
New Academic Building	0.49	0.55	0.64
Library	0.76	0.77	0.78
Mechanical Workshop	0.55	0.64	0.72

Month	Jun	Jul	Aug	Sept
Building				
Mosque	1.8	0.67	0.59	0.3
South Cafeteria	1.09	0.95	1.11	2.11
Medical Centre	0.81	0.53	0.85	0.42
North Hall	0.66	0.65	0.72	0.64
South Hall	1.17	1.57	1.86	1.46
South Student Centre	1.00	0.89	0.76	0.66
Administrative Building	1.02	0.91	0.93	0.95
Old Academics Building	0.92	0.74	0.84	0.44
New Academic Building	4.71	1.86	1.10	2.12
Library	1.33	0.75	0.93	0.70
Mechanical workshop	0.92	0.94	0.71	0.69
Electrical Workshop	0.95	0.88	0.67	0.64

4.1.4 Electrical Conductivity:

Electrical Conductivity of water is a measure of its ability to conduct electricity. It also estimates mineralization or the amount of solids dissolved in water (i.e. TDS) since the electrical conductivity of water is directly linked with the ions of dissolved solids.

Table 4.4
The Result Chart: Parameter: Electrical Conductivity
Standard Value in Drinking Water: **- 50**

Month	February	March	April
Building			
Mosque	0.45	0.47	0.5
South Cafeteria	0.42	0.46	0.5
Medical Centre	0.44	1.2	1.9
North Hall	0.43	0.48	0.5
South Hall	0.43	1.1	1.8
South Student Centre	0.41	0.9	1.9
Administrative Building	0.42	0.95	1.9
Old Academic Building	0.42	0.5	0.6
New Academic Building	0.44	1.2	1.8
Library	0.41	1.1	1.7
Mechanical Workshop	0.42	0.5	0.6

Month	Jun	Jul	Aug	Sept
Building				
Mosque	0.50	1.54	0.52	1.73
South Cafeteria	0.51	1.59	0.49	1.74
Medical Centre	0.52	1.78	0.51	1.80
North Hall	0.52	1.66	0.50	1.75
South Hall	0.51	1.50	0.49	1.68
South Student Centre	0.48	1.70	0.46	1.75
Administrative Building	0.51	1.63	0.47	1.76
Old Academics Building	0.51	1.60	0.48	1.74
New Academic Building	0.53	1.77	0.48	1.89
Library	0.50	1.49	0.51	1.70
Mechanical workshop	0.52	1.73	0.50	1.80
Electrical Workshop	0.51	1.72	0.48	1.79

4.1.5 Iron Concentration:

The problems related with Iron concentration are most critical for groundwater. Since groundwater usually contains significant amounts of carbon-dioxide and the adjacent soils contain Iron, groundwater can possess appreciable amount of ferrous carbonate.

Table 4.5
The Result Chart: Parameter: Iron Concentration
Standard Value in Drinking Water: **0.3 – 1.0**

Month	**February**	**March**	**April**
Building			
Mosque	0.1	0.2	0.3
South Cafeteria	0.2	0.4	0.5
Medical Centre	0.1	0.4	0.6
North Hall	0.2	0.3	0.4
South Hall	0.2	0.5	0.8
South Student Centre	0.3	0.5	0.8
Administrative Building	0.4	0.6	0.7
Old Academic Building	0.2	0.4	0.7
New Academic Building	0.1	0.5	0.6
Library	0.5	0.6	0.8
Mechanical Workshop	0.3	0.5	0.7

Month	**Jun**	**Jul**	**Aug**	**Sept**
Building				
Mosque	0.3	0.06	0.04	0.34
South Cafeteria	0.5	0.07	0.07	0.70
Medical Centre	0.2	0.01	0.04	0.27
North Hall	0.4	0.07	0.06	0.55
South Hall	0.7	0.09	0.08	0.78
South Student Centre	0.6	0.08	0.07	0.71
Administrative Building	0.6	0.07	0.07	0.67
Old Academics Building	0.3	0.07	0.06	0.59
New Academic Building	0.5	0.05	0.06	0.61
Library	0.6	0.08	0.07	0.66
Mechanical workshop	0.3	0.06	0.04	0.52
Electrical Workshop	0.2	0.06	0.04	0.49

4.1.6 Manganese Concentration:

Manganese concentration is a very significant water quality parameter. The problems regarding it in groundwater are very critical and sometimes more critical than those regarding Iron concentration. The soil adjacent to aquifer contains appreciable amount of manganese, and groundwater definitely holds certain amount of it.

