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Status of shallow tube-well water qualities in the Chittagong district of Bangladesh

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ABSTRACT

Related water quality tests were carried out in different areas of Chittagong district. Water qualities of eight upazila/thana[1] were examined and found significant variation among them. Water quality parameters did not cross the safe limit of drinking water standard largely. For example TDS (highest value-711mg/l; standard limit-1000mg/l), Alkalinity (highest value-254mg/l; standard limit-500mg/l), Sulfate (highest value-18mg/l; standard limit-400mg/l), Phosphate(highest value-3.32mg/l; standard limit-6mg/l), Total Hardness(highest value-68mg/l; standard limit-200-500mg/l), Cu(highest value-0.19mg/l; standard limit-1mg/l), Zn(highest value-0.06mg/l; standard limit-5mg/l) and Nitrite (highest value-0.05mg/l; standard limit-1mg/l) value of any areas did not cross the safe limit. Some areas crossed the standard level in case of pH and Free Chlorine; however the value did not correspond with much deterioration. A relative comparison with the safe limit, As and Fe of some areas were identified at risk. Mirsharai got the As concentration 0.45 mg/l. Variability in Fe was found in six upazila such as Panchlaish(3.05 mg/l), Kotowali(2.22 mg/l), Chandgaon(2.39 mg/l), Shatkania(1.69 mg/l), Banskhali(3.12 mg/l) and Fatikchari(2.82 mg/l) of Chittagong over the standard level.

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[1] A district is consisted of some upazila or thana. Upazila is a lower administrative unit of a district and use synonymously as thana. The word 'upazila' is used for both upazila and thana here after.

I. Introduction

Comprising over 70% of the Earth's surface, water is undoubtedly the most precious natural resource that exists on our planet (De, 2000). Gleick (1996) stated that humans have available less than 0.08% of all the Earth's water. Global ground water withdrawal is of 3,906 km^3 estimated for 1995 and estimated the consumptive water use of around 1,600 km^3 (Rosegrant*et al.,* 2002). In 1999, UNEP (2003) reported water shortage as one of the two most worrying problems for the new millennium (the other was global warming). Water resources are one of the most critical and vulnerable components of the resources of a nation (Siddiqui, 1992) and availability of safe drinking water is an indicator of development. The developing countries of the Himalayan region like Bangladesh, are under threat of drinking water supply and sanitation (Ahmed, 1990). Bangladesh is suffering for the flood in every year, but it cannot hide the need for safe water due to lack of drinking water quality. Chittagong city is situated within a cavity of surface water source from Bay of Bengal, Karnaphuli River and Halda River (a tributary of Karnaphuli) (Banglapedia, 2003). Total population accounted as about 3.2 million (BBS, 2001) with an immense demand of minimum water supply 550 million liter/day (BSS, 2014). Against this demand, Chittagong Water Supply and Sewerage Authority (CWASA) have the capacity to supply of 90 million liter of water from deep tube-wells, 45 million liter Kalurghat Water Treatment Plant and additional 40 million liter from Mohora Surface Water Treatment Plant. Thus, the total supply is about 180 million liter. This huge gap between supply and demand, city dweller tends to install 2373 (Anon, 2006) number of private wells in the city. Among these only 197 well dwellers has taken written permission to install well as describe by CWASA. Countrywide, about 95.5% of the urban population and nearly 88.3% of the rural population have access to safe drinking water supply (BBS, 2001) in Bangladesh. In rural areas, due to lack of awareness and accessibility problem, use of tube-well water for all domestic purposes is limited to about 46% of the population. Most of the drinking water (about 85%) comes from ground water sources. In 1989, the Master Plan Organization estimated that 25,750 million-meter cube (MMC) of ground water was reserved in Bangladesh. From that 1,686 MMC is unavailable. However, 900 MMC would be available for domestic and industrial use, and 12,809 MMC is for agriculture (Banglapedia, 2003). In some rural areas, increasing demand for irrigation water will affect the availability of drinking water. Globally, withdrawals for domestic and industrial uses grew four-fold between 1950 and 1995, compared with just over a doubling for agricultural uses (Cosgrove and Rijsberman, 2000) similes with this Chittagong city municipal abstraction supposed to increase. But due to rapid decline in recharge area over the local ground water basins and excessive withdrawal rate, water levels is falling in many parts of the country. In Dhaka city, the ground water level has fallen by 20 meters (Alam, 2003) in the last decade alone. According to Local Government and Rural Development (LGRD), ground water table was within the suction limit of eight meters in 65-70% of the country in 2000, which was used about 75 percent in early 90's. Thus,the main source of safe drinking water in Bangladesh is tube-well water (Konikow, 2002). The study tried to evaluate the qualities of shallow tube-well water in Chittagong and compared with the drinking water standard of 'The Environment Conservation Rules (ECR) 1997'.

