Assessing the Groundwater Quality of Rohingya Refugee Camp Cox Bazar Bangladesh

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Abstract

Groundwater is the singular source of drinking water in Rohingya Refugee Camps, CoxBazar Bangladesh. A study was conducted to assess the quality of the groundwater and its suitability as potable water. Samples collected from ten water points that are hand pumps connected to borehole wells locally called tube wells of Rohingya Camp16 was collected for analysis of water quality parameters. The water quality parameters that were measured were:pH, turbidity, total hardness, arsenic, manganese, iron, and total coliform. The results indicate that the water is moderately hard with pH values within regulatory limits. Some of the water samples exceed the limit for total iron based on the Government of Bangladesh regulatory standards. The water samples were arsenic free which is a relief for many localities in Bangladesh suffer from the purge of arsenic contaminated groundwater. Unfortunately, many of the water samples collected contains higher than accepted levels of manganese which can be an issue with prolonged consumption. Chronic exposure to manganese results in developmental problems in adolescents. Majority of the waters samples also showed the presence of total coliform and sure indication the fecal contamination of the water wells is occurring. The water quality data pointsto a senior that calls for pragmatic water quality assurance and management measurers for thesustainable wellbeing of the refugee communities in the refugee camps of Cox Bazar, Bangladesh. We will be putting forth evidence based sustainable solutions to achieve sustainable supply of safe drinking water to the Rohingya communities in the camps.

Key Words: Groundwater Quality, Rohingya Refugee Camps, Potable Water

Introduction

Rohingya are a minority stateless Muslim population of Myanmar, close to one millionof the Rohynga people have taken refuge in Bangladesh escaping persecution in Myanmar. TheRohingya refugee camps were constructed spontaneously in an unplanned way with the suddenrush of a million soles escaping Myanmar and coming to Bangladesh. The close to a million Rohingya refugees living in these camps require water for drinking, cooking, bathing, and other domestic use. It is estimated that the daily water demand is around eighty million gallons.

Groundwater is the main source of drinking water for the people in these camps (reliefweb, 2019). It is estimated that different agencies both local, and international have install around20,000 shallow tube-wells within a very short time to provide water for the Rohingya refugees (Rahman, 2019).

Unfortunately, the tube wells were bored during a very short span of time to meet the sudden influx of the refugees. The end result is that the wells were shallow, close to each other,and in close proximity to latrines and other open source of fecal pollutions.

Figure 1 Open source of contamination in the Rohingya refugee camps

Figure 2 Water point next to Open source of contamination in the Rohingya refugee camps

Inevitably, there was a concern of water borne diseases outbreak due to fiscal contamination from the proximity latrines and open source of surface pollution. United Nations Children's Fund (UNICEF)Bangladesh took an initiative to test the presence of fecal coliform in the Rohingya camps of Cox's Bazar. 3500 water sample were collected and amongthem 1977 were tested the Environmental Microbiology lab of International Centre for Diarrheal Disease Research, Bangladesh. 37.12% of the water samples tested positive for fecalcoliform, a clear indicator that fecal contamination was occurring. It was postulated that the fecal contamination was introduced by contamination of the mouth of the tube-wells through contact with human hands during water collection from the wells, which caused the bacteria's from the hands to transfer to the snout of the tube-wells (UNICEF, 2018). After the snout of the tube-wells were decontaminated, around 93% of the water samples were free of the fecal bacteria. To try to ensure supply of pathogen free water United Nations Refugee Agency (UNHCR) has initiated a program an energy efficient safe water network in the Kutupalong- Balukhali refugee camps (Dhaka Tribune, 2019). The network consists of large tanks where source water is chlorinated and them pumped to the receiving points the required power for the pumps are provided by solar panels. The ongoing effort is limited in scale with the majorityof the population of refugees are consuming unsafe water. UNCHR are planning to install morenetworks at the cost of around $US 10 million, as well as installing more deep tubewells to reduce the risk of fecal contamination (Dhaka Tribune, 2019).

The sampling and testing programs conducted by the refugee organizations were targeted for microbial water born contaminants and to undertake remedial action to mitigate their immediate threats. However, no water sample was tested for non-biological water quality parameters that can cause adverse health effects and aesthetic concerns. This paper reports on a limited water quality testing program where water samples were collected from tube wellsand analyzed from Ukhiya camp number 16 and compare the obtained values with World Health Organization (WHO) standards.