Table 4.6
The Result Chart: Parameter: Manganese Concentration
Standard Value in Drinking Water : **<0.4**

Month	February	March	April
Building			
Mosque	0.215	0.232	0.256
South Cafeteria	0.222	0.256	0.294
Medical Centre	0.231	0.321	0.510
North Hall	0.197	0.208	0.235
South Hall	0.237	0.409	0.553
South Student Centre	0.212	0.316	0.506
Administrative Building	0.236	0.421	0.515
Old Academic Building	0.199	0.227	0.286
New Academic Building	0.210	0.358	0.423
Library	0.229	o.367	0.488
Mechanical Workshop	0.219	0.343	0.395

Month	Jun	Jul	Aug	Sept
Building				
Mosque	0.277	0.037	0.023	0.249
South Cafeteria	0.336	0.053	0.035	0.462
Medical Centre	0.321	0.051	0.041	0.453
North Hall	0.247	0.044	0.031	0.371
South Hall	0.416	0.072	0.043	0.594
South Student Centre	0.495	0.067	0.044	0.593
Administrative Building	0.449	0.063	0.045	0.517
Old Academics Building	0.307	0.032	0.021	0.289
New Academic Building	0.391	0.062	0.041	0.568
Library	0.415	0.059	0.039	0.484
Mechanical workshop	0.288	0.046	0.038	0.383
Electrical Workshop	0.256	0.043	0.032	0.356

4.1.7 Hardness:

Hardness is caused by multivalent metallic cations. The principal hardness causing cations are – Calcium, Magnesium, Strontium, Ferrous and Manganese ions. Usually, groundwater is harder than surface water.

Table 4.7
The Result Chart: Parameter: Hardness
Standard Value in Drinking Water: no specific value

Month	February	March	April
Building			
Mosque	10.45	9.29	10.45
South Cafeteria	5.8	5.8	6.97
Medical Centre	6.97	5.8	6.97
North Hall	4.64	3.48	5.8
South Hall	2.32	4.64	9.29
South Student Centre	3.48	4.64	5.8
Administrative Building	2.32	5.8	8.13
Old Academic Building	3.48	4.64	9.29
New Academic Building	4.64	6.97	9.29
Library	3.48	6.97	8.13
Mechanical Workshop	4.64	5.8	8.13

Month	Jun	Jul	Aug	Sept
Building				
Mosque	16.01	50.04	34.03	44.04
South Cafeteria	22.02	58.05	42.04	54.05
Medical Centre	16.01	38.03	22.02	40.03
North Hall	18.02	40.04	30.03	42.04
South Hall	34.03	74.07	40.04	68.06
South Student Centre	20.02	56.05	38.03	52.04
Administrative Building	30.03	66.06	50.04	62.05
Old Academics Building	16.01	58.05	40.04	56.05
New Academic Building	22.02	52.05	42.04	50.04
Library	24.02	60.05	36.03	52.04
Mechanical workshop	12.01	52.05	28.02	48.04
Electrical Workshop	14.01	50.04	32.03	46.04

4.1.8 E.coli Concentration:

Escherichia coli (also known as E.coli) are gram-negative, facultative anaerobic, rod-shaped bacteria of the genus Escherichia. They are commonly found in the lower intestine of warm-blooded organisms. Most E.coli strains are harmless but some stereotypes can cause serious food poisoning in their hosts.

