Effect of Drinking Water: A Survey on Health Hazard

A project submitted

by

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Certification statement

This is to certify that this project title ‘A study on the presence iron and its effect on the quality of drinking water and health in the remote area of Bangladesh’ submitted for the partial fulfillments of the requirements for the degree of Bachelor of Pharmacy from the Department of Pharmacy, BRAC University constitutes by my own work under the supervision of Imon Rahman, Lecturer, Department of Pharmacy, BRAC University and that appropriate credit is given where I have used the language, ideas or writing of another.

Signed,

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Countersigned by the supervisor.

_____

Dedicated to my parents, who sacrificed their every desire since my birth to make me human beings and inspire me in every steps of my life.

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Abstract

This study is specifically concerned with the excessive iron content in drinking water and raising awareness among the inhabitants about health vulnerability and the prevalence of health risk of a remote community of Bangladesh as a developing country model.

In the beginning of the thesis, the importance of pure drinking water was described along with different types of available usable water. In addition to these, different reasons behind this water pollution, health risks due to this polluted water & vulnerability in the remote community were marked also. The important message of this study is to show the importance, as well as toxic effects of iron on drinking water quality and human health. Thus it provides clear understanding and awareness to develop the methods of drinking water quality for a healthy lifestyle among the remote society in Bangladesh.

For the primary data collection, a study has been conducted in Dhamrai Upazila of Dhaka, Bangladesh which was carried out by providing questionnaire to all the families of that area. All the data were put to SPSS analysis to measure the frequency of iron in water. Analyzing the result of the study, it is found that drinking water of that particular place is contaminated with iron and this might be the cause of various manifestations of diseases in the local people.

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Abbreviation Index:

SPSS- Statistical Package for the Social Sciences.

DI- Deionization.

UNEP- The United Nations Environment Programmed.

WHO- World health organization.

UNICEF- The United Nations Children's Fund.

USEPA - United States Environmental Protection Agency.

USAID- The United States Agency for International Development.

AWWA- American Water Works Association.

APHA- American Public Health Association.

WEF- Water Environment Federation.

WASSA- Water Supply & Sewerage Authority.

Mg- Milligram.

µg- Microgram.

Kg- Kilogram.

Ng/m3- - Micrograms per Cubic Meter.

L- Litre.

Chapter 1

Introduction

Introduction:

1.1 Importance of water:

Water is the foremost constituent of the fluids of livings and is decisive for all known forms of life. No other planet in the universe other than Earth is a livable place for humans and other living things because of the non-existence of water. Water is essential for drinking, agricultures, household, food preparation, personal hygiene, livestock and every important works of our life. It is impossible for us to survive without pure drinking water. So the importance of water in our life is beyond description. Many of the things will come to a halt without pure water, like household works, agriculture, irrigation, food preparation, personal hygiene and also for some special purposes, such as renal dialysis and cleaning of contact lenses and also in pharmaceutical use, but not for consumption. People use normal water for drinking and everyday use. As the natural sources of pure drinking water become inadequate, scientists invented different processes to purify water. The most purified form of water is distilled water but, in modern times, water is frequently purified by processes including deionization (DI), reverse osmosis, carbon filtering, microfiltration, ultra filtration, ultraviolet, oxidation, or electro-deionization. A combined number of these processes have come into use to produce such highly purified water that its contaminants are measured in parts per billion or parts per trillion. Purified water has significant number of uses, especially in science and engineering laboratories and industries and is produced in a range of purities. But this purified water may contain harmful contaminates which is not safe for drinking.

Providing safe drinking water to the inhabitants is one of the major public health priorities for any Government of any country because it is related to human health. Approximately 70% of human body mass is composed of water excluding fat. Water is also involved in biological process and essential for growth and maintenance of our body which is also a critical component of metabolic process and many bodily solutes are served as a solvent (Gyamfi, et al., 2012). On the other hand, water covers almost 71 percent of the earth's surface, and is significantly essential for all form of life. The earth consists of only 2.5% fresh water among which 98.8% is in ice and ground water, and rivers, lakes and the atmosphere contains 0.3% of all fresh water. 0003% or lesser amount of fresh water is present within biological bodies and manufactured product (Gleick, 1993). Earth's water such as from river, ponds, lakes, ground water are the main

sources of water including rain water which is also a sources of water. We all know that sea water contain more salt so people mainly collect drinking water from river, lakes, ponds and well. Moreover individual person uses about 70000 liters of water during their life time.

A survey conducted in UK shows that, their demand for domestic water were 153 liters in 1993 but in 2000 they used 235 liters of domestic water per persons per day. During summer, the demand of domestic water increase up to 500 liters around the world (Goel, 2006). In winter season people use as much as water which increase a lot in summer season. The huge amount of water loss from our body through urine, sweating and include breathing and diarrhea so people need to drink more water or water containing food.

Only water can complete the thirst more than other drink. An adult should be drinking at least 2-3 liters water per day (Schulsinger, 2015). When we do not drink sufficient amount of water as a result dehydration may occurs. Water is very important to maintain structure of our body cells, help to maintain our body volume, help to regulate our body temperature, make easier in all digestion and absorption function, facilitate in excretion of bowl kidney, and most important component to digestive juice and also lubricates mucous membrane in the gastrointestinal and respiratory tracts (Schulsinger, 2015). When low quality water is used for drinking, irrigation, livestock, aquaculture, poultry consumption and other purpose, iron toxicity may occur (Zaman & Rahman, 1996). So the importance of pure water is very essential in our life. Without it we will not able to survive.

As long as any element present in water even more international recommended limit for specific limit may be treated as pollutants (Gupta & Gupta, 1998). However, guidelines have been developed in order to support the development and implementation of risk management strategies that will ensure the safety of drinking water supplies through the control of possible risk to constituents of water. These guidelines describe minimum requirements practice to protect human health and also indicator of water qualities. Overall health protection strategies that include sanitation and managing food contamination should include these guidelines as well. The development and implementation relating to water, health and local government being taken into account is very much necessary and to view that the regulators are capable enough to take these measures into account is essential as well (WHO).