II. Materials and Method

Collection of water samples: Samples were collected by random sampling method, selecting half of the upazila in Chittagong District. The selected areas were Panchlaish(C_1), Kotowali(C_2), Chandgaon(C_3), Shatkania(C_4), Potyia(C_5), Banskhali(C_6), Fatikchari(C_7) and Mirsharai(C_8). Samples were collected from three shallow tube-wells around 1km circumference from observation well of Bangladesh Water Development Board in each area. The water samples were collected in the month of July and August. Sample water was collected in a 500milimeter plastic bottle and filled the total volume of the container and cap was locked sufficiently so that no air space can be remained inside to minimize the chemical changes. Proper labeling was made in each sample by mentioning the name and location of sample site date and time of collection. Water samples were immediately shifted to the laboratory of the Department of Environmental Technology, Chittagong Polytechnic Institute, Chittagong for analysis.

Water quality analysis: pH and TDS (mg/l) test was done by using "Pocket-sized pH meter (pHep)" by Hanna (Model:HI 98107). Total Alkalinity (mg/l $CaCo_3$), Sulfate (mg/l SO_4), Phosphate (mg/l PO_4), Free Chlorine (mg/l Cl_2), Total Hardness (mg/l $CaCo_3$), Iron (mg/l Fe), Copper (mg/l Cu), Zinc (mg/l Zn) and Nitrite (mg/l N) tests were done by using "Photometer System-Tintometer" by Lovibond, Germany. Arsenic was tested by Arsenic Test Kit-highly sensitive (Measuring Range from 0.005- 0.5 mg/l) made in Germany.

III. Results and Discussion

pH: Within eight upazila the highest value of pH was found in Shatkania (C_4-8.8) and lowest in Panchlaish (C_1-7.3; from Figure 01). Though upper safe limit (8.5) of pH crossed in Satkania(C_4) and Potiya(C_5) but still they were not much higher than the standard. This result concluded that pH values of ground water in Chittagong were safe. But from the statistical analysis the pH values of different upazila showed significant ($P \leq 0.001$) variation from their mean. Banskhali and Panchlaish differed from other areas. Similarly,Chandgaon, Fatikchari, Kotowali and Mirsharai possessed no significant values within them but differed from others. Lastly, Potiya and Shatkania had same values than that of the other areas. Ahmed and Rahman(2000) stated that pH was important for coagulation, disinfection, water softening and corrosion control in water supply. In biological treatment of water, pH is very important as the organisms involved in treatment processes operate within a certain pH range. Dissolution and mobility of metals in the natural water are also greatly influenced by pH.

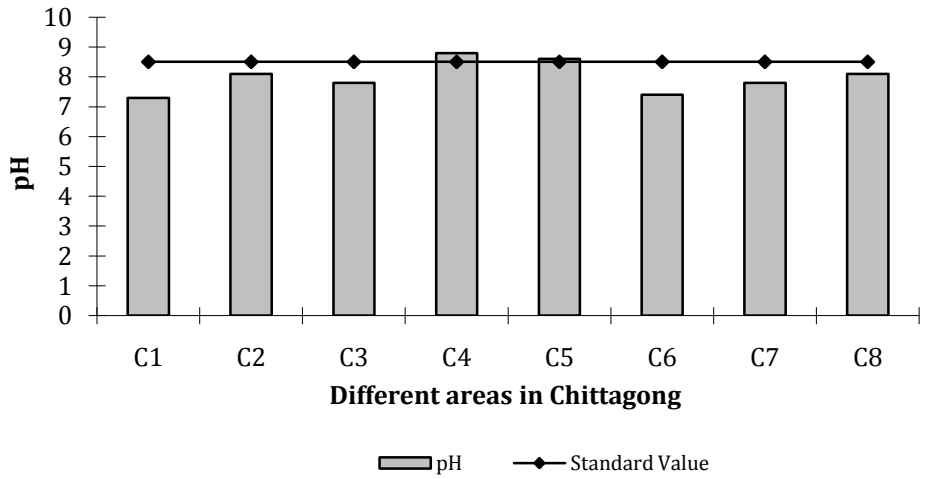

Figure 01. pH of ground water in different areas at Chittagong and safe limit of drinking water

Total Dissolved Solids (TDS): Within eight upazila the highest value of TDS was found in Kotowali (C_2-711mg/l) and lowest in Panchlaish (C_1-57mg/l; from Figure 02). The safe limits (1000mg/l) of TDS were not crossed by any upazila. This result concluded that TDS of shallow tube-well water in Chittagong was safe. Statistical analysis of TDS values of different upazila showed significant ($P \leq 0.001$) variation from their mean. Panchlaish(C_1), Kotowali(C_2), and Chandgaon(C_3) differed from other upazila. Similarly,Kotowali(C_2), Chandgaon(C_3) and Shatkania(C_4) possessed no significant difference among themselves but differed from others.

