Analysis of the Quality of Water in Hand Dug Wells and Boreholes in Ogbia Local Government Area.

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ARTICLE INFO	ABSTRACT

This research work focuses on the quality of water between hand dug wells and borehole in Ogbia Local Government Area. Water samples were collected from Otuoke, Onuebum and Emeyal I communities. The microbial and physicochemical parameters were analyzed in the laboratory and the data analysis was conducted using SPSS. The results of physicochemical parameters of the hand dug wells indicated a pH range of 7.34 to 8 21. The Total Dissolved Solids (TDS) for hand dug well is 562.60 mg/L, 891.47 mg/L, and 1230.47 mg/L respectively. While Turbidity is 3.47NTU, 5.75NTU and 754NTU sequentially for each community sampled. The physicochemical parameters of the borehole samples indicate a pH of 5.8, 5.05 and 6.05, The TDS were 202.33 mg/L, 232.50 mg/L and 207.13 mg/L. The physicochemical parameters of the samples examined when compared with the WHO standard indicate that some of the parameters are slightly below the WHO standard while others were within the permissible limits of WHO standard for drinking water. The bacteria isolated in the water samples were *Staphylococcus spp. Serratia spp., Citrobacter spp., Bacillus spp. Streptococcus spp., Salmonella spp. Shigella spp. Pseudomonas spp. Proteus spp. Micrococcus spp., Arthrobacter spp. Klebsiella spp. Enterobacter spp., Cellulabiosoccus spp. Escherichia spp.* The total heterotrophic bacteria for the water samples did not meet up the WHO drinking water standard and the coliform level was above the WHO limit. This indicates that the water in the area is unsafe for drinking.

INTRODUCTION

Water is a very essential substance for human existence. Adequate supply of water is important to life. The provision of water in most parts of the world in the past was solely a government affair. However, the inability of the government to meet the daily demands of water for the people has forced some private individuals and communities to seek alternatives and self-help of providing water [1]. Private individuals drill their own deep wells (boreholes), In some localities, they dig wells due to its affordability. This hand dug wells are contracted to serve as a source of water supply [2]. Water meant for food preparation and drinking must be free from contaminants (organism) capable of causing diseases and from minerals and organic substances producing adverse physiological effects. In some communities, water from deep wells is sold to the public without reference and conformance to requisite quality standards such as set by the World Health Organization [3][4].

The quality of groundwater resource depends on the management of human waste as well as the natural physico-chemical characteristics of the catchment areas [5]. Also, depending on the geology of an area underground waters are typically rich in dissolved solids especially carbonates, sulphate, calcium and magnesium. Other ions may also be present including chlorides and bicarbonates [5]. Hence, it is necessary to obtain physico-chemical characteristics of the groundwater so-as to compare and monitor water quality and to determine the type of treatment that may be required before use.

MATERIALS AND METHODS

Study Area

Ogbia Local Government Area (LGA) is well known for its historic value to the today Nigeria state economy mainstay i.e., its oil industry being the local government area encompassing Oloibiri the first place oil was discovered in commercial quantities in Nigeria in 1956. Fishing and farming are the major occupation of the people of Ogbia LGA with the areas rivers and streams been rich in aquatic organisms, other economic activities in include trading and making of fishing nets and canoes, civil service, craftsmanship, tailoring, contracting and consultancy. In Ogbia the wet seasons is warm and overcast, the dry season is hot and mostly dry.

3.2 Sample Collection

A total of six groundwater samples were collected at three different locations within the study area; Otuoke, Onuebum and Emeyal I communities. The water samples were collected using hard plastic and screw-capped bottles that have been sterilized to avoid contamination by any physical, chemical or microbial means. The collected well and borehole water samples were then transferred into sterile containers before taken to the laboratory [6].

Bacteriological analysis

Preparation of nutrient media

The nutrient media used for this study were sterilized by autoclaving. Nutrient agar and Macconkey agar were used for the cultivation and enumeration of the bacterial population of the samples. Other nutrients media were used for biochemical test of the isolates. Kliger iron agar was utilized for detecting lactose and glucose fermentation, gas and hydrogen sulfide production. Simmon citrate agar was used for the detection of Indole production [6].

The power medias were weighed and dissolved in distilled water according to the manufacturer's instructions. The dissolved media were autoclaved at 121^0C for 15 minutes, following standard operation procedures [6].