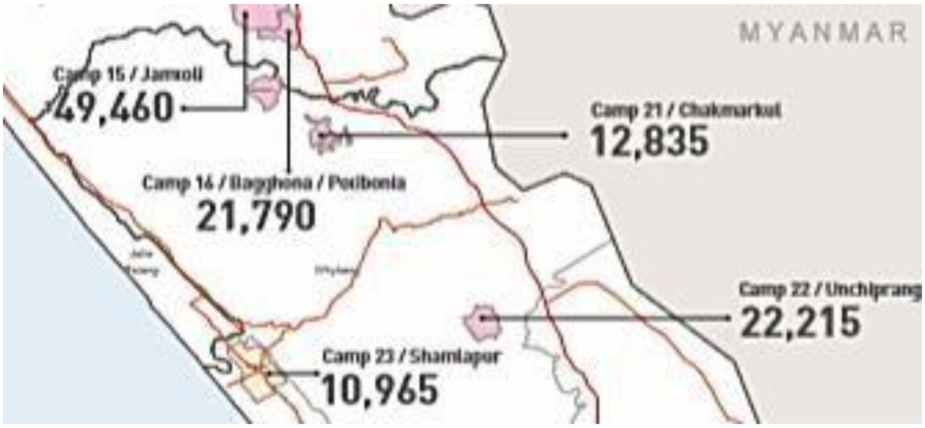

Figure 3 Location of Camp 16, Ukhiya, Cox's Bazar, Chattagram

Ten samples were collected from tube wells within Camp 16, located in a place calledPotibonia, the wells were chosen based on their usage as the prime sources of drinking waterfor refugees. The water samples were analyzed in the Department of Environmental Science and Management laboratory of North South University. The water quality parameters that were analyzed for include pH, turbidity, total hardness, iron, arsenic, manganese, dissolved oxygen, salinity, electrical conductivity, total dissolved solids, and salinity.

Figure 4 Collection of water from camp 16

Materials and methods

Prior to sampling of the tube-well water the hand pumps were operated to ensure requiredflushing of the withdrawal pipeline and pump head. This ensure that representative samplingof the aquifer was occurring. The water samples were collected in prior cleaned plastic water bottles filled to the top with no headspace, ensuring that the water matrix was not compromisedprior to laboratory analysis.

The water sample's pH was measured by a portable HANNA pH meter and probe. Arsenicwas measured using a HACH field arsenic test kit. Total iron was measure by HACH total irontest kit. Total hardness was measured using HANNA hardness measurement kit. For measuring d dissolved oxygen (D.O) HQ40D portable multi meter designed by HACH was used. For turbidity, Lutron's turbidity meter was used. The device is ranged to measure turbidity from 0- 1000 NTU with an accuracy of 0.5 NTU. For manganese the spectroscopy technique was usedas per Standard Methods (American Public Health Association, 1989) . For electrical conductivity, total dissolved solids and NaCl percentage, HANNA HI2300 EC/TDS/NaCl meterwas used. By the help an electrode, the meter can show the following parameter values.

Results and Discussion

The sampling and testing programs conducted by the refugee organizations were targeted for microbial water born contaminants and to undertake remedial action to mitigate their immediate threats. However, no water sample was tested for non-biological water quality parameters that can cause adverse health effects and aesthetic concerns. This paper reports on a limited water quality testing program where water samples were collected from tube wellsand analyzed from Ukhiya camp number 16 and compare the obtained values with World Health Organization (W.H.O) recommended maximum contaminant levels allowable in drinking water.

The water quality parameters that were analyzed for and reported in Table 1 include pH, turbidity, total hardness, iron, arsenic, manganese, dissolved oxygen, salinity, electrical conductivity, total dissolved solids, and salinity. The three parameters of known concern in Bangladesh groundwater are: (1) Arsenic: Arsenic contamination of ground water is a known problem associated with Bangladesh groundwater that has sever health consequences due to chronic consumption, and it is of utmost importance that the camp water is free of arsenic. (2)Manganese: Manganese is a contaminate associate with Bangladesh groundwater as is a known to produce neural development problems in adolescents. (3) Salinity (NaCl): The adverse effect of drinking water with high salinity is hypertension in adults and of severe concern is eclampsia in pregnant women a condition in which convulsions occur in a pregnant woman suffering from high blood pressure, threat to the health of mother and baby. End resultsis still births in the discussion below we addressed the results of our analysis and their implication for all parameters analyzed in the collected water samples have been discussed indepth.

Table 1. The ten water quality parameter analyzed for the well water samples collected from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh. Values reported as mean ± Standard deviation.