Total dissolved solids comprise inorganic salts and small amounts of organic matter. There is no health effect data reported due to TDS in drinking water. However, TDS sometimes claimed for corrosion and encrustation in water distribution system (WHO, 2003b). Due to the low level of TDS in almost all the areas of Chittagong, people loved to use ground water for their daily consumption.

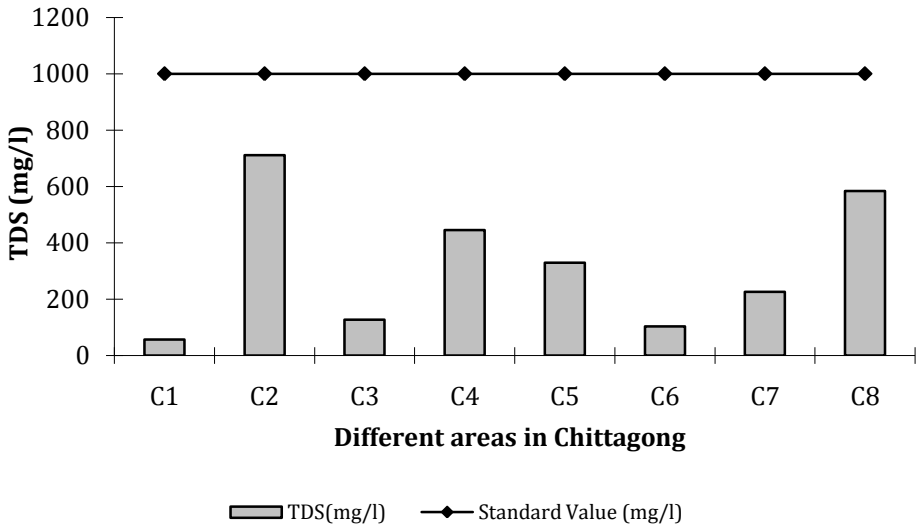

Figure 02. TDS (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Alkalinity: Figure 03 depicted that within eight upazila, the highest value of alkalinity was found in Shatkania (C_4-254mg/l) and lowest in Banskhali (C_6-54mg/l). No areas crossed the safe limit (500mg/l) of alkalinity. This result concluded that ground water in Chittagong were safe in terms of alkalinity. Alkalinity values of different upazila showed significant ($P \leq 0.001$) variation from their mean. Banskhali(C_6) differed from its mean value than others. Kotowali(C_2), Shatkania(C_4) and Potyia(C_5) differed from other upazila. Similarly,Panchlaish(C_1), Fatikchari(C_7) and Mirsharai(C_8) possessed no significant difference among themselves but differed from others.

Alkalinity of water measures capacity to neutralize acids. Most of the alkalinity in natural water causes by three major classes: bicarbonates, carbonates and hydroxides. High alkalinity in drinking water shows soda-like taste. It can dry out skin and sometimes cause scaling problems in water pipes (SDWF, 2015). The values found in this study were under the safe range which might not interfere in water treatment process.

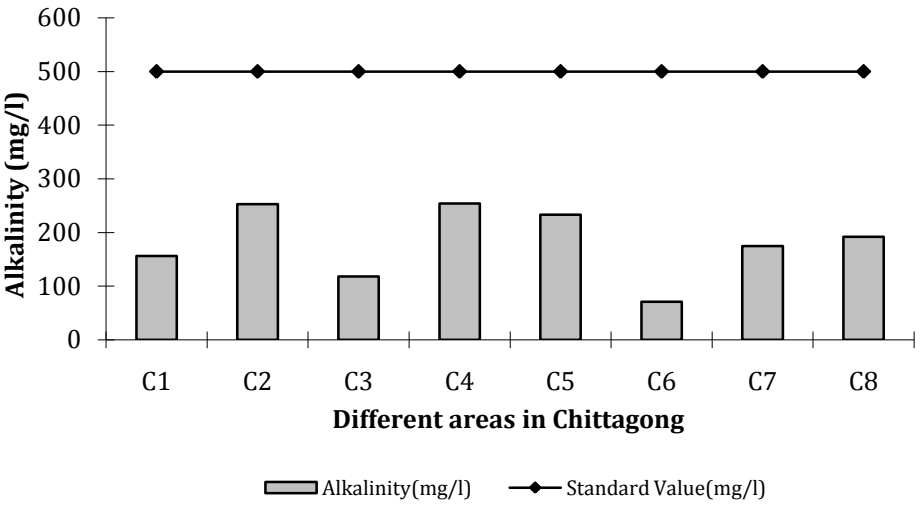

Figure 03. Alkalinity (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Sulfate (SO_4): Figure 04 showed that within eight upazila, the highest value of sulphate was found in Mirsharai (C_8-18mg/l) and lowest in Potyia and Banskhali (C_5 andC_6-4mg/l). No areas crossed the safe limit (400mg/l) of SO_4. This result concluded that ground water in Chittagong was safe in terms of SO_4. Values of SO_4 in different upazila showed significant ($P \leq 0.001$) variation from their mean. Banskhali(C_6) Shatkania(C_4) and Potyia(C_5)differed from its mean value than others. Kotowali(C_2) and Panchlaish(C_1) differed from other upazila. Similarly Fatikchari(C_7) Chandgaon(C_3) and Kotowali(C_2) possessed no significant difference among themselves but differed from others.