Preparation of Sample

Serial dilution of samples was done to achieve a reduction of the microbial population in the water samples. 1ml of the sample was collected aseptically with a syringe and poured into a test tube containing 10ml of normal saline, to form a stock culture/solution. The stock culture was properly mixed, thereafter, 1ml was collected and transferred into the first dilution tube (1:10). The dilution of the sample was done up to the 5th dilution (1:100000)

Cultivation of total heterotrophic bacteria

The cultivation of the total heterotrophic bacteria was done on nutrient agar using pour plate method. Inoculation was done with the 2nd dilution (1:100) in triplicates.

Cultivation of coliform bacteria

The cultivation and enumeration of the coliform bacteria associated with the water samples was done on Macconkey agar. The 2nd dilution of the prepared samples was plated using pour plate method.

Isolation of bacteria

To identify the bacteria associated with the water samples, selected bacterial colonies were sub cultured. The colonies were randomly selected and picked off with sterile wire loop. The colonies were sub-cultured

on fresh nutrient agar plates by streaking colonies on the agar surface using the three-loop method.

Biochemical tests and characterization of bacterial isolates

The biochemical tests and characterization of bacterial isolates was done by using the gram staining technique, catalase test, indole test, oxidase test, Kliger iron agar slant test, citrate, H_2S, glucose and lactose fermentation test, gas and hydrogen sulphide (H_2S) production test were used to identify the organisms [6].

PHYSICO-CHEMICAL ANALYSIS

Determination of PH

A calibrated pH meter (standardized with two buffer solutions pH4 and pH5) was used for the determination of the pH of the groundwater samples [7].

Determination of conductivity and salinity (us/cm-1)

The electrical conductivity and salinity of the groundwater sample was measured with the conductivity meter which also has the salinity meter attached.

Determination of total dissolved solids (TDS)

The total dissolved solids (TDS) were determined by adding 100ml of water sample into the dish and evaporated to dryness in a water bath. The dish and its content were placed in an oven and dried at 105^{0}C to a constant weight [7].

Determination of turbidity

The turbidity was determined by inserting the water sample into the calibrated turbid meter and the turbidity was measured directly in NTU units.

Determinants of Nitrate (NO_3)

To determine the Nitrate, the spectrophotometer was set at 570nm and the % Transmittance was taken and the concentration of nitrate (NO_3) in mg/l was read directly from a concentration chart.

Determination of total alkalinity (TA)

To determine the total alkalinity (TA), 100ml of filtered water samples were placed in 250ml conical flask, 2 drops of methyl orange indicator were also added to give the orange color. This was titrated with a 0.02m HCl to a light pink color end point. Values were calculated following the formular below: V_T = Vol. of

HCl, M = Molarity of HCl, 1000, 000_n = Molar mass of $CaCo_3$ in (mg).

$$TA = \frac{V_T \times M \times 100,000}{\text{Vol. of Sample}}$$

Determination of total hardness (TH)

A 50ml titration Burette was filled with a 0.01m EDTA solution to the 'O' mark. 100ml of filtered water samples were introduced into a 250ml conical flask. 1ml of ammonia ammonium

Chloride buffer was then added to the flask. 3 drops of Eriochrome Black T indictor were added to produce the red wine colour. This was titrated to a marine blue end-point (colour). A = mg equipment of 1ml EDTA which is (1ml= 10 units)

$$\text{Total hardness } TH = \frac{V_T \times M \times 1000}{\text{Vol. of Sample}}$$

Mineral analysis (Metal Ions)

Wet ashing method was used in the determination of metal irons.

Potassium (K) was determined by flame photometry while Calcium (Ca), Chlorides (Cl), Iron (Fe), Sulphates (SO_4), were determined by AAS at their various wavelengths using Acetylene / Air gas combination.

Statistical analysis method

Data analysis was conducted with the statistical Programmed for Social Sciences (SPSS) version 20. Data from the laboratory were presented in tables, and descriptive statistics was conducted on the data. Thereafter, inferential statistics was conducted which was used to reach conclusions at 0.05 (5%) level of significance.

RESULTS

Borehole Otuoke = BO, Borehole Onuebum = BHO, Borehole Emeyal I = BE, Hand dug well Otuoke = HO, Hand dug well Onuebum = HDO, Hand dug well Emeyal I = HE.