Table 4.8
The Result Chart: Parameter: E.coli Concentration
Standard Value in Drinking Water: **20-80**

Month	February	March	April
Building			
Mosque	500	300	1300
South Cafeteria	100	400	500
Medical Centre	100	200	100
North Hall	0	0	100
South Hall	0	100	0
South Student Centre	100	200	800
Administrative Building	300	200	300
Old Academic Building	200	100	200
New Academic Building	0	100	100
Library	200	300	600
Mechanical Workshop	200	0	300

4.2 Causes of the variation of values of the parameters from building to building

The factors that influence the mutual variation of values of the parameters are –

a. Corrosion of pipes
b. Rust deposition on walls of pipes
c. Leachate from inner walls of pipes
d. Permeation from outside of the pipes

The pipes that are used for the distribution of water in IUT are Mild Steel pipes. Mild Steel is an Iron-Carbon alloy containing Carbon (< 0.25%) and Manganese (0.4%).[8] The collision of transporting water with the walls of pipes results into intrusion of their molecules in water. This is how Iron and Manganese concentrations increase in water that is finally obtained from tap. The intruder carbon molecule dissociates the water molecule H_2O into H^+ an OH^- ions. The generation of H^+ lowers the pH value of the water. Furthermore, Carbon reduces redox potential which enhances the concentration of Calcium and Magnesium ions(i.e. hardness), Iron and Manganese. Finally, the increment in the concentrations of the dissolved solids increases the Electrical Conductivity (EC). EC of water is directly related to the concentration of dissolved ionized solids in water. Ions from these solids create the ability for that water to conduct an electrical current. The relation between TDS (Total Dissolved Solids) and EC can be shown as follows :

$TDS = K_e \, EC$

where,

TDS is in mg/L and
EC is in mS/cm
At 25ºC
K_e is the co-relation factor. It's value range is : 0.55~ 0.8.[9]

$pH = -\log \{H^+\}$

The intrusion of molecules in water from pipes in aforementioned way is called "Leachate ".

Sometimes at a certain velocity of water, release of soft deposits, re-suspension of sediments, detachment of bio-films and so on may occur which increases the turbidity of water.

Since color of water is associated with dissolved solids and suspended geological materials, it also varies due to aforementioned incidents.

Though transportation of water through the mild steel pipes cause minimum damage to them, these pipes are not totally free from corrosion. Corrosion culminates into leachate. Corrosion also affects the flow.
Permeation implies the entrance of organic carbon and other materials from outside sources, which in this case are – surrounding soil and walls. Permeation influences the values of the parameters in ways similar to those by leachate.

Rust gets gathered on pipes due to chemical reaction among iron, oxygen and water. Rust deposition also influences the values of water quality parameters the same ways as permeation and leachate do.

However, the variation eventually occurs on account of the variation of the aforementioned factors from one pipe to another which, in turn, is associated with many factors:

a. Pipe diameters (since it puts effect on velocity which is responsible for leachate and rust deposition). The relation between velocity, flow and are is—

   $Q = VA$

   V = Velocity of water
   Q = flow of water
   A = Area of pipe[10]

b. Sudden or gradual expansion or contraction of pipes
c. Friction
d. Absolute roughness: The surface roughness of a material which a fluid may flow over.
e. Permeability of pipe ingredients
f. Drainage slope
g. Drainage length
h. Temperature and pressure in environment
i. Gravity effects

Permeation is influenced by an additional factor– the concentration of contaminant in pores of soil surrounding the pipes.

As these factors vary from one portion of distribution system to another, the leachate, permeation, corrosion and rust mingling vary over the entire system. Hence, water from different buildings show different values of the parameters.

4.3 Causes of the seasonal variation of the water quality parameters

The values of the parameters change from one season to another. The reasons of this phenomenon have been discussed here. The discussions have been divided into two parts. There are separated groups of parameters in each of which all the parameters influence each other and are somehow interconnected. The reasons of the variation of the groups are also different.

4.3.1 pH, Iron and Manganese concentration, Hardness, Electrical Conductivity :

Three reasons have been identified –-

1. Volatile rainfall pattern
2. Temperature fluctuation
3. Redox potential drop in summer

1. Volatile rainfall pattern:

Rainfall began in March and increased up to the end of April. It again appeared in the period of June-July. An appreciable amount of rainfall occurred in September as well. Rainwater is the source of groundwater recharge which is slightly acidic since it combines with the carbon-dioxide in atmosphere, forming carbonic acid (H_2CO_3). It dissociates into HCO_3^- and H^+ ions (Krauskopf,1994).[11] Increment in these ions after mixing with rainwater lowers the pH of groundwater since pH is the negative log of activity of H^+ in an aqueous solution. Lowering of pH (i.e. increment in H^+ concentration) results into more solubility of salts. [12]

These ions are very tiny and are able to enter and disrupt mineral structures so that they contribute to dissolved constituents (TDS) to groundwater. As a result, the concentration of iron, manganese, calcium and magnesium (hardness) in groundwater increases.