Sulfates with Ca and Mg can cause hardness in water. High Sulfate levels have a corrosive effect on plumbing. Report states that Sulfate over 600 mg/l in drinking water causes cathartic effect on human health and with magnesium or Sodium it causes dehydration (WHO, 2004). But the level of sulfate showed in this study was much less than the standard limit.

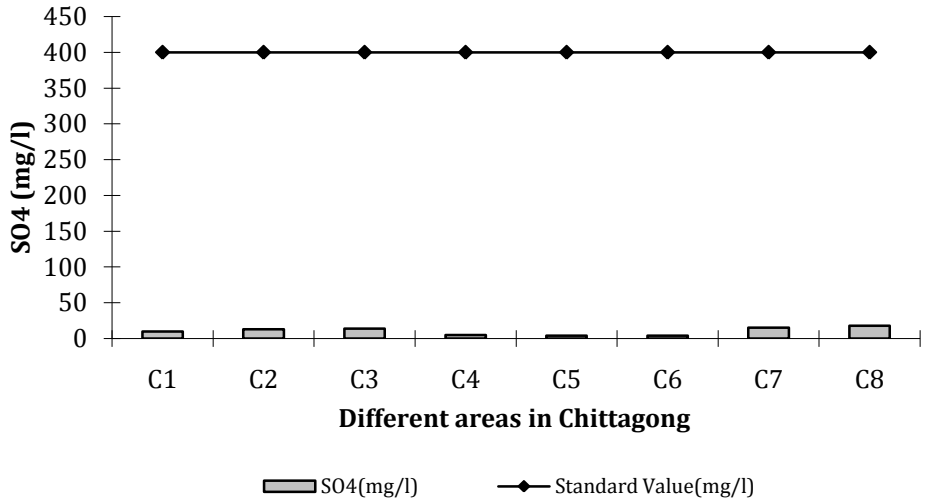

Figure 04. SO_4 (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Phosphate: From Figure 05, the highest value of phosphate was found in Potyia (C_5-3.32mg/l) and lowest in Panchlaish (C_1-0.19mg/l). No areas crossed the safe limit (6mg/l) of PO_4. This result concluded that ground water in Chittagong was safe in terms of PO_4. Values of PO_4 in different upazila showed significant ($P \leq 0.001$) variation from their mean. Banskhali(C_6) Shatkania(C_4) and Potyia(C_5) differed from its mean value than others. Kotowali(C_2) and Panchlaish(C_1) differed from other upazila. Similarly,Fatikchari(C_7) Chandgaon(C_3) and Kotowali(C_2) possessed no significant difference among themselves but differed from others. Lastly, Fatikchari(C_7) and Mirsharai(C_8) had no significant variation in their mean value but differed from other.

Phosphorus is an essential element for human bone and important for energy production and storage (WHO, 2005). Phosphate exists in three forms; orthophosphate, metaphosphate and organically bound phosphate. Ortho form is produced by the natural process. PO_4 is not toxic to people unless it presents in higher concentration and its deficiency is rare in population level (WHO, 2005). Digestive problems couldoccurfrom extremely high levels of PO_4. In Chittagong, PO_4 level was found under the safe limit.