The total heterotrophic bacteria in Borehole water shows that Onuebum boreholewater has the mean of 130.33, Otuoke has the mean of 90.67 and Emeyal I borehole water has the smallest mean of 51.00. From their mean occurrence its shows that the total heterotrophic bacteria in Onuebum and Emeyal I are high when compared with Otuoke borehole. The heterotrogphic bacteria in Hand dug wells water shows that Otuoke sample has highest mean of 263.67,

Onuebum has the mean of 185.67, and Emeyal I has the smallest mean of 149.00. From their mean occurrence its shows that the total heterotrophic bacteria in Otuoke are high when compared with Onuebum and Emeyal hand dug well. The descriptive statistics on the coliform bacteria in borehole water shows that Onuebum borehole water has the highest number of coliform bacteria with the average mean of 240.00 followed by Emeyal borehole water 115.67 and Otuoke with the smallest number of coliform bacteria with average mean of 115.67. The descriptive statistics on the Coliform Bacteria in hand dug well water shows that Onuebum sample has highest mean of 266.33, Otuoke sample has mean of 135.00 and Emeyal has the smallest mean of 97.33.

Table 1: Descriptive Statistics on the Physico – Chemical Properties of Borehole Water

Properties	Sample Stations for Borehole Water						
	Borehole Water Otuoke, Onuebum and Emeyal						WHO Standard (2011)
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	
Ph	5.84	0.2	6.05	0.3	5.02	0.01	6.5-8.5
Cond	156.00	3.46	238.63	0.40	181.57	0.60	1000
Sal	0.35	0.02	0.22	0.01	0.54	0.02	0.5
Tds	202.33	0.35	232.50	1.84	207.13	0.23	500
Turb	3.19	0.31	4.08	0.13	3.64	0.11	5
Nitrates	2.69	0.04	8.44	0.28	1.38	0.06	45
TA	23.28	0.37	17.21	0.05	30.36	0.06	120
T.H	31.63	0.35	21.20	0.17	68.53	0.25	100
Ca	17.10	1.08	21.27	0.31	26.70	2.04	75
CI-	53.70	0.30	34.30	1.76	14.00	1.31	250
Fe	0.04	0.01	0.08	0.02	0.20	0.01	1.5
SO_4	0.42	0.07	3.23	0.19	3.08	0.73	250

pH - Cond = conductivity, Sal = Salinity, TDS = Total dissolved solids, Turb = Turbidity, Nitrates, T.A = Total alkalinity, T.H = Total hardness, Ca = Calcium, CI -= Chloride, Fe= Iron and SO_4 = Sulphates.

The result of the pH obtained in Otuoke were about the range of 5.8 and Emeyal I 5.05 were below the WHO standard and this implies that it is acidic so it's dangerous for drinking. Onuebum 6.05 is within the WHO drinking water standard, and the acceptable WHO limit is 6.5-8.5. The results of the conductivity ranged from 156.0 uS/cm, 238.63 uS/cm, 181.57 uS/cm, respectively among the three locations indicates that it is below the WHO drinking water limits which is 1000 mg/l. The TDS result ranged from 202.33 mg/l, 232.50 mg/l, 207.13 mg/l among the three locations and are all below the WHO drinking limits and the WHO acceptable limit is 500-1000mg/l. Turbidity ranged from 3.19 NTU, 4.08 NTU, 3.64 NTU respectively and is below the required WHO drinking water standard, the acceptable standard is 5 NTU. The result of the Salinity obtained in Otuoke was about the range $0.35^0/_0$ and Emeyal $0.22^0/_0$ were below the WHO limits and Onuebum $0.54^0/_0$ was within the accepted standard, and the required standard is $0.5^0/_0$. Nitrate, Total Alkalinity (TA), Total hardness (TH), Calcium (Ca) Chloride (CI-), Iron (Fe), and Sulphates (SO_4) are all below the WHO drinking water standard.

Table 2: Descriptive Statistics on the Physico-Chemical Properties of Hand-dug Wells

Properties	Sample Stations for Hand-dug Wells						WHO Standard (2011)
	Hand-dug Wells Otuoke, Onuebum and Emeyal I						
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	
Ph	7.34	0.03	8.21	0.01	7.35	0.09	6.5-8.5
Cond	431.10	0.78	730.43	0.51	581.80	1.04	1000
Sal	0.07	0.02	0.15	0.02	0.06	0.02	0.5
Tds	562.60	2.23	1230.47	0.57	891.47	0.47	500
Turb	3.47	0.22	7.54	0.12	5.75	0.21	5
Nitrates	0.20	0.03	1.72	0.06	0.09	0.02	45
TA	210.87	0.60	176.40	0.30	122.87	0.76	120
T.H	18.20	0.60	43.77	0.59	33.63	1.10	100
Ca	46.03	0.75	77.10	0.98	53.77	0.45	75
Cl-	1.20	0.14	61.57	2.93	41.37	0.60	250
Fe	0.13	0.02	0.02	0.01	0.24	0.01	1.5
SO_4	1.25	0.38	0.59	0.27	13.63	1.56	250