Parameter	**Mean ± Standard deviation**	**HO drinking water standard limit**
pH	6.39 ± 0.38	6.5-8.5
Turbidity (NTU)	1.34 ± 3.18	1
Total Hardness(mg/L)	310 ± 86.1	60 mg/L or below (soft water) Up to 300 mg/L
Dissolved Oxygen (mg/L)	8.28 ± 0.09	
Iron (mg/L)	1.16 ± 2.31	0.3
Manganese (mg/L)	0.05 ± 0.02	0.1
Conductivity (µS/cm)	249 ± 101	0-2500
Total Dissolved Solids (mg/L)	164 ± 92.1	<300 mg/L (recommended) 1500 mg/L
NaCl (%)	0.48 ± 0.18	300 mg/L or 0.03%
Arsenic	Nil	0.01

pH

pH is a measure of how acidic or alkaline water is, the ideal range of pH for potable water is from 6.5-8.5 (Guidelines for Drinking-water Quality, 2003). A lower pH than this range meansthe water is acidic, and a pH of as low as 5 or less or a high pH of around 9.5 or more may cause skin irritations or swelling of fibres (Guidelines for Drinking-water Quality, 2003).

The average pH (6.39 ± 0.38) observed for all samples was slightly lower than the accepted range of World Health Organization potable water pH. However, since the source of this water is groundwater, it is natural to have a pH of around 6.35 as a large percentage of groundwater recharge is achieved by rainwater, which is slightly acidic, usually with a pH ofaround 5.5 (Guidelines for Drinking-water Quality, 2003).If we consider each sample's pH from Figure 5,we can see that the pH of batch 3 is lower than 6,somewhere around 5.7.This sample is a bit of concern as it is well below the standard range. Even though this will not poseas a health risk to human for aesthetically the water may taste slightly metallic due to the elusion of metals from the pump head that is made out of cast iron at lower pH values.

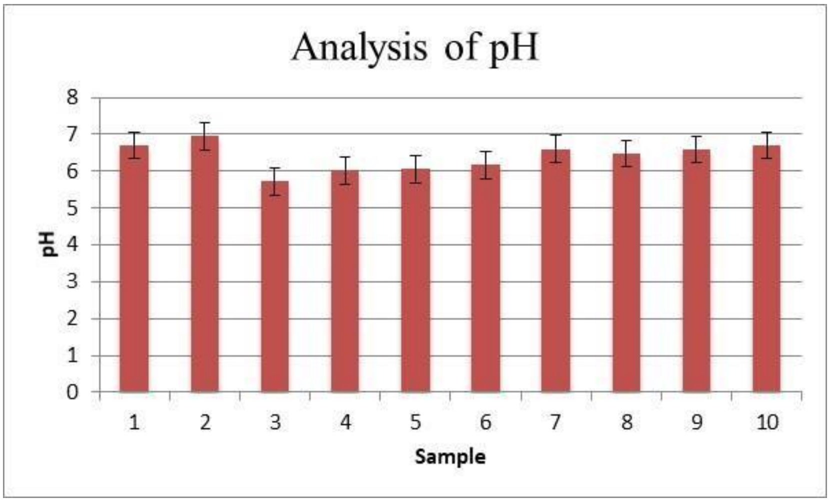

Figure 5 Distribution of pH values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Turbidity

The turbidity distribution is shown in Figure 6 with the average being 1.34 ± 3.18 NTU.The average turbidity was higher than the standard range provided by World Health Organization of 1.0 NTU. Suspended particles in water gives rise to turbidity as well as makingthe water look slightly cloudy or murky. However, if the batches are observed individually fromFigure 6, it can be seen that only batch 8 has turbidity greater than 10.NTU. Since the water is coming from groundwater, one of the reason for such high turbidity could be due to presence of inorganic geological substances. Also, since the tube wells are shallow, there is a probabilityof that the aquifer may get contaminated with surface water, resulting in this turbidity.

However, the health hazards for high turbidity are quite subjective, depending on the substances that are causing the turbidity. Most of the time slight rise in turbidity doesn't cause much than disrupting the aesthetic property of the potable water, however, high turbidity maymean that the suspended particles will be an obstacle in the process of disinfection, or even directly pose health hazard to human if they are harmful organic substances (Health & Health,2011). Therefore, this tube well and the aquifer must be examined further to check if the turbidwater contains any harmful suspended particle or not.