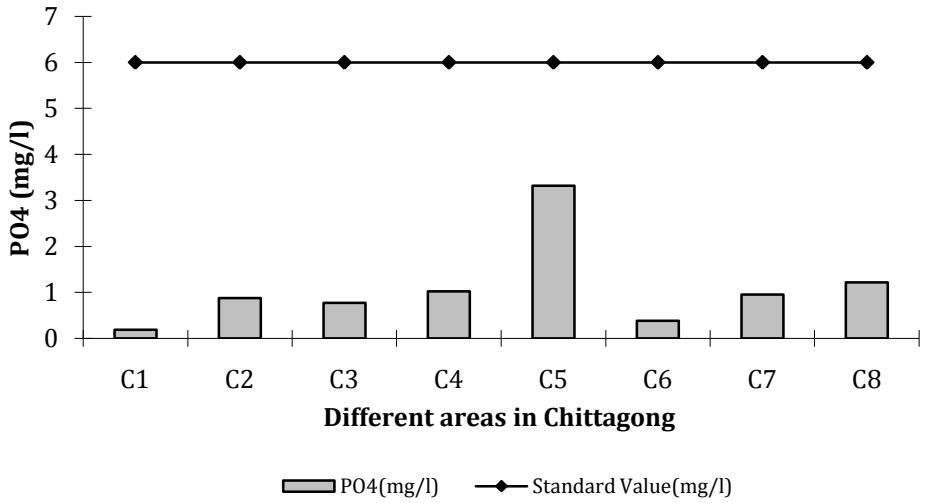

Figure 05. PO_4 (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Free Cl: Within eight upazilathe highest value of free Cl was found in Kotowali (C_2-0.39mg/l) and lowest in Panchlaish and Potyia ($C_1$and C_5-0.01mg/l) (Figure 06). Kotowali(C_2), Chandgaon(C_3) and Fatikchari(C_7) crossed the safe limit (0.2mg/l) of free Cl. This result concluded that ground water in Chittagong were much safer in terms of free Cl. Free Cl values of different upazila showed significant ($P \leq 0.001$) variation from their mean. Banskhali(C_6), Panchlaish(C_1) and Chandgaon(C_3), differed from its mean value with them and others. Kotowali(C_2) and Fatikchari(C_7) differed from other upazila. Similarly,Shatkania(C_4) and Fatikchari(C_7) possessed no significant difference among themselves but differed from others. Mirsharai(C_8) and Potyia(C_5) differed by themselves and others.

Cl present in water as hypochlorous acid, hypochlorite ions and molecular Chlorine are defined as free available Chlorine. Cl when added with water to as free Chlorine oxidizes some of the organic and inorganic compounds. While reacting with ammonia and organic amines, it forms chloramines (WHO, 2003a). When Cl crosses its safe limit then bleaching powder odour comes out and changes the taste of water. From estimated free Cl it is found that shallow tube-well water of Chittagong is safe with some exception.

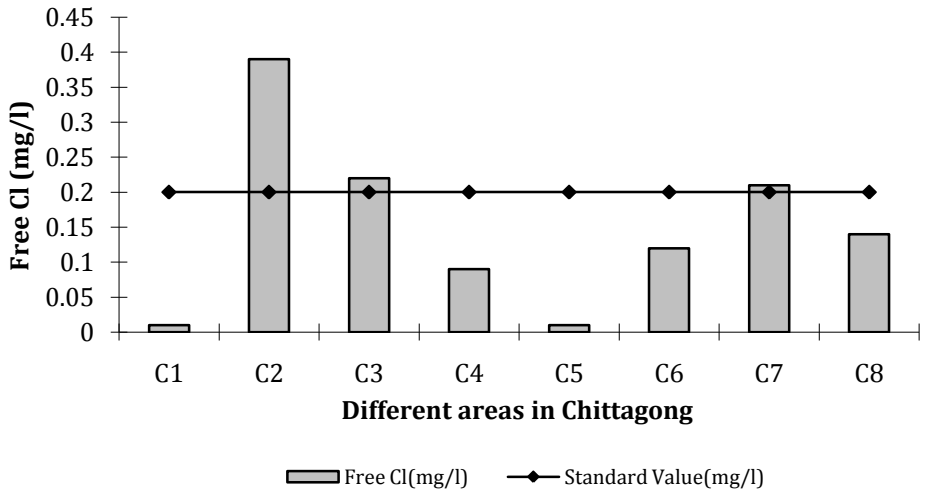

Figure 06. Free Cl (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Hardness: Figure 07 showed that within eight upazila the highest value of hardness was found in Potyia (C_5-68mg/l) and lowest in Panchlaish (C_1-15mg/l). Each of them showed under lower range

(200-500mg/l) of hardness. This result concluded that ground water in Chittagong were not suitable in terms of hardness. Hardness values of different upazila showed significant (P≤0.001) variation from their mean. Banskhali(C_6), Kotowali(C_2), Fatikchari(C_7) and Mirsharai(C_8) differed from its mean value than others. Shatkania(C_4) and Chandgaon(C_3) differed from other upazila. Similarly,Panchlaish(C_1) and Potyia(C_5) possessed significant difference among themselves and differed from others.

Hard water is generally considered being those that requires considerable amounts of soap to produce foam or lather and that also produces scale in hot water pipes, heaters, boilers and other units (WHO, 2011). The report also states that deficiency of calcium in drinking water may enhance the risk of osteoporosis, nephrolithiasis (kidney stones), colorectal cancer, hypertension and stroke, coronary artery disease, insulin resistance and obesity. In case of magnesium deficiency hypertension can be found. The result showed below standard in all the areas of Chittagong.