1.2 Scenario of pure water:

Water being one of the foremost constituent of life has different form throughout all the spheres of the Earth but these forms of water are not necessarily pure and consumable. Though the largest source of water is sea, it contains about 3.5% salt on average and smaller amounts of other substances. The physical properties of sea water differ from fresh water in some important compliments like seawater has a lower freezing point at −1.9 °C and its density increases with declining temperature to the freezing point. The salinity of water in major seas varies from about 0.7% to 4.0% and because of this salinity sea water is not suitable for consumption. Consumable water is normally called potable water or drinking water. Non-potable water can be purified by different water purification processes but in developing countries people hardly know about these methods and consume contaminated water as well. Unlike the developing countries, in one of the leading developed countries, USA non-potable forms of wastewater generated by humans referred as grey water, is treated and thus easily made potable again and can be used for toilet flushing or irrigation (Duttle, 1990 (Retrieved 23 January 2010)). Moreover there is another type of water, the black water, containing sewage and other forms of waste, require further treatment in order to be made reusable. The developed world is reusing both grey and black water by various methods in order to fight the scarcity of the most precious resource water (Tilley, Ulrich, Luthi, Reymond, & Zurbrugg)(Sharvelle, Roesner, Qian, & Stromberger, 2010). On the other hand people of Bangladesh and other developing countries are not even concerned about the water they drink. The natural resources of water are becoming scarcer and its ease of availability and use is a major social and economic concern. At present, almost a billion people around the world frequently drink unhealthy water and most have accepted the challenge of halving the number of people worldwide by 2015 not having access to safe water and sanitation during the 2003 G8 Evian summit (G8, 2 June 2003. Retrieved 25 July 2010). Even if this goal is achieved, it will still leave around a billion people having no access to adequate sanitation and more than half a billion people without access to safe drinking water. Inadequate water quality and terrible sanitation are so lethal that five million deaths per year are caused by polluted drinking water. It was estimated by the World Health Organization 1.4 million child deaths from diarrhea each year could be prevented by safe drinking water (World Health Organization, 25 June 2008).

Since the non-renewable resources of water are in decline due to the excessive human consumption, the availability, distribution of potable, pure and irrigation water is scarce already. In the developing world, 90% of all wastewater goes untreated into local rivers and streams and pollute the natural sources of water (UNEP International Environment, 2002). Around 50 countries, with approximately one third of the world's population, suffer from medium or high water stress and 17 of these countries annually extract more water than it is recharged through their natural water cycles (Nijavalli & Sathaye, 2010). Not only the surface freshwater resources like rivers and lakes are polluted by this water, it also degrades groundwater resources. Therefore in order to ensure the accurate quality of water before consumption is very much essential since the human health vastly depends on consuming pure water containing no contaminants.

1.3 Scenario of impure water:

Now a days it becomes difficult to get pure drinking water as our water is polluted day by day but at the same time many techniques are available though it is not enough to get pure drinking water out of it. Developed countries are very conscious about their health so they take modern techniques to get pure drinking water whereas developing countries cannot take modern techniques for purifying water. It is a major problem all over the world and if we carefully analyze it, then we can see that the problems occurring due to impure water in every corner of the world is actually a dangerous issue and people should take it into consideration. Some developed countries have successfully overcome these problems but some are still trying to overcome it and many failed to overcome these problems yet.

Water is mainly getting contaminated and has started to contain various heavy metals due to industrial waste contamination in water, marine dumping, radioactive waste mixing, atmospheric deposition, oil pollution, underground storage leakages, sewage and waste water and also because of global warming. Due to carelessness of some people like many industries are located in rural areas and they dump the industry waste in rivers or ponds so in addition other people are suffering. Climate change is also a fact to be considered, such as during flood water is affected and growing cities is also considered which itself brings many challenges in supplying water. All these circumstances are the main sources of impure drinking water.

Many developing countries like our countries, India, Pakistan, Sri Lanoka, Nepal, and Bhutan affected mainly many Asian countries especially in rural areas people are affected from pure drinking water. Developed countries like United State, United Kingdom, Canada; they are less affected due to these problems.

1.4 Scenario of health related problems:

People use water for both drinking and many other various purposes, so as a result these sources of water are getting polluted gradually. Polluted water is dangerous for human health as we said before, but still after knowing all these reasons most of the people are using these dirty water and suffering. So the quality of pure drinking water is very essential for every people's life which can save several peoples life and also can take many people's life if they are deprived from it. Some are deprived from it especially rural areas people, flood affected people so they are the main victim of pure water otherwise many people are affected for other reasons. The main purpose of pure drinking water is for human safety.

Therefore those countries people are suffered from dangerous diseases especially rural areas people suffer from cholera, dysentery, diarrhea, gastrointestinal disease and jaundice etc. This impure water hazarded our body's component, so as a result dangerous disease attack our body. Impure water content microorganism which affects body immunological system as a result disease occurs. Infants are mainly affected because of their immune system and they are easily affected by microorganism and suffer from various diseases. Therefore pure water is essential for everyone especially infants.

Seven hundred million people of the developing world do not have access to pure water due to large amount of microorganism and chemical contamination which is the recent report by WHO/UNICEF (Winifred, Nsikak, Anuoluwa, Cyril, & Ifedayo, 2014). Water contains a large amount of pathogenic compound like bacterial pathogens for example E. coli, shigella, salmonella, mycobacterium, protozoan pathogens, viral pathogens and toxic chemical compounds like iron, cobalt, zinc, sodium, chlorine, copper, manganese, sulfate, aluminums, ammonia etc which can change the taste, odor and color of the water which is also harmful for body elements.