EC of water is directly related to the concentration of dissolved ionized solids in water.

Ions from dissolved solids create the ability for that water to conduct an electrical current.

$$TDS = K_e \, EC$$

where, the unit of TDS and EC are respectively mg/L and ms/cm at 25^o C. The value of correlation factor K_e varies between 0.55 to 0.8[9].

2. Temperature fluctuation:

At any given temperature, there is a specific concentration of a dissolved mineral's constituents in the groundwater that is in contact with that mineral (Dennis Nelson,2002).[11]

Temperature has been raised in transition from spring to summer and also in transition from rainy season to autumn. This rise decreases pH. Gazipur area falls in the Madhupur-Barind tract aquifer, a moderately deep aquifer of Pleistocene age. So, temperature change does not bring about large variation, and neither is it negligible.

Furthermore, at higher temperatures water can dissolve more mineral and TDS concentration has increased thereby.[13]

As mentioned earlier, due to correlation between EC and TDS, EC of groundwater also increases eventually.

3. Redox Potential Drop in Summer:

The solubility of in water depends on whether they are oxidized or reduced. They are more soluble in water in reduced form (Dennis Nelson,2002).[11] So in reducing environment, water has higher concentration of iron and manganese.

Reduction potential (also known as redox potential, oxidation / reduction potential, ORP, pE, ε, or) is a measure of the tendency of a chemical species to acquire electrons and thereby be reduced. Reduction potential is measured in volts (V), or millivolts (mV) (Trevor V. Suslow, 2004).[14]

The most common cause of reducing reactions is organic matter, either in solid form or as dissolved organic carbon(DOC).The oxidation of these molecules(contributing electron) results in iron as solid oxide mineral that is being dissolved in water as reduced iron(receiving electrons)(Dennis Nelson,2002).[11] Due to rainfall, the DOC got elevated.

In our case, soil of Madhupur tract is highly oxidized. Rainfall (seasonal recharge) brought a situation where the groundwater was layered with oxygenated water above and reduced water below. Routine pumping resulted in bulk of water coming from upper oxygenated water. As pumping continued in summer, this layer got depleted and more and more water came from deeper reduced layer. As reduced water dominated, iron and manganese concentration stirred.

4.3.2 Turbidity, Color, E.coli:

Turbidity is a measurement of water clarity that denotes how much the suspended solids impede the passage of light through water. Groundwater is comparatively more vulnerable to faecal contamination. In it, turbidity is associated with inorganic metal oxides (e.g. of Fe, Al etc.), geological materials (e.g. clay particles) and macromolecular components of DOC (e.g. humic acids)(Backhus, 1993; Puls, 1991).[15]Due to rise in DOC after rainfall, turbidity got enhanced.

Furthermore, in reducing environment as explained earlier, the aforementioned inorganic metal oxides form easily and increases turbidity. However, the major cause was the alteration of water table. During spring, little evapo-transpiration occurs from soil and plants respectively. Therefore, ample amount of rainfall and surface water become available for groundwater replenishment. Consequently, the water table increases. But in summer, at peak evapo-transpiration, most rainfall doesn't contribute to groundwater. Water table declines as a result of loss to plants, streams, etc. Lowering of peizometric height of water imparts rapidity in movement of water, resulting in mingling of more geological particles and increase in turbidity. The color of water is influenced by several factors:

a. Adsorption
b. Scattering of light
c. TSS

Since scattering of light is linked with turbidity, color is affected by it. The increment in turbidity results in the increment in color.