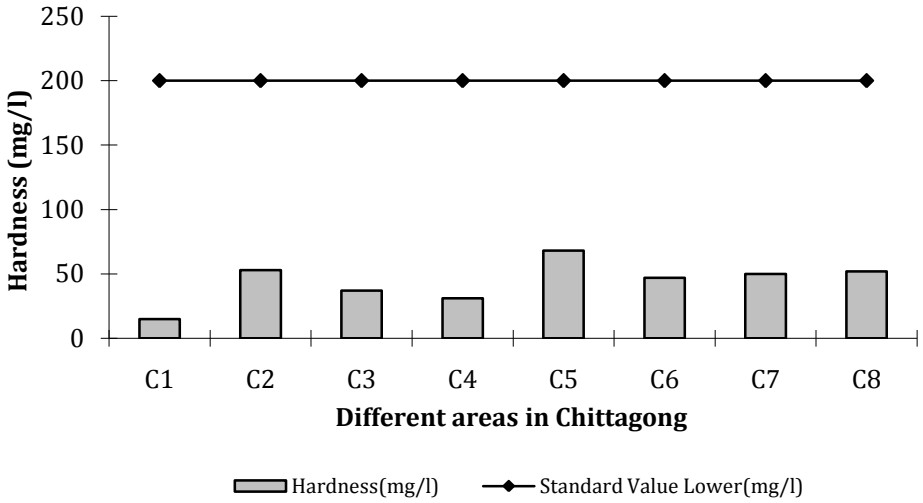

Figure 07. Hardness (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Arsenic (As): Within eight upazila the highest value of As was found in Mirsharai (C_8-0.45 mg/l) and nil (approximately) in Chandgaon and Fatikchari (from Figure 08). Though upper safe limit (0.05 mg/l) of As crossed by C_8 but other upazila were within the standard. This result concluded that As values of ground water in Chittagong are much safer than other parts of the country because Smith et al. (2000) estimated 21 million people of Bangladesh exposed to As contamination over 50µg/l concentration.

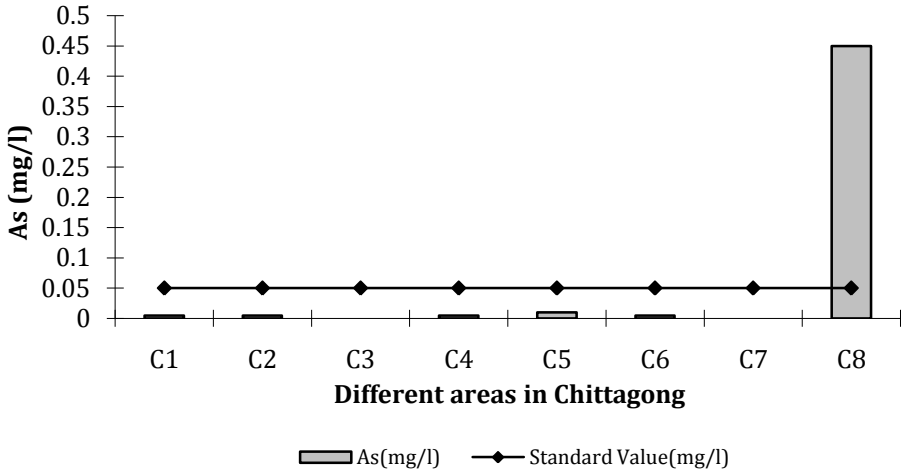

Figure 08. As (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

From the statistical analysis, it was evident that As values of different upazila have shown significant variation from Mirsharai. But within the upazila (C_1-C_7) there was no significant ($P \leq 0.001$) difference. BBS (2005) supported this result where they found only two upazila i.e. Mirsharai and Sitakunda had As contamination over the safe drinking water quality standard in Chittagong district. The report stated that 35.86% tube-well was found As contaminated in Mirsharai. Ahmed and Rahman (2000) explained that nearly one in every three shallow tube-wells produced with As in excess of the acceptable limit. From this result, it can be said that Chittagong belt is much safer for As contamination than compared to other regions of Bangladesh.

Iron (Fe): Within eight upazila the highest value of Fe was found in Banskhali (C_6-3.12 mg/l) and lowest in Mirsharai (C_8-0.14mg/l from Figure 09). Upper safe limit (1mg/l) of Fe was crossed by each of the upazila except Potyia(C_5) and Mirsharai(C_8) This result concluded that Fe values of ground water in Chittagong were not safe. From the statistical analysis, it was evident that Fe values of each upazila showed significant ($P \leq 0.001$) variation from their mean except betweenKotowali(C_2) and Chandgaon(C_3).

It was observed from a survey in 1993 that 1230 unions in Bangladesh possessed Iron content of more than 5mg/l. Dissolved Iron in shallow tube-well water was about 67% areas of Bangladesh which had excess of 2mg/l (Ahmed and Rahman, 2000). Shova (2014) stated that though Fe was abundant in nature, but the small quantity in water had no significant impact on human health. In urban areas Iron removal plants were constructed and in rural areas community type Iron removal units attached to hand-pumps were provided. In Chittagong there was an Iron removal plant in Chandgoan from where ground water was supplied to the city area. However, Fe content in deep tube-well water showed comparatively lower. For this reason, people choose ground water as a source of consumption.