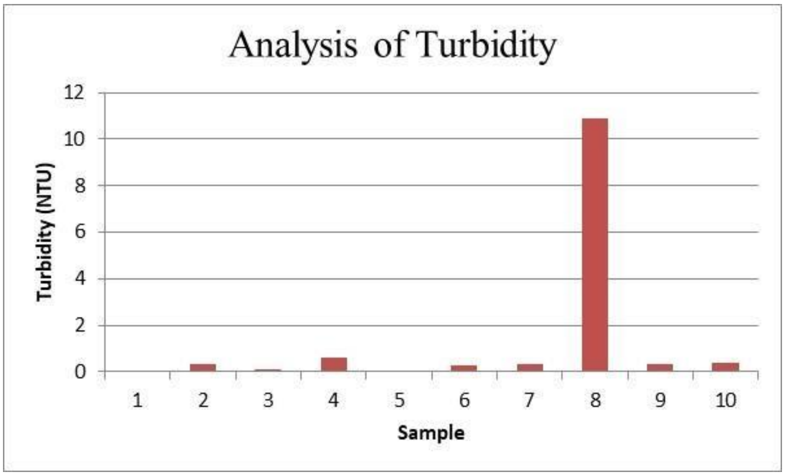

Figure 6 Distribution of Turbidity values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Total Hardness

Total hardness is determined by the amount of calcium and magnesium compounds in water and reported as calcium carbonate hardness. Groundwater can have hardness greater than 100 mg/L. However, potable water requires hardness to be below 60 mg/L to be palatable. The average total hardness found from the collected well water samples were 310 ± 86 mg/L, which falls in the range of very hard water (Hardness in groundwater, 2007) therefore making it unpleasant to drink. If the individual batches are observed from Figure 7, it can be seen that sample 1, 7 and 8 has an alarming concentration of total hardness of around 400 mg/L,500 mg/L and 400 mg/L respectively. Even though calcium and magnesium ions are vital for our health and concentration up to 300mg/L is acceptable by consumers , exceedingly high amounts of can lead to kidney stones, hypertension stroke, and coronary artery disease. (Organization, 2011).Usually total hardness can be reduced by filtration techniques like reverse osmosis, ion exchange or oxidizing filters, but the camps do not provide filters, nor does the refugees can afford to buy one. One simple way could be by boiling the water before drinking, as boiling can reduce the total hardness up to certain extent. Well waters from samples 1,7 and 8 must be treated before consumption because such high total hardness in drinking water is not recommended at all.

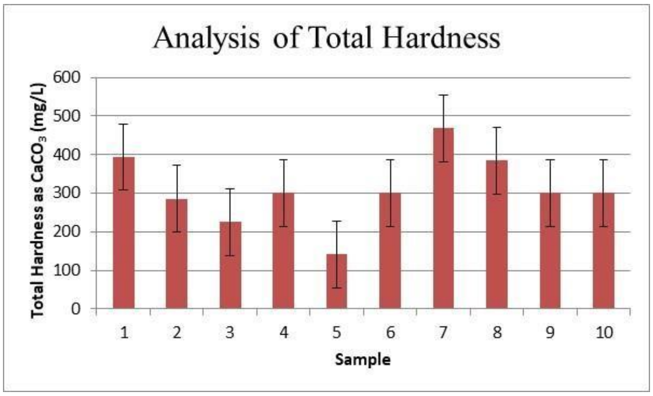

Figure 7 Distribution of Total Hardness as CaCO3 values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Dissolved Oxygen

The concentration of dissolved oxygen in drinking water does not have any correlation to health effects for humans. However, higher concentration of dissolved oxygen in water is associated taste of the water (Lenntech, 1998). The World Health Organization, therefore, does not specify a specific standard of dissolved oxygen concentration for drinking water. Figure 8 shows the distribution of dissolved oxygen in the collected water samples with an average dissolved oxygen concentration of 8.28 ± 0.09 mg/L. This indicates we are getting saturation values in the sample. This means that equilibration of the water with respect to dissolved and atmosphere oxygen occur while extracting the sample or in storage and the values observed does not reflect the dissolved oxygen levels in the aquifer. No inference can be made from the collected data accurately.