Focusing on Bangladesh it can be observed that pure water is not available in rural areas. People are continuously using the water for household works, agricultural purpose, and industrial plans and so on and mostly for drinking which is dangerous for human health. Surface water mainly used for drinking but it also contains microorganism and toxic chemicals' compound which causes disease mainly among infant and children, so they suffers the most. The majority of water related to diseases is the result of microbial growth and chemical contamination as a result every day the victim are increasing but adequate recovery is not established yet. Boiling water or filtration may kill some certain microorganism but many organisms are not killed by this process so organism is still present in the water. Boiling water is very common though it is not enough and filter is expensive for rural people so it becomes a question mark actually about what steps they should take. Every countries review is necessary and it can only save each and every country public health issues. In many countries where people are responsible for polluting the water and also people who do not understand the negativity resulting from drinking impure water government should step forward and take some measures to improve public health and moreover some organizations can work on it to create awareness among rural areas people who do not take it seriously.

1.5 Importance of metal ion:

Chemical elements are essential in biochemical and physiological mechanisms in living organism. In fact many food components contain metal ion when we take these food it enters into our body and give energy to our body but all metal ions do not provide energy.

1.6 Toxic effect of metal ion:

Excess amount of metal ion can harm our body elements because of its toxicity. Some trace metals like Iron, Cobalt, Manganese, Zinc, and Copper in appropriate amounts are very essential for healthy lives of both human and animals on earth but high level of these metals can have a risk of cancer, heart disease, endocrine problems and liver disease (Al-Mezori & Hawrami, 2013). Excess amount of trace metals causes vomiting, pneumonia, asthma, vision problems and adverse effect (Solanki, Gupta, Singh, & Ahirwar, 2014). Therefore excess amount of metals can be hazardous for every living cell like human and animals. Ground water contains high amount of metal ion which mixes with water and causes various problems. High concentration of Iron,

Zinc, Cobalt, Chromium, Aluminum, and Manganese present in ground water can causes an adverse effect and it becomes unable for drinking (Islam, Han, Ahmed, & Masunaga, 2014). These trace metal is also harmful when it is used in agricultural purpose and threatens the environment, atmosphere and dangerous for human health and animal. Large quantity of metals and microorganism resulting in poor hygiene is also a great risk to public health. The physical appearance of water is also changed which makes it unable to drink so drinking water quality assurance is more important.

1.7 Sources of iron:

- Liver.
- Meat.
- Beans.
- Nuts.
- Dried fruits such as apricots.
- Soybean flour.
- Dark green vegetables such as watercress and curly kale.
- Whole grains such as brown rice.
- Fortified breakfast cereals.
- **Iron Rich Foods containing Heme Iron:**

1. Clams - 23.8 mg per 3 oz
2. Oysters - 7.8 mg per 3 oz
3. Liver per 3 oz
    a. Chicken - 8 mg
    b. Beef - 5.8 mg

4. Mussels - 5.7 mg per 3 oz
5. Sardines - 2.4 mg per 3 oz
6. Turkey - 1.6 mg per 3 oz
7. Beef per 3 oz
    a. Extra lean ground - 2.5 mg
    b. Prime rib - 2.1 mg

a. Short rib - 2 mg
b. Rib eye - 1.7 mg
c. Sirloin - 1.6 mg

8. Lamb chop - 2.1 mg per 3 oz
9. Egg - 1.2 mg per 2 large eggs.

- **Iron Rich Foods containing Non-Heme Iron:**

10. Pumpkin seeds - 8.6 mg per 1/4 cup
11. Firm Tofu - 8 mg per 3/4 cup
12. Beans per 3/4 cup cooked
    a. White beans - 5.8 mg
    b. Red kidney beans - 3.9 mg
    c. Soybeans: 3.4 mg
13. Lentils - 4.9 mg per 3/4 cup cooked
14. Some whole-grain breakfast cereals (per cup)
    a. Total - 18 mg
    b. Raisin Bran - 10.8 mg
    c. Cheerios - 8.9 mg
    d. Special K - 8.7 mg
    e. All-Bran - 5.5 mg
15. Baked potato with skin - 2.7 mg
16. Chickpeas - 2.4 mg per 3/4 cup cooked
17. Blackstrap Molasses - 3.6 mg per Tbsp
18. Prune juice - 3.2 mg per cup
19. Dried fruits per 1/2 cup
    a. Peaches - 1.6 mg
    b. Raisins - 1.4 mg
    c. Plums - 1.3 mg
    d. Apricots - 1.2 mg.

20. Nuts per 1/4 cup:
    a. Cashew: 1.7 mg
    b. Almonds: 1.4 mg
    c. Pistachio: 1.2 mg
    d. Walnuts: 0.9 mg
    e. Pecan: 0.7 mg

1.8 Importance of Iron:

Iron is essential in biochemical and physiological mechanism in live organism it takes and important parts in blood circulation. For instance as excess amount of iron we take is hazardous for human beings and other living organism so it has to be reduced.

The Iron contents present in water may differ depending upon the geological area of the water source and other composing constituents of the water. The iron forms of concern in the aquatic environment are Ferrous and ferric ions mainly and also may be in either organic or inorganic wastewater streams secondarily. It appears to be a potential health hazard. Taste thresholds of iron in water containing 0.1 mg/l of ferrous iron and 0.2 mg/l ferric iron give a bitter or an astringent taste. Less than 0.2 mg/l iron is present water used in industrial processes usually. Swamp waters may contain iron concentrations of several mg/l but this iron form has lesser effect on aquatic life. The current water life standard is 1.0 mg/l iron presence based on toxic effects.