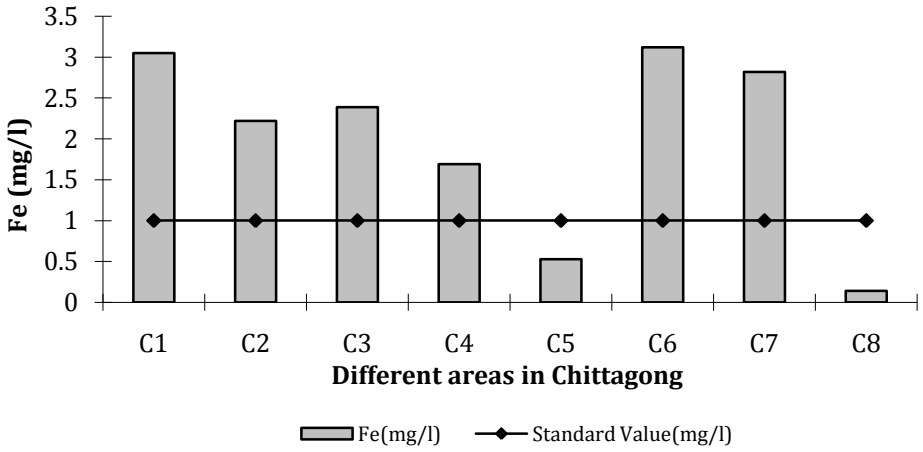

Figure 09. Fe (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Copper (Cu): Within eight upazila the highest value of Cu was found in Panchlaish (C_1-0.19 mg/l) and lowest in Chandgaon (C_3-0.04mg/l from Figure 10). No area crossed the upper safe limit (1mg/l) of Cu. This result concluded that Cu values of ground water in Chittagong were safer. From the statistical analysis, it was evident that Cu values of each upazila showed significant ($P \leq 0.001$) variation. Potiya(C_5) and Chandgaon(C_3) showed differences from other areas significantly. Kotowali(C_2) and Fatikchari(C_7) also varied in their mean than others. Similarly, Kotowali(C_2), Shatkania(C_4) and Banskhali(C_6) also found different from other upazila.

Although Cu uses commercially for various purposes, its major source in drinking water is corrosion of copper pipes used for water conveyance. Cu is a gastrointestinal irritant but generally not harmful in low concentration (Ahmed and Rahman, 2000). Studying the figure, it was concluded that the water of study areas was safe.

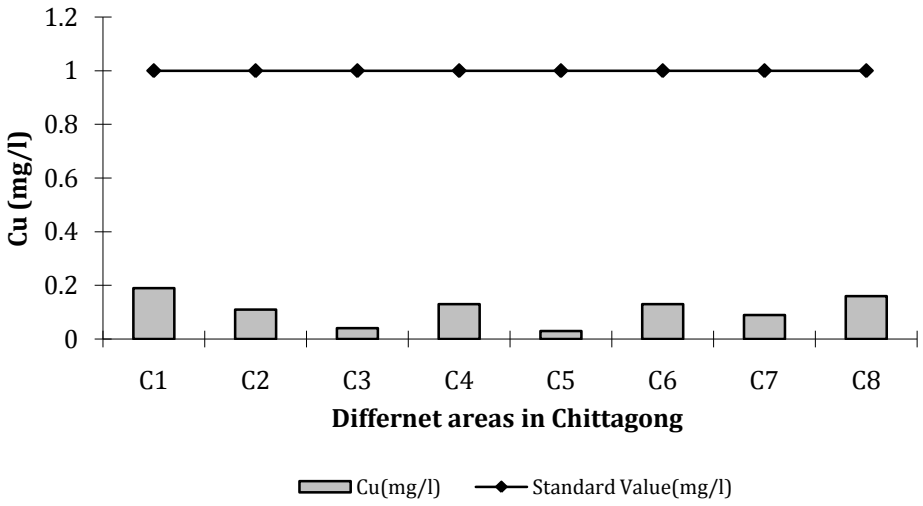

Figure 10. Cu (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Zinc (Zn): From Figure 11, the highest value of Zn was found in Chandgaon(C_3) and Mirsharai(C_8) (0.06mg/l) and lowest in Shatkania (C_4-0.02mg/l). No area crossed the safe limit (5mg/l) of Zn. This result concluded that ground water in Chittagong was safe in terms of Zn. Zn values of different upazila showed no significant variation from their mean. Only Panchlaish(C_1), Kotowali(C_2), Shatkania(C_4), Potyia(C_5), Banskhali(C_6) and Fatikchari(C_7) varied from other two upazila. Similarly,Panchlaish(C_1), Kotowali(C_2), Chandgaon(C_3), Potyia(C_5), Banskhali(C_6), Fatikchari(C_7) and Mirsharai(C_8) had significant difference than Satkania.

Zinc most commonly enters the domestic water supply from deterioration of galvanized Iron and dezincification of Brass. It is known as an essential micronutrient for human health but high concentration cause corrosive to skin, eye and mucous membranes (Juneja and Chaudhary, 2013). Concentration more that 5mg/l might cause a bitter astringent taste and opalescence in alkaline waters.