Drinking water should ideally have no visible color. In our case, there was substantial change in the values of color in rainy season. Color in drinking water is usually due to the presence of colored organic matter (primarily humic and fulvic acids) associated with the humus function of soil. Color is also strongly influenced by the presence of Iron and other metals, either as natural impurities or as corrosion products it may also be the result of the contamination of the water source with industrial effluents and maybe the first indication of hazardous situation. The source of color in our drinking water supply should be further investigated.

A study (Power and Nagy,1989)[15] exhibited a correlation between E.coli, faecal coliform and turbidity. Our result is not flawless and this aspect has been discussed later.

4.3.3 Some Major Findings: Potential for some future problems:

In this study, we found no health hazards regarding the water of IUT. However, we found potential for some problems regarding secondary contaminants (mainly, Iron and Manganese). There is a wide variety of problems related to secondary contaminants which could be grouped into three categories:

- Aesthetic effects: undesirable taste or odor
- Cosmetic effects: effects which do not damage the body but are still undesirable
- Technical effects: damage to water equipments or reduced effectiveness of treatment for other contaminants[16]

Standards for iron and manganese are based on levels that cause taste and staining problems and are set under EPA secondary Drinking Water Standards. For most individuals 0.3 ppm or mg/L of Iron and 0.05 ppm or mg/L of Manganese is objectionable[17]. The potential problems that were found from the study are given below:

1. **Unpleasant taste imparted by Iron :**

   In this study, it was noted that the value of iron concentration often went across the taste threshold (0.04-0.1). This indicates the presence of a typical bitter, astringent taste to water (JMM 1985)[18].

2. **Growth of Iron, Manganese and Sulfur bacteria :**

   A problem that frequently results from Iron or Manganese in water is 'Iron bacteria' and 'Manganese bacteria'. These non-pathogenic (not health threatening) bacteria feed on Iron and Manganese in water[19].

   Manganese concentration in groundwater is usually high. However, high manganese concentration increases growth of unwanted bacteria. Iron is also very common in groundwater. Therefore, iron and sulfur bacteria can grow easily in aquifer, though it occurs in case of massive amount of Iron. Iron passing the distribution system may promote the growth of micro-organisms(O' Connor 1970;Salvato 1992).[18]

   Bacterial contamination of a water supply system doesn't always mean "health hazard". Some types of bacteria are more annoying than harmful. Iron and sulfur bacteria are two of the most common bacterial contaminants that are confronted by users of groundwater. Neither of them is harmful for human health but they can be incredible nuisances[20].

   Iron bacteria are more common, since iron is abundant in groundwater. They combine iron and manganese in groundwater with oxygen as "oxidizing agent". A side effect of it is a foul smelling slime which coats pipes and plumbing fixtures. It's not a health hazard but can cause unpleasant odors, corrode plumbing equipment and clog the pipes. Sometimes, strange smell resembling fuel oil, cucumbers or sewage maybe noticeable[20].

Manganese bacteria form brownish-black slime in toilet tanks and clogged water systems too[21]. They create nuisance in the similar way of Iron.

Sulfur bacteria impart a distinctive “rotten egg” odor of hydrogen sulfite gas. They also blacken the water or create dark slimes on pipe surfaces[20]. Sometimes iron and sulfur bacteria reduce the yield of water supply[22].

3. **Increased turbidity and Color in water:**

The accumulation of thick slime of several centimeters has been observed in distribution pipes. Sloughing and resuspension of this material by high flow causes high turbidity and the color of water is also, thereby, increased (O’ Connor 1970; Salvato 1992)[18].

4. **Undesirable taste and odor imparted by Manganese :**

In this study the value of manganese concentration often was found to be greater than 0.05 mg/L. Since EPA set the standard value of Manganese concentration regarding taste, odor and color at 0.05 mg/L, this condition denotes unaesthetic conditions like unpleasant taste and odor and so on[16].

5. **Hypothetical adverse neurological effects by Manganese :**

Manganese is a trace element naturally occurring in soil, water and plants. We need small amount of it in our diet, not too much. One study in adults (Kondakis et.al, 1989) [23]show that high Manganese levels in water can be neurotoxic .