1.9 Toxicity of Iron:

Ground water contains large amount of iron when directly pump from the well. When iron is exposed to the atmosphere the ferrous iron is oxidized to ferric iron and adds reddish brown color to water and thus toxicity can be observed from the appearance (WHO). When large amount of iron is present in water, it becomes toxic for health and the appearance has changed as well which indicates that the water is unable for drinking. The growth of" iron bacteria" is also associated with it which derives their energy from the oxidation of ferrous iron to ferric iron and deposit a thin coating on the piping during the process (WHO). Presence of iron can change the color of water and also the taste of water. This iron is mainly present in water as free radical but when it enters into our body it is oxidized and it becomes toxic for our health. At high level of

0.3mg/liron stains laundry and plumbing fixtures but below 0.3mg/l concentration iron has no noticeable taste even though turbidity and color may appear (WHO). In rural areas people mainly use tube well water which directly pumped through the ground. Iron mainly mixed with the soil but when pressure is excised, it mixed with water and become toxic (WHO). After investigation it is found out that iron toxicity is increasing a lot every day and people are becoming victim of it. So it is important to remove iron from water. But health based guideline value is not proposed yet so it is essential to take some step since high doses of iron over 20mg can cause nausea, vomiting, constipation, stomach pain and other disease.

Surface water is mainly use for drinking and it is also important to use surface water for portable water. Surface water consumption such as natural organic matter and turbidity depends on geographical area and season. Since surface water has a low mineral content and low alkalinity, there is generally a low hydrolysis of coagulant in tropical regions (Guilleret, Kayem, Molletre, & Roques, 1990). Treatment of drinking water in order to remove natural organic compounds and turbidity Physico-chemical methods are commonly used (Edzwald & Tobiason, 1999) ; (Volk, Bell, Ibrahim, Verges, Amy, & LeChevallier, 2000). On the other hand treatment of drinking water include three steps which are

1. Clarification,
2. Filtration and
3. Refining.

In the step of clarification, coagulants are used in water to dissolve organic matter, colloidal substances and destabilize suspended solids. These substances are then aggregated to form flocs which settle down and finally are separated by sand filtration (Sieliechi, Kayem, & Sandu, 2010). The aim of clarification is to provide water free from suspended solids, dissolve organic matters and containing residual coagulants such as aluminum and iron salts, which is widely used in drinking water treatment (Edwards & Amirtharajah, 1985) ; (Benschoten & Edzwald, 1990). The derivation of the content in treated water can be done from two sources such as –

I. Overdose when treating raw water.
II. Poor hydrolysis of metals during treatment (Klos & Guminska, 2009).

Iron:

1) General aspects:

   Iron is necessary for human body but the existence of excess amount of iron in human body is harmful. According to European legislation, iron content in drinking water has been fixed at a maximum contaminant level of 200µg/L and WHO has fixed the limit of iron at 2mg/L (Namiensnik & Rabajcszk, 2010).

2) Health problems:

   Existence of high amount of iron in drinking water may be responsible because of-

   a. Metallic taste of water.
   b. The coloration of water.
   c. The neutralization of disinfectants to kill the microorganism (Sieliechi, Kayem, & Sandu, 2010).

   High level of iron in the blood can damage gastrointestinal tract, inhibiting them from the regulation of iron absorption. Above 20 milligram of iron per kilogram of mass and 60 milligram per kilogram is a lethal dose in human body is considered as iron toxicity and lethal dose (El-Harbawi, et al., 2010).

   Iron can cause many diseases including involvement in Alzheimer's disease, interaction of iron and cholesterol promoting oxidative damage and causing both atherosclerosis and neuro degeneration (Ong & Halliwali, 2004). Excessive amount of iron in the selective regions of the brain may cause neuro degeneration disorder (Perez, et al., 2010).

3) Drinking water distribution network:

   The existence of iron in drinking water can cause microorganism and proliferation. And when it enters into the human body it damages our immune system. These residual irons mainly mixed with the drinking water throughout the pipeline system and a thick layer of iron is deposited throughout the pipeline. So, when the machine is pumping the water from the ground, the iron mixed with water and makes the water poisonous. The existence of this residual iron can result in proliferation of ferruginous bacteria sources

and it can reduce the diameter of pipeline or causes corrosion (Desjardins, Koudjonou, & Desjardins, 2002).

Table 1: Range of iron contents: (National Research Council, 1979) **;** (National Food Agency of Denmark, 1990) **;** (National Research Council, 1989) **;** (Finch & Monsen, 1972)**.**

Subject	Objective	Levels of iron concentration
Air	**Remote areas**	**50–90 ng/m3;**
	Urban areas	**1.3 µg/m3.**
	Steel production plants	**12 µg/m3**
Food	**Liver, kidney, fish, green vegetables.**	**20–150 mg/kg,**
	Red meats, egg yolks	**10–20 mg/kg.**
	Rice, fruits, vegetables	**1–10 mg/kg**
Water	**River**	**0.7 mg/L.**
	Ground water.	**0.5–10mg/L or 50 mg/L can be found.**
	Drinking water	**0.3 mg/L**
Daily intakes of iron	**Food**	**10-14mg**
	Drinking water	**0.3 mg/L**
	Air in urban areas	**25 µg/day**
Total body iron	**Adult males**	**50 mg/kg of body weight.**

Table 1 (continued)

Adult female		**32-40 mg/kg of body weight.**
Daily requirements' of iron.	**Depend on age, sex, physiological status, and iron bioavailability**	**10 to 50 mg/day**
Adverse effects in healthy persons		**0.4-1 mg/kg of body weight per day.**
Lethal dose		**200-250 mg/kg of body weight.**

1.10. Symptoms of iron toxicity: (Govorova & Galabutskaya, 1934)**.**

1. **Airways and lungs:**

a) Buildup of fluids in the lungs.

2. **Gastrointestinal system:**

a) Black, and possibly bloody stools
b) Diarrhea
c) Liver damage
d) Metallic taste in mouth
e) Nausea
f) Vomiting blood

3. **Heart and blood:**

a) Dehydration
b) Low blood pressure
c) Fast and weak pulse

4. **Shock.**

5. **Nervous system:**

a) Chills
b) Coma (decreased level of consciousness and lack of responsiveness, may occur within 1/2 hour to 1 hour after overdose)
c) Convulsions
d) Dizziness
e) Drowsiness
f) Fever
g) Headache
h) Lack of desire to do anything.