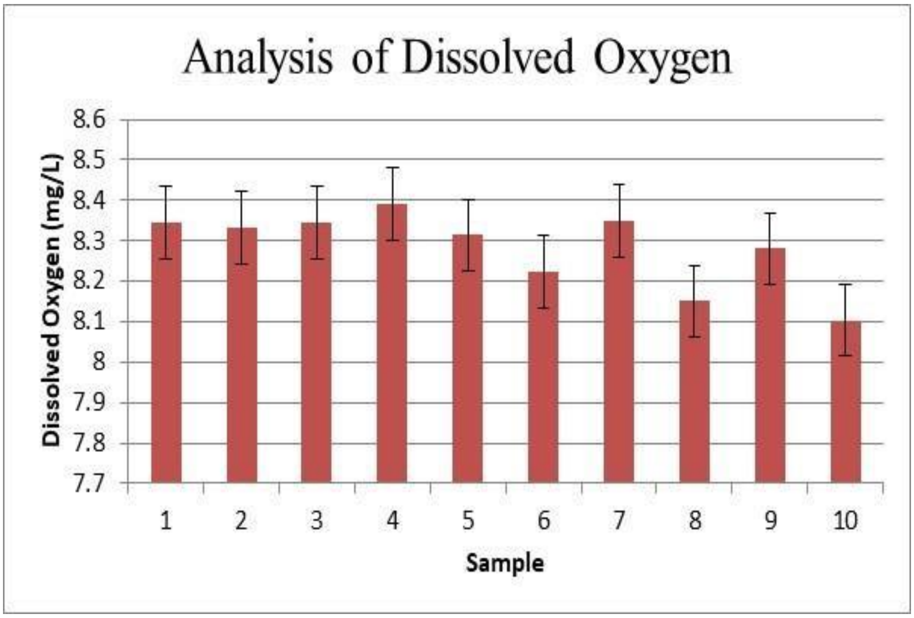

Figure 8 Distribution of dissolved oxygen values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Iron

Being the second most abundant metal, iron is readily found in the earth's crust, however, only 5% of the iron is usually found in its elementary state as iron readily reacts withoxygen to form Fe^{2+} and Fe^{3+} (Illinois Department of Public Health, 2010). In drinking water supply, Fe^{2+} is unstable oxidizing further to insoluble Iron (III) compound which is reddish brown in color. This compound is responsible for the reddish brown cloudy color that we see in water with high iron content. When rainwater percolates through the soil and other geological formations, the iron present it dissolved in the rainwater and seeps into the groundwater (Guidelines for Drinking-water Quality, 2003). Iron is an essential substance for human health; however, insufficient intake can have negative impact in human health. Iron is usually not hazardous to human health; however it is a secondary or aesthetic contaminant. Water containing excessive iron causes the water to taste metallic, which is quite unpleasant. As well as taste, Iron may also promote bacterial growth from waterworks or delivery pipes, which makes the water contaminated (Guidelines for Drinking-water Quality, 2003).

The average iron concentration in the collected samples was 1.16 ± 2.31 mg/L, whereasWorld Health Organization standard criterion for iron concentration in drinking water is 0.3 mg/L. If Individual well samples are considered in Figure 8, samples 4,8 and 9 has high concentration of iron and these batch's pH are also lower than 6.5. Therefore, we can infer from these data that the amount of ferric compound could be due to the low pH. However, the pH is not significantly low to cause ferrous iron to oxidize to ferric iron compound. For well water sample 8, the iron concentration is 8 mg/L which is alarming and the water should be treated before consumption. Some methods of treatment are filtration, post chlorination or aeration which could effectively remove the iron from water. Again, these methods are costly and possible for a single Rohingya family to afford and one must look at community treatment remedial methods.

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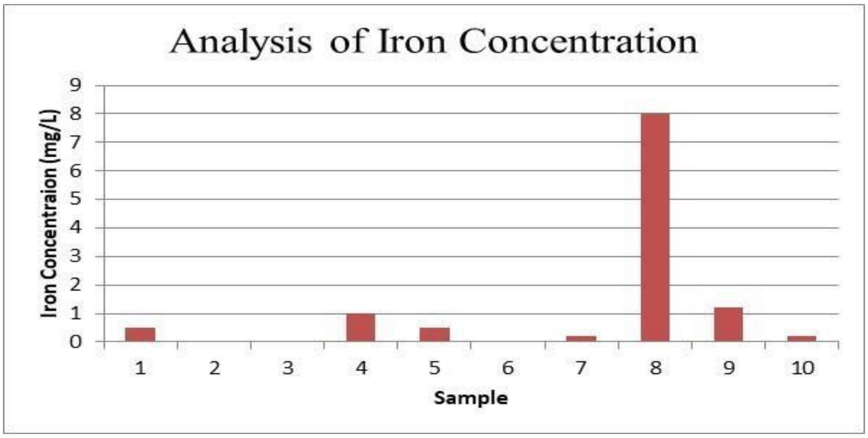

Figure 9 Distribution of total iron values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Manganese