Several studies(Bouchard et al in 8 municipalities in Quebec, 2007;He et al ,1994; Zhang et al ,1995)[24] showed that values of manganese concentration above 0.4 mg/L indicate chances of decreased performance and comparatively lower Intelligence Quotient (IQ) among consumers.

Adverse neurological effects (decreased performance in school and in neurobehavioral examinations of World Health Organization Core Test Battery) were reported in children whose average exposure to drinking water was 0.241 mg/L. But, total exposure data were not well-characterized. So a direct link between the disorder and the exposure could not be possibly established[24].

Many studies of similar categories have been conducted throughout the world which eventually compelled WHO to lower the guideline value of manganese concentration in drinking water from 0.5 mg/L to 0.4 mg/L in 2006[25]. Yet, the link between neurobehavioral functions and manganese consumption from drinking water is hypothetical, as these studies could not satisfactorily prove anything on a firm basis.

6. **Reduction of water yield :**

   Iron and manganese deposits gradually build up in pipelines, pressure tanks, water softeners and so on. These reduce the available quantity and pressure of the water supply. Over time as the deposits become excessive, the pipes of the system may need to be substituted. When water supply system needs to be replaced (the whole system or parts of it) an economic problem arises. Also, pumping water through constricted pipes increases energy costs. Thus, the reduction in flow of water poses great inconveniences[26].

7. **Industrial Contamination of groundwater :**

   Manganese and iron are two of the most abundant metals in earth's crust. The sources of iron and manganese in ground water are:

   - Weathering of minerals and rocks which bear iron and manganese
   - Industrial effluent, acid-mine drainage, sewage and landfill leachate[27]

Since Gazipur is a thickly industrialized area, there is a huge chance of contamination of the aquifer by the industrial effluent.

CHAPTER 5

RECOMMENDATION AND CONCLUSION

5.1 Recommendation:

In light of the findings of this study, the following recommendations can me met:

1. There is a need for a wider range and volume of more precise data regarding the quality parameters of IUT water selected for this study in order to assess the suitability of IUT water as potable water source more precisely.
2. There should be conducted adequate study on other paramount quality parameters of IUT water with a view to finding out adversities that may arise from the water and discovering if there is requirement of treatment of water.
3. The color of IUT water was very intense (value being beyond the standard value) during rainy season. Therefore, significance of this behavior should be investigated which requires a more precise and time consuming study in the future.
4. If, by study, it is sought out that the iron and Manganese concentration of IUT water is enhancing day by day, there may be need of treatment plant for this water. In our study, the potential for aesthetic problems due to these parameters' behavior was found. So, further detailed study on these parameters should be conducted.
5. The results of the analysis of the E.coli concentration in IUT water were faulty. There should be more scrutiny of this parameter with adequate precautions and utmost vigilance.
6. Popular intervention studies to evaluate potential health impacts should be conducted in IUT to find out the changes before and after the consumption of IUT water.
7. Periodical study should be conducted on the impact of distribution system over IUT water to evade both health hazards and unaesthetic conditions.
8. Detailed studies should be executed on the rate and trend of water consumption in IUT.
9. Studies should be conducted to ensure if the water of the aquifer is being contaminated with industrial effluents.
10. There should be more study on the rate of changes of the water quality parameters and all the possible reasons of their variations should be found out.

5.2 Conclusion:

Since the source of IUT water is the aquifer, its behavior depends massively on the behavior of the aquifer. The characteristics of the distribution system also have an influence on the water. The behavior of the aquifer changes from season to season due to several climatic factors- rainfall, temperature, etc- and also the properties of the soil adjacent to the aquifer. On account of the characteristics and attributes of the distribution system, the water's behavior also changes from building to building.

Improving aesthetic conditions and health benefits of potable water can have significant impact on the rate of intake. Aesthetically acceptable potable water is definitely more consumed. The vulnerability of the source of potable water to contamination should also be minimum. People of IUT are very much dependent on tap water. In such case, water's potential of becoming aesthetically unpleasant and contaminated is an alarming fact. Precautions ought to be taken in this regard. The water of IUT is, for the present time, safe from health hazards and extreme unaesthetic conditions. But to eradicate, its possibility of becoming polluted or unaesthetic, studies should be continued and future adversities should be sought out.

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