6. **Skin:**

a) Bluish-colored lips and fingernails
b) Flushing
c) Loss of color from the skin (pallor) (Govorova & Galabutskaya, 1934).

1.11. Iron treatment:

1. 11.1 Global:

Iron poisoning has some symptoms including vomiting, diarrhea, pain in the abdomen, and lethargy. But sometimes there might not be any symptoms at all.

There are many techniques which are applied in the laboratory for removing iron from the soil clays. These methods were known as ammonium oxalate and aluminum-ammonium tartarate methods. But both of the methods have some disadvantages, especially when determining the iron by sodium salicylate, sodium hydrosulphite, sodiumthyosulphyite (WHO) (Guidelines for drinking water quality, 4th edition). It has been fully investigated in the hope that it will lead the development into a satisfactory, inorganic procedure.

It is appeared that, the hydrosulphite method brings the best result among other treatment, because

i) Removal of iron oxides is satisfactory

ii) Extraneous factors are not involved here

iii) Only inorganic reagents are used and laborious treatment before iron determination is avoided

iv) There is no undue destruction of clay minerals

v) It is relatively rapid

vi) Very few precautions are necessary.

1. 11. 2 Bangladesh:

Surface water in Bangladesh is microbial not safe enough to drink. A study conducted in 1998 and 1999 shows that, twenty nine types of chemicals including Arsenic existed in the ground water throughout Bangladesh. According to the WHO reports in 2000 and 2001, 97% people of Bangladesh drink well water. In 1997, a USAID field program discovered that ten million Bangladeshis may be drinking endangered levels of toxic metals besides Arsenic in their regular drinking water. In that study it shows that, an analytical interference to the 1, 10-phenanthroline methods were contained in at least 27% of the samples for measuring iron in the water and the interference was observed during the measurement of iron and from improper color development during the measurement of total iron, from suppressed matrix spike recovery (34%). However, the literature has suggested that 1 or more toxic non-arsenic metals in these drinking water samples were the reason by behind the results (Bangladesh Rural Electrification Board, 1997).

The WHO and USEPA have not yet established health based drinking water guidelines for iron. However, approximately 69% area of Bangladesh may have already exceeded the WHO and USEPA's 0.3 mg/L secondary criteria (American Public Health Association (APHA); American Water Works Association (AWWA); Water Environment Federation (WEF), 1995). Additionally, the Arsenic contaminated water has relatively high iron concentrations where much significant number of tube-wells in Bangladesh is Arsenic contaminated and moreover drinking water samples exceeding 0.05 mg/L arsenic have an average of 8.0 mg/L iron. Though the potential health effects of these high iron concentrations on chronic arsenic poisoning are still unknown there are reports suggesting that high body iron stores and dietary intakes of iron are associated with hepatocellular carcinoma in humans (Marrogi, et al., 2001). And mammary carcinogenesis in female Sprague-Dawley rats (Diwan, Kasprzak, & Anderson, 1997). Therefore the knowledge on iron toxicity in drinking water is highly essential (Sarfaraz, Kitchin, & Cullen, 2000).

Chapter 2

Objectives

2. Objectives:

The objectives of this work was to determine the presence of iron content in the drinking water sources of rural Bangladeshi inhabitants and the health significant health consequences of iron toxicity. Therefore specified objectives of the projects are as follows-

1. To measure the presence of excessive iron in drinking water in the local community.
2. To aware the community people about the health risk due to excessive iron toxicity on drinking water.

Chapter 3

Methodology

3. Methodology:

For primary data the following questionnaire survey focused on the impression and opinions of the residents of Madhudanga Village. The questionnaire were filled with blank box and also Yes/ No answer to find out the inhabitants opinion about the presence and effect of iron in drinking water. Given in table 2 was performed among the inhabitants of Madhudanga village of Dhamrai sub-district, Dhaka, Bangladesh. All the data were then put to SPSS analysis to measure the frequency of iron in water and no of owed tube wells at Madhudanga Village.

In order to obtain secondary data for the project large number of literature review has been done efficiently. The information collected from articles that are especially written in English language with English abstracts. For relevance, studies were justified on the abstracts. A systemic search of international peer-reviewed literature was carried out on iron toxicity especially in drinking water and its impact on global and Bangladeshi sectors. Using generic search engines like Google, yahoo etc., grey literature such abstracts, presentation, technical reports were identified on these topics. The search terms used were health hazard due to iron toxicity, drinking water problems, presence of iron in drinking water due in global arena, impact on Bangladesh due to iron toxicity in drinking water etc. The data's were analyzed by the search result individually to find potentially eligible studies. The publications were sorted by titles and abstract and only eligible studies were selected for full text review. During this stage all the irrelevant studies were excluded

Chapter 4

Result

4. Results:

Frequencies Variables= Tube well usage own
/Bar chart Percent
/Order=Analysis.

Table 2: Sample of survey questionnaire which is collected from- village: Madhudanga, sub district-Dhamrai, district-Dhaka.

Serial number	Head of the family	Father/husband's name	Address	Member of the family	Water used for drinking		Iron in water	
					Own	Others	Yes	No

Table 3: Frequencies on the user number of tube well:

Statistics

Tube well usage own

N	Valid	192
	Missing	0

Tube well usage own:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	68	35.4	35.4	35.4
	yes	124	64.6	64.6	100.0
	Total	192	100.0	100.0	