The pH in the three locations ranges from 7.34, 8.21, and 7.35 respectively and it indicates that they are within the WHO drinking water standard, the acceptable WHO standard for pH is from 6.5-8.5. The result of the Total dissolved solids (TDS) that of Otuoke 562.60 mg/l and Emeyal 891.47 mg/L samples were within the WHO standard and that of Onuebum 1230.47 mg/L was very high above the WHO standard, the acceptable standard is from 500-100 mg/L. Result of Turbidity, Otuoke 3.47 NTU sample was low, Emeyal I 5.75 NTU sample was above the WHO Standard and Onuebum 7.54 NTU sample was too high above the drinking water standard, the acceptable standard is 5 NTU. Result from Total alkalinity were all above the WHO drinking water standards with Otuoke 210.87 mg/L the acceptable WHO standard, Emeryal I 53.77 mg/L the acceptable WHO standard for T.A is 100 mg/L. The result for Calcium (Ca) show that, that of Onuebum which is 77.10 mg/L has the highest value which is above the WHO standard. The acceptable WHO standard for Ca is 75 mg/L. The result of Nitrates ranges from 0.20 mg/L, 1.72 mg/L, 0.09 mg/L, respectively among the three locations and it indicates that they are all below the WHO drinking water standard and the acceptable WHO standard is 45 mg/L. Conductivity (Cond), Salinity (Sal), Nitrate, Total hardness (T.H), Chloride (Cl-), Iron (Fe), and Sulphate (SO_4) are all below the WHO standard.

TABLE 3: Biochemical tests and characterization of bacterial isolates in sample BO

Gram stain TENTATIVE BACTERIA	Catalase	Indole	Oxidase	Citrate	H_2S	Glucose	Lactose	Gas
+ve cocci *Micrococuss sp.*	+	-	-	+	-	+	-	-
-ve rod *Pseudomonas sp.*	+	-	+	+	-	-	-	-
-ve rod *Escherichia sp.*	+	+	-	-	-	-	-	-
+ve rod *Bacillus sp.*	+	-	-	+	-	+	+	+
+ve cocci *Streptococi sp.*	+	-	-	+	-	+	+	+
-ve rod *Proteus sp.*	+	+	+	-	-	+	+	+

TABLE 4: Biochemical tests and characterization of bacterial isolates in sample BHO

Gram stain TENTATIVE BACTERIA	Catalase	Indole	Oxidase	Citrate	H_2S	Glucose	Lactose	Gas
+ve cocci *Cellulobiosoccus sp.*	+	-	+	+	+	-	-	-
-ve rod *Citrobacter sp.*	+	-	-	+	-	+	+	+
-ve rod *Shigella sp.*	+	+	-	-	-	+	-	-
-ve rod *Escherichia sp.*	+	+	-	-	-	+	+	+
-ve rod *Serratia sp.*	+	-	-	+	+	+	-	+

TABLE 5: Biochemical tests and characterization of bacterial isolates in sample BE

Gram stain TENTATIVE BACTERIA	Catalase	Indole	Oxidase	Citrate	H_2S	Glucose	Lactose	Gas
-ve rod *Escherichia sp.*	+	+	-	-	-	+	+	+
+ve cocci *Staphylococcus sp.*	+	-	-	+	-	+	+	+
-ve rod *Salmonella sp.*	+	-	-	+	-	+	-	+
-ve rod *Serratia sp.*	+	-	-	+	+	+	-	+
-ve rod *Citrobacter sp.*	+	-	-	+	-	+	+	+
+ve cocci *Streptococci sp.*	+	-	-	+	-	+	+	+

TABLE 6: Biochemical tests and characterization of bacterial isolates in sample HO

Gram stain TENTATIVE BACTERIA	Catalase	Indole	Oxidase	Citrate	H_2S	Glucose	Lactose	Gas
-ve rod *Proteus sp.*	+	+	+	-	-	+	+	+
-ve rod *Serratia sp.*	+	-	-	+	+	+	-	+
+ve rod *Salmonella sp.*	+	-	-	+	-	+	-	+
-ve rod *Pseudomonas sp*	+	-	-	+	-	-	-	-
-ve rod *Escherichia sp.*	+	+	-	-	-	+	+	+
-ve rod *Shigella sp.*	+	+	-	-	-	+	-	-

TABLE 7: Biochemical tests and characterization of bacterial isolates in sample HDO