Manganese is one of the most abundant elements in earth earth’s crust with iron most of the time (Ann, 2005). It naturally exists in groundwater via soil erosion or human activitieslike producing industrial wastes may lead to manganese being introduced to groundwater (Organization, 2011). Often anaerobic conditions in groundwater may lead to an increase in level of dissolved Mn. Manganese is an important element for both human and animals as theyhelp in functioning of a lot of cellular enzymes as well as activating many others (Organization, 2011). The samples have an average Mn concentration of 0.05 ± 0.02 mg/L, which is well below the maximum allowable concentration in drinking water provided by WHO. From Figure 9 it can be seen that all batches have manganese concentration less than 0.1 mg/L, except sample 2, which has a Mn concentration around 0.11 mg/L, however the concentrationis within the margin error of analysis and can be considered within the limit specified by the World Health Organization. The wells in camp 16 are manganese safe.

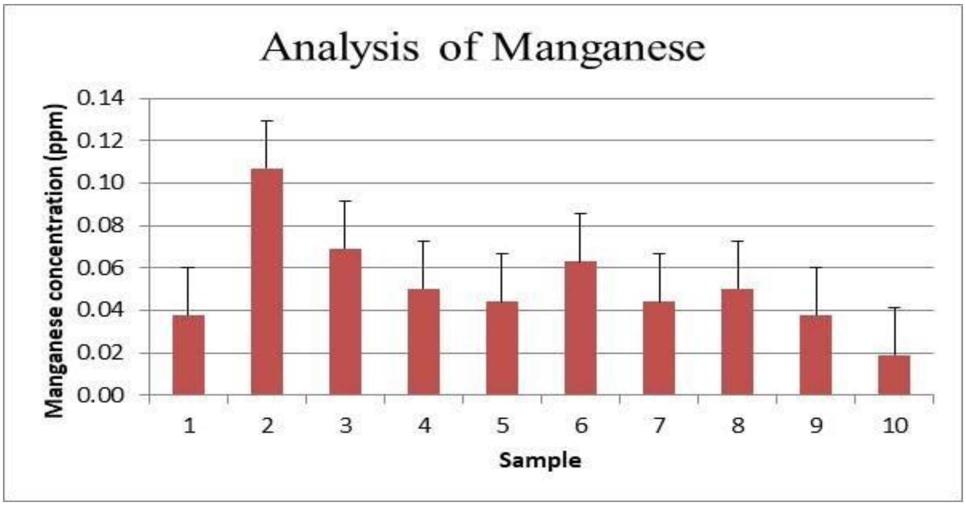

Figure 10 Distribution of total manganese values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Electrical Conductivity

Electrical conductivity is a test which is done to see the salinity of the water. Water containing high amount of ions will have a high electrical conductivity as moving ions can conduct electricity. Sea water has an electrical conductivity of as high as 50000 µS/cm, whereasfresh water usually as conductivity of 0-1500µS/cm (Mary River Catchment Coordinating Committee, 2013). For drinking water, electrical conductivity must be within 800 µS/cm to ensure that the salinity is not too high to restrict consumption. Human can consume water with electrical conductivity up to 2500 µS/cm, however it is not recommended. Consumption of water with high salinity may lead to skin diseases, respiratory diseases, diarrheal diseases and miscarriages (Paolo Vineis, 2011). The average electrical conductivity found in our samples were found to be 249 ± 101 µS/cm, which is a decent figure and confirms the water to be potablein terms of salinity. If individual batches are considered from Figure 11, all the samples collected have an electrical conductivity less than 800 µS/cm again with the limits of consideration for potable water.

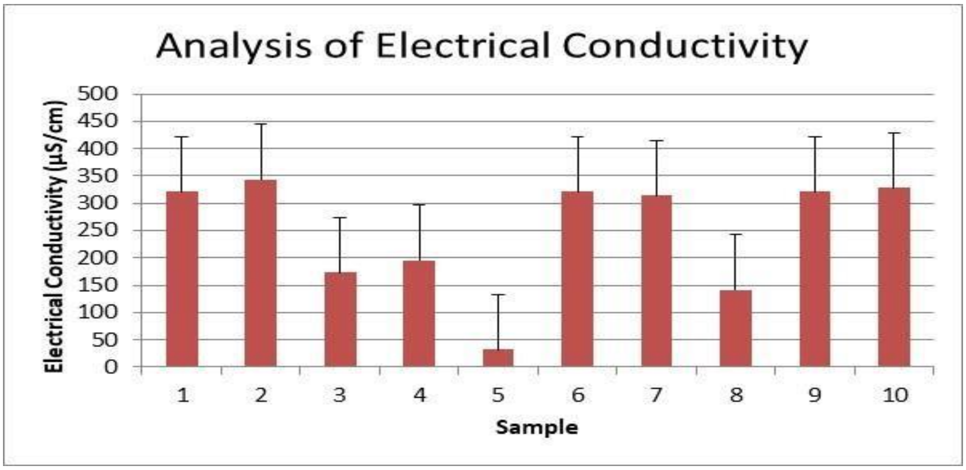

Figure 11 Distribution of total conductivity values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Total dissolved solids