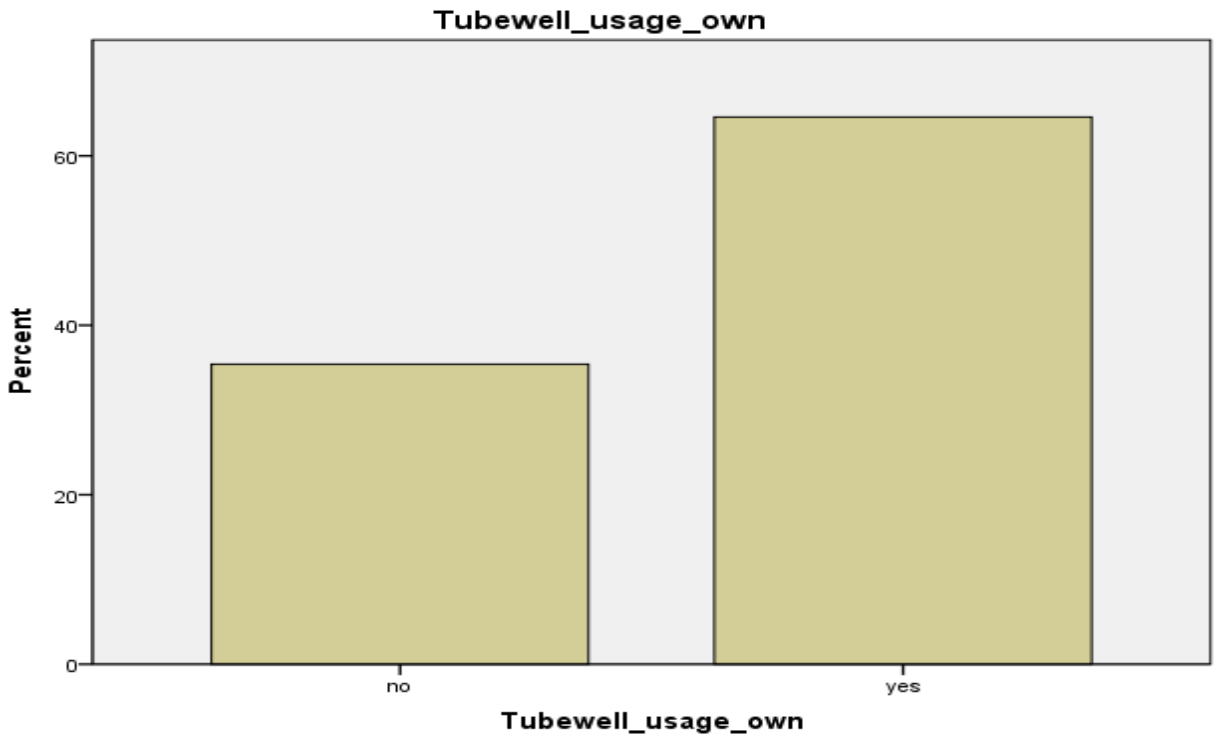

Figure 1: Percentage of people using their own tube well

```
Frequencies Variables=Iron presence in water
  /Bar chart Percent
  /Order=Analysis.
```

Table 4: Frequencies on the Iron Presence in water:

Statistics:

Iron presence in water:

N	Valid	192
	Missing	0

Iron presence in water:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	12	6.3	6.3	6.3
	yes	180	93.8	93.8	100.0
	Total	192	100.0	100.0	

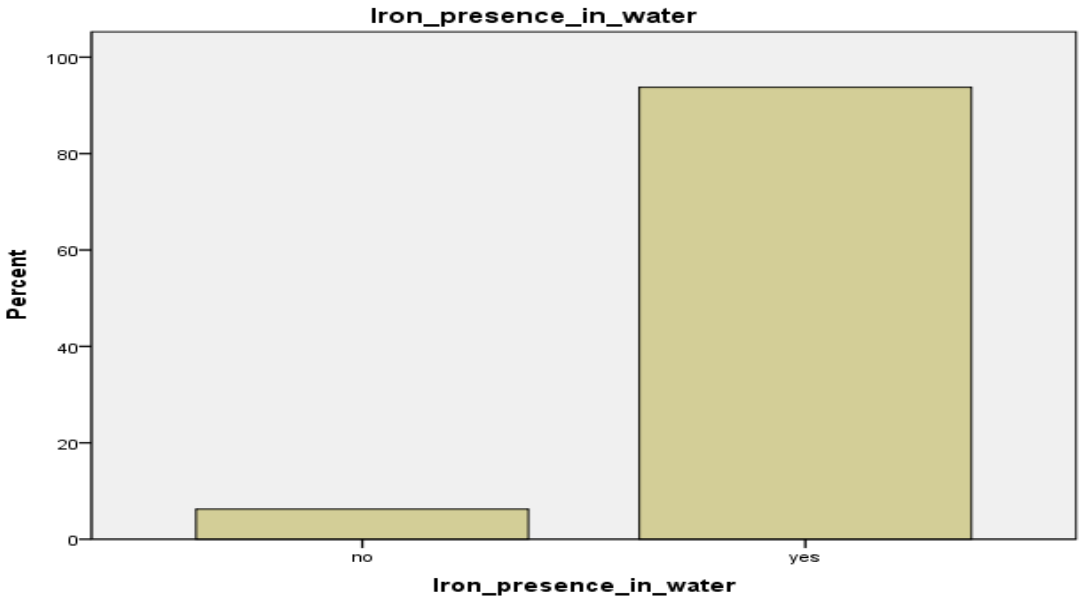

Figure 2: Percentage showing prevalence of iron contamination in drinking water sources

Table 5: Descriptive statistics of iron present in water.

Descriptive Statistics:

	N	Range	Minimum	Maximum	Sum	Mean
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
Iron presence in water	192	1	0	1	180	.94
Valid N (list wise)	192					

Descriptive Statistics:

	Mean	Std. Deviation	Variance
	Std. Error	Statistic	Statistic
Iron presence in water	0.018	0.243	0.059
Valid N (list wise)			

Table 6: Case Processing Summary:

Case Processing Summary:

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Iron presence in water	192	100.0%	0	.0%	192	100.0%

Figure 3: Map of Dhamrai Upazila.