Gram stain TENTATIVE BACTERIA	Catalase	Indole	Oxidase	Citrate	H$_2$S	Glucose	Lactose	Gas
-ve rod *Serratia sp.*	+	-	-	+	+	+	-	+
-ve rod *Escherichia sp.*	+	+	-	-	-	+	+	+
+ve cocci *Staphylococcus sp.*	+	-	-	+	-	+	+	+
-ve rod *Arthrobacter sp*	+	-	-	+	-	+	+	+
+ve rod *Bacillus sp.*	+	-	-	+	-	+	+	+
+ve cocci *Streptococci sp.*	+	-	-	+	-	+	+	+

TABLE 8: Biochemical tests and characterization of bacterial isolates in sample HE

Gram stain TENTATIVE BACTERIA	Catalase	Indole	Oxidase	Citrate	H$_2$S	Glucose	Lactose	Gas
-ve rod *Citrobacter sp.*	+	-	-	+	-	+	+	+
-ve rod *Enterobacter sp.*	+	-	-	+	-	+	+	+
+ve cocci *Staphylococcus sp.*	+	-	-	+	-	+	+	+
-ve rod *Klebsiella sp*	+	-	-	+	-	+	+	+
+ve rod *Bacillus sp.*	+	-	-	+	-	+	+	+
-ve rod *Escherichia sp.*	+	+	-	-	-	+	+	+

The results in table 3 to 8 above represent the biochemical test and characterization of bacterial isolates in sample BO, BHO, BE, HO, HDO and HE. A total of six organisms were identified in each of the samples, the identification was done base on biochemical test and added by advance bacterial identification software (ABIS).

DISCUSSION

The presence of heterotrophic bacteria generally indicates poor environmental sanitation and recent pollution by sewage [8]. On site observation of the boreholes and hand dug wells showed that a good number of these sources are not protected and lack concrete floor around the hand dug well, this reflects poor environmental sanitation and higher contamination. The use of buckets which have been left on ground in collecting water from the unprotected water sources might contribute to the increase contamination levels.

The results of this study reveal the mean of coliform bacteria estimated to be high for majority of the samples which clearly exceeded the standard limit set by WHO. WHO standard of portable water states that no microbial indicator is supposed to be present in any 100ml of drinking water. The presence of bacteria makes the water unsafe for drinking and for domestic use. water samples from boreholes of the three locations confirms that they are not safe for drinking [9]. The high level of coliform bacteria level recorded in this work could be as a result of poor refuse and sewage disposal system, mainly open disposal method practiced in these areas.

Human and Animal faeces are the common sources of microbiological contamination of underground water sources. [10] also found that distance between sanitary facilities, boreholes and hand dug wells were in most cases close, hence the high contamination with human feaces which gain access into ground water during leaching process. The presence of these organisms indicates inadequate water treatment or fresh water contamination. Coliform

in distribution system and stored water supply can reveal growth and possible biofilms formation or contamination through foreign materials, including soils or plants. These water bacteria are causative agents of many diseases and their presence pose a potential threat to human health [11].

The pH of the borehole water samples collected from the three different locations are mostly below the WHO Standard. This implies that they are acidic so it's dangerous for drinking. Onuebum pH of 6.05 is slightly below the WHO drinking water standard, and the acceptable WHO limit is pH 6.5-8.5. The result obtained indicate that the drinking water is weakly acidic to neutral, this value may affect the toxicity of microbial poisons in the water [12]. The results of the conductivity ranged from 156.00 uS /cm, 238.63 uS/cm, 181.57 uS/cm, respectively among the three locations these values are below the WHO drinking water limits which is 1000 mg/L. The result further revealed that there is moderate dissolved salt in the water [13]. The TDS result ranged from 202.33 mg/l, 232.50 mg/l, 207.13 mg/l among the three locations and are all below the WHO drinking limits and the WHO acceptable limit is 500-1000 mg/l. TDS concentrations across sampled wells are quite low and there is the tendency for the water to become flat and insipid in taste [14]. WHO drinking water standard is 5 NTU and this result is similar with that reported by [15] in a similar work in Eastern Nigeria. The result of the Salinity obtained in Otuoke was between the range of $0.35^0/_0$ and Emeyal $0.22^0/_0$ were below the WHO limits and Onuebum $0.54^0/_0$ was within the accepted standard, and the required standard is $0.5^0/_0$ Nitrate. Total Alkalinity (TA), Total hardness (T.H), Calcium (Ca) Chloride (CI-), Iron (Fe), and Sulphate (SO$_4$) are all below. It has been noted that low SO$_4$ concentration has no