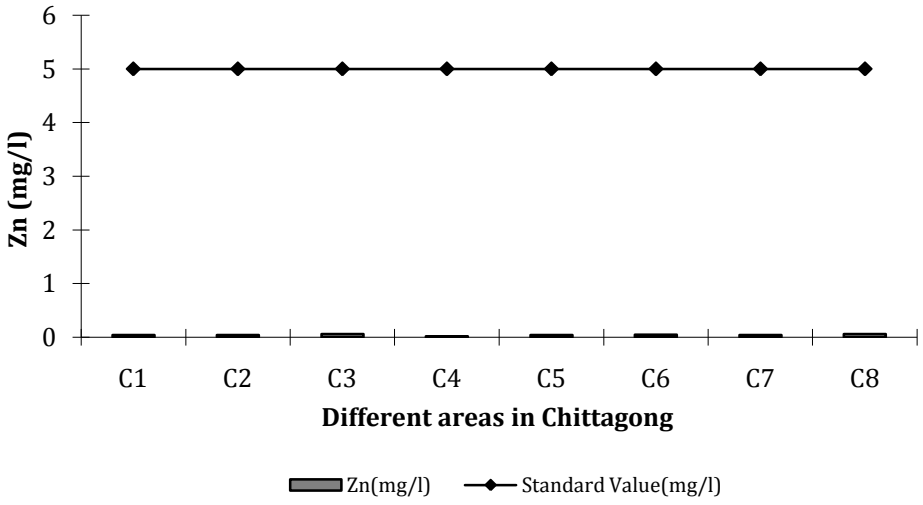

Figure 11. Zn (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

Nitrite (NO_2): From Figure 12, the highest value of NO_2 was found in Mirsharai (C_8-0.05mg/l) and lowest in Panchlaish(C_1), Kotowali(C_2) and Potyia(C_5) (0.01mg/l). No area crossed the safe limit (<1mg/l) of NO_2. This result concluded that ground water of Chittagong is safe in respect of NO_2. All the upazila did not differ from its mean value than others except Mirsharai(C_8).

Nitrogen is one of the essential elements mostly for the plants and algae. The standard value of Nitrite-N differs from 1993 WHO guide lines where NO_2 was proposed to remain within 3 mg/l for drinking purposes where as in ECR, 1997 limited the value <1 mg/l.

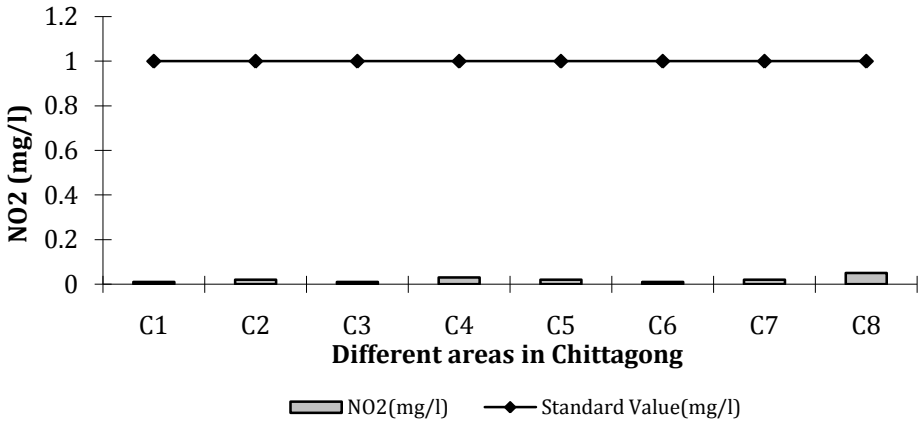

Figure 12. NO_2 (mg/l) of ground water in different area at Chittagong and safe limit of drinking water

IV. Conclusion

Some drinking water quality parameters such as pH, TDS, Alkalinity, Sulfate, Phosphate, Free Chlorine, Total Hardness, Cu, Zn and nitrite were examined in different areas of Chittagong district and found the values within the safe limit. Only Iron and Arsenic showed little distortion from the drinking water quality standard. Out of eight upazila, six were contaminated with Fe which represented the overall condition of the district. Though As was found beyond the safe limit in only one upazila of Chittagong district, however, due to its serious health implication to human body, people should be encouraged to find out surface water sources, for example, rain, pond and river. In addition, Arsenic removal plant can be made available to arsenic prone areas. Like Arsenic, Iron contamination also needs to be handled properly by using the alternative source of water and purification technology.

V. Acknowledgement

We are debt to Mr. Md. Salim Uddin, Departmental Head, Department of Environmental Technology, Chittagong Polytechnic Institute, Chittagong for his kind cooperation to test the water samples in the Department's laboratory.

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