4.1 Iron toxicity in Dhamrai Upazila:

Existence of Iron in natural drinking water is a common phenomenon in Bangladesh. As a matter of fact, most of the natural sources of drinking water in this country contain iron. Because the common source of collecting consumable water is deep tube well water. Deep tube well water contains iron due to the existence of iron in the soil. The deeper the tube well is the possibility of the existence of iron in that water elevated. Because the iron existed in the soil mix with water due to the pressure. And in Bangladesh, most of the deep tube wells are deep enough to contain iron in it. The visual appearance of the water also proves that fact.

Dhamrai is one of the six Upazila of Dhaka District. It is a densely populated area containing more than three lakh people in it according to 1991 census. Madhudanga is a little village situated within this Upazila. Around 192 families with 948 members live in this village. The only source of drinking water in this area is tube well. Most of the tube wells owned by the families lived in those villages. The others who have no tube well of their own borrow water from their neighbors.

After researching on each family living in Madhudanga village it was found that, most of the families have a significant number of female members and children in them. As it is known, the impact of iron toxicity is prominently visible among the female and child members of the family. The common symptoms of iron toxicity are buildup of fluids in the lungs, black, and possibly bloody stools, diarrhea, liver damage, metallic taste in mouth, nausea, vomiting blood, dehydration, low blood pressure, fast and weak pulse, shock, chills, coma (decreased level of consciousness and lack of responsiveness, may occur within 1/2 hour to 1 hour after overdose), convulsions, dizziness, drowsiness, fever, headache, lack of desire to do anything, bluish-colored lips and fingernails, flushing, loss of color from the skin (pallor) (Liebelt) ; (Velez & O'Connel). After researching on the people of Madhudanga village, it was found that most of the children suffer from diarrhea and constant fever. Some adult female and male members of the families suffer from liver damage, dizziness, drowsiness, fever and headache. From visual observation it was found that most of them got bluish-colored lips and fingernails and loss of the color from the skin, especially the children.

According to the data collected by the field visit on Madhudanga village, 63.54% of the total villagers are in possession of tube wells of their own. The other 35.41% depend on the tube wells of their neighbors. Though there are ponds in that area, the major source of their drinking water is tube well. The water of that area was never tested for iron before and the villagers are unaware of the fact of iron toxicity. The symptoms of the diseases they suffer from frequently shows the possibility of the existence of excessive amount of iron which is above 0.3 mg/liters.

After examining the villagers in the field visit it was found that almost 91.66% people think that there is a possibility of the existence of iron in the tube well water. As prove to that thought they showed their water jars which contain iron stain. Also they mentioned the difference of taste of water than the water collected from WASA. Though they are used to with the taste of the water of their territory, they can tell the difference of taste of their water from the water provided by WASA.

Chapter 5

Discussion

5. Discussions:

The water from the area of research has never been subjected to any examination for iron toxicity before. The people living in that area also have never become aware of the existence of iron in their drinking water. Since, the water is collected from natural source, it is considered as pure drinking water. Furthermore they are unaware of the fact that the natural source of water can also be contaminated by the act of human being. Though they are familiar with the fact that the natural sources like river and pond water can be polluted and contaminated by human waste and many other way, they consider tube well water as a pure drinking water as it comes from underground. As the consequence of continuous usage of iron containing and contaminated drinking water common symptom the people of Madhudanga village frequently face is the dizziness. As they never knew about the iron toxicity of drinking water, they never consider that the water could be the reason of their dizziness. As the research does not include any scope of testing the water of the subject area, it is not possible to tell it in certainty about the iron toxicity of the water as the reason behind their dizziness.

The medical facility of the subject area, the Madhudanga village, is quite adequate. Though there are two medical centers for the use of 948 people of the village but the medical service given there is not up to date. There is lack of medicine and the environment of the medical centers is not healthy enough for the patients. The medical wastes were not properly dumped and the hospitals are not clean enough for the patients. The doctors of the medical centers are also unavailable every so often as the doctors have their personal chambers to attend to. There are some doctors who are really dedicated but they are outnumbered. Sometimes doctors also failed to understand the reason for their illness as there was never been any survey on iron toxicity in the water. Sometimes the hospitals have to refer their patients to Dhaka Medical College Hospital for better treatment. They get some patients with liver damage, dehydration, low blood pressure and diarrhea. Diarrhea is the most common disease in that area and the doctors suggest that this could be for their unhygienic living as well.

As Madhudanga village is situated near Dhaka city, it is easy for the villagers to go to the better hospitals in the city area. But the transport system is not well enough and sometimes they take medical service from the Dhamrai Upazila health complex. The Upazila health complex has

better facilities than the two medical centers in that village. People of the village prefer to go to the medical centers in their village as the Upazila health complex is also far away.

Iron is very essential component for human health. But taking excessive amount of iron can damage the health of a person. When someone takes excessive amount of iron they can suffer from iron toxicity. But lack of iron can also cause health problem. The common disease caused by the lack of iron in any human body is known as anemia. This disease is caused when the red blood cells stop reproducing due to the lack of iron. Because iron is the most essential element to reproduce red bold cell which carry oxygen in the blood. Iron deficiency has some common symptoms such as, fatigue, dizziness, pallor, hair loss, twitches, irritability, weakness, pica, brittle or grooved nails, Plummer-Vinson syndrome which is painful atrophy of the mucous membrane covering the tongue, the pharynx and the esophagus, impaired immune function, pagophagia, restless legs syndrome etc. There are some similarities between iron toxicity syndromes and iron deficiency syndromes like dizziness. So sometimes the patients need the proper examination to determine the cause of disease.

Iron toxicity of water has some visible effects. The color of the water and the taste of the water can be used as a tool to determine the existence of excessive amount of iron in the water. Iron itself has a brownish color, especially the ferric iron. When it mixes with water it gives the water an opaque appearance. Also it creates some heap of rust in the metals get in touch with it for a long time. That is why the metal water jars get brownish color. Iron also tastes metallic. People who are used to drink iron water cannot tell the difference, but the people who are not used to drink iron water can feel the metallic taste in their tongue.