Total dissolved solids (TDS) is another parameter to determine the salinity in water. It also includes any organic substance dissolved in water. Usually the main components that makes up total dissolved solids are calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions (Guidelines for Drinking- water Quality, 2003). The amount of TDS in water can be introduced by natural sources like soil, rocks, urban and agricultural run-off, sewage and industrial waste water (Guidelines for Drinking-water Quality, 2003). The presence of total dissolved solids can make difference in the taste of water. Water with TDS of less than 300 mg/L is said to be excellent and water with TDS of 1200 mg/L or greater is unacceptable (Guidelines for Drinking-water Quality, 2003). However, negligible amount of TDS can also make the water taste very dull. No health issues are directly linked with increased amount of TDS, however high TDS does make the water very hard and unpleasant to drink, as discussed earlier. But a study in Australia have found correlation between increased TDS intake and heart diseases ,however it wasn’t yet confirmed if increased TDS was the only parameter to cause these diseases (Guidelines for Drinking- water Quality, 2003). In our study, the collected samples had an average TDS of 164 ± 92.1 mg/L which is within the range of excellent. However, if individual batches are considered from Figure 12, samples 9 and 10 have very high TDS, exceeding the limit of excellent standard, however the water is still drinkable.

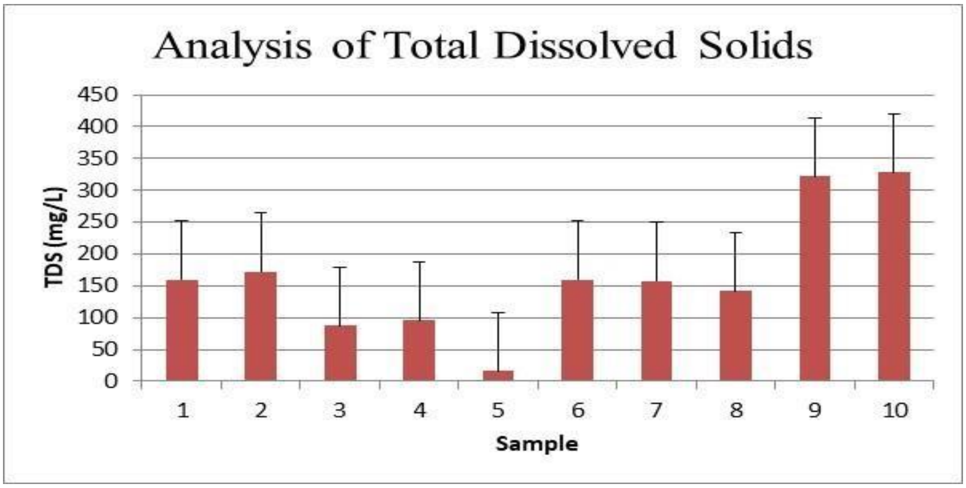

Figure 12 Distribution of total dissolved solids values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Sodium Chloride

Sodium chloride is naturally present in groundwater. Especially in southern region of Bangladesh, due to sea water as a large source of surface water, seawater intrusion can introduce chlorides into groundwater. High uptake of sodium chloride can lead to diseases such as dehydration, irritation in skin or stomach, kidney diseases and high blood pressure (Healthline, 2005). The average NaCl found to be 0.48 ± 0.18, which is noticeably greater thanthe threshold value provided by World Health Organization. If individual batches are considered from

Figure 13, none of the batch has sodium chloride percentage lower than 0.03%. Unfortunately, excess NaCl can only be removed by deionization or reverse osmosis filtration, and both are expensive and quite difficult as a treatment process (Guidelines for Drinking-water Quality, 2003). With further extraction and the close proximity of the camps to the sea one excepts that the problem will worsen with time. This is an unfortunate situation that calls for prudent water management practices.

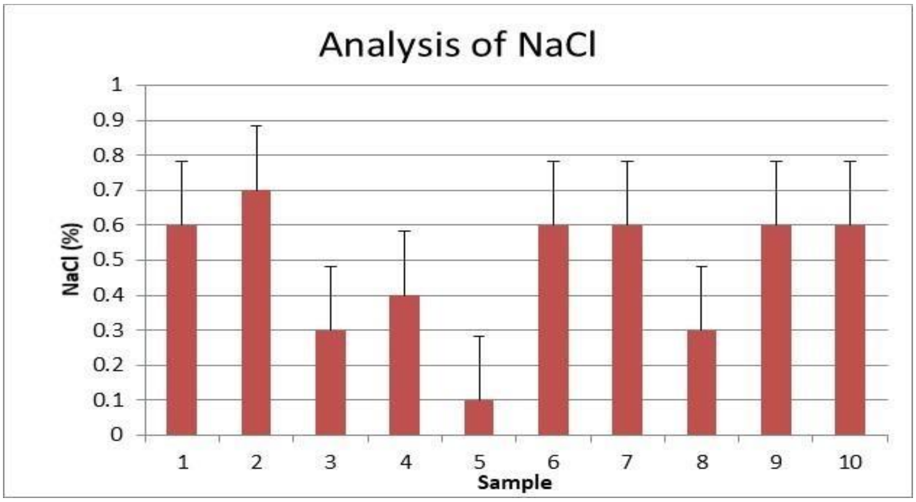

Figure 13 Distribution of salinity values of the collected samples from Camp 16, Ukhiya, Cox's Bazar, Chattagram, Bangladesh

Arsenic

One of the deadliest metals that can lead to fatal heath diseases is Arsenic. Starting from black foot disease, skin lesions, and cancer, heart diseases which may lead to amputation of affected limbs or death even. Many groundwater aquifer of Bangladesh is contaminated with Arsenic greater than the maximum contaminant level (MCL) which is 0.05 mg/L. Fortunately, none of the samples collected and analyzed had arsenic.

Rohingya families are leading an uncertain life as refugees. Even though many organizations are trying their best to ensure a better life for them, the process requires more time and hefty amount of fund.

However, conditions have still improved from what was earlier, the people barely having a tent to live in. Still now, a lot of children are suffering from malnutrition and sometimes water-borne diseases like diarrhea. From our study, we discoveredthe water quality of the camp was found to be of moderate quality, with moderately high iron content, sodium chloride, turbidity and total hardness. Some of the parameters can only be removed by filtration like iron and sodium chloride, but turbidity and total hardness can be reduced by boiling the water. Therefore, Rohingya families should be informed to at least boilthe water for 1 minute for drinking purpose. Even though there haven't been reports of severewater-borne diseases yet, measures should be taken to relocate latrines away from tube wells which can get contaminated by fecal coliform. The organizations are working hard to improvethe conditions of the camp every day, for example they have installed chlorination tank to disinfect water, making it safe for drinking before reaching the families. More organizations need to step up to increase the amount of funding, and also basic hygiene knowledge should be provided to Rohingya families to keep wash their hands before cooking or filling water from tube wells, as fecal contamination was caused by hand contact with the mouth of tube wells. As previously mentioned, the improvement will require time to develop as well as help from organizations.

Salinity is the only issue that will progressively get worse with continued extraction and needs a progressive water management policy needs to be in place in the camps. One optionwhich is viable and sustainable is rain water harvesting needs to be introduced in the camps toprovide salinity free water in the camps. Also to augment rain water harvesting in the dry mothsReverse Osmosis plants will have to be placed in the camps to provide drinking water free of salinity. Digging of deep wells will not be a solution for deeper aquifers are more prone to saline intrusion and the water in the coastal wells will have high salinity. Only way forward isa progressive policy for the short term that manages the extraction of water from the aquifer, harvest rain water and put in place along with the more expensive option of community reverseosmosis systems needs to be in place in the camps to provide safe drinking water for the campresidents.

Conclusion

The main objective of this pilot study was to ascertain if there is any non-biological water quality was of concern in the Rohingya refugee camps. The pilot study conducted in Camp 16 show the only no biological water quality of concern is the high salinity of the water exceeding the World Health Organization recommended limit by a factor ten. Long term implication of this finding is grave, risks of hypertension in the population. Gestational hypertension in child bearing women may cause increases in still births and aborted births. Progressive policy that manages the extraction of water from the aquifer, harvest rain water and introduction of community reverse osmosis systems needs to be in place to supply drinkingwater free of salinity and pathogen.

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