The people of Madhudanga village are used to with the iron water for a long time, so it is impossible for them to taste the metal in their water. But they face the problem of rust in their daily commodities. Also they showed the symptoms of iron toxicity, like dizziness and low blood pressure. So it is necessary to check for iron toxicity in the tube well water. There were researches on the existence of arsenic in the water and there were reasonable cause behind that. Arsenic is a deadly disease and need proper treatment. Though iron toxicity does not have that kind of deadly impact on people, it causes some serious health issues. It is necessary to find a better and contemptible way of treating iron toxic water. Because most of the people who suffers

from iron toxicity in water are from the poorer section of Bangladesh. So it is necessary to find out a cheaper way to treat iron toxic water. Also a proper survey is needed to determine the iron toxicity in water like the survey for arsenic (Bangladesh Rural Electrification Board, 1997). There are many areas in Bangladesh where the water contains an excessive amount of iron. The amount of iron is so acute that it is visible in bare eyes. The water shows a brownish color and it also creates a layer of brown color in its container.

The children in Madhudanga village always keep suffering from diarrhea. Also their nails are very fragile. Some of them have low blood pressure as well. As it is known that the symptoms of iron toxicity are visible in woman and children more than man, it is visible that the children of Madhudanga village show some of those symptoms. Though these symptoms are also similar to unhygienic environment and lack of food nutrition, this can also be a symptom of iron toxicity. To find out the appropriate answer it is necessary to conduct a proper survey on the area. This research is merely a field visit and basic data collection on a very tiny area which is a little village in Dhamrai Upazila, one of the six Upazila of Dhaka Division. Moreover, the research area is near the capital city of Bangladesh. The remote areas contain worse situations which is still unknown due to lack of suitable surveys.

The framework for safe drinking-water is a preventive management approach though it has not been fully initiated yet in the developing countries like Bangladesh But unlike the developing countries it has been playing a major role in the developed countries since long ago. In Stockholm, in 1999, it was agreed that future guidelines for drinking-water, wastewater and recreational water should integrate assessment of risk, risk management options and exposure of control elements within a single framework with entrenched quality targets whereas the developing countries like Bangladesh has hardly such measures to assess the quality of drinking water (Guidelines for drinking water quality, 4th edition).

According to the agreement drinking water has to be examined properly before consumption comprising three key components:

i. Health based assessment based on the evaluation of health risk

ii. Water safety plans including the monitoring and documenting the drinking water consumed by the citizens.

iii. Taking adequate measures including upgrade and improvement of the water supply system.

iv. An independent surveillance to monitor and verify the above mentioned process (WHO).

Based on this framework, the Government needs to evaluate the water quality consumed by the people of Madhudanga village. Those people facing various kinds of diseases every year and the proper reason behind these diseases are still unknown.

Due to over population around the world the scarcity of pure drinking water is increasing every day. Nitrogen deposition, warming, and shifts in precipitation, runoff patterns and other environmental changes occurring at the global scale are superimposed upon all of the threat categories.

According to the previous surveys around the world, existence of iron in water more than 91.66% is considered a huge amount for consumption which is seriously harmful for health. Maximum people use tube well water in the research area for consumption and this water contain a large amount of iron but knowing all these reason villagers are still use these tube well water because they have no other options. The main purpose of these projects is to determine the amount of iron in tube well water which people use for drinking purpose and it was found that huge amount of iron is present in the tube well water. So the next survey needed to be arranged to determine the amount of iron toxicity which is harmful for the villagers. Moreover adequate treatment have to be applied to remove the excess amount of iron from the tube well water so people can consume safe drinking water and their life can be protected from harmful diseases.

Chapter 6

Conclusion

6. Conclusion:

It is said that, prevention is better than cure. Prevention of microbial and chemical contamination of sources of water, especially iron toxicity, is the first challenge against drinking-water contamination of public health concern. Because with the increased amount of population the need for daily use of water and water for consumption is rising every day. Moreover the unrefined industrial wastes pollute water in a very fatal way. Sometimes the water become so polluted that it is beyond treatment. Pure drinking water is essential for heath purpose. Though there are some water refiners in the market now a day, those are beyond reach of the poorer section of our country who is the worse sufferer of the water pollution. In the developed countries Government ensure that every citizen gets the pure drinking water and monitor the water supply system intimately. But the Government of developing and the lower developed countries like ours cannot afford to take that much concerns regarding the purity of drinking water where there are other more important issues to take care of. But taking some initiatives to survey the water quality consumed by the mass people can help a lot to invent a way to provide consumable water. Apart from surveys, Government can also take measurements to organize some awareness programs. Such programs should normally include:

- Awareness raising on water hygiene;
- Basic technical training and technology transfer regarding drinking-water supply and management;
- In order to achieve the acceptance of water quality interventions consideration of approaches for overcoming socio-cultural barriers;
- Motivational acts and activities of mobilization and social;
- To achieve and maintain sustainability a system of continual support, follow-up and dissemination of the water quality program.

Most of the people in Bangladesh are not aware about the iron toxicity of water. As the underground water level is decreasing day by day, the possibility of iron toxicity is increasing as well. Because the iron existed in the soil get mixed with the water and increased the amount of iron normally existed in the water. Due to iron toxicity different kind of diseases embark on people, especially those who cannot afford pure drinking water.

After researching on the people of a small village near Dhaka city, a massive amount of indication of iron toxicity was found. Though there was no survey or examination to determine the iron toxicity in the tube well water used by the villagers, the diseases they suffer from are very similar to the symptoms of iron toxicity. So it can be deduct from the symptoms present among the villagers that there is a possibility of iron toxicity in the tube well water. This is only a small illustration of iron toxicity in the ground water. The other areas of Bangladesh are still in darkness. To develop the overall situation a proper survey on the iron toxicity of the water is required to ensure the safety of the citizens of this country. Because water is considered as life and it is always better to take action when there is still time to prevent something enormous in nature.

Chapter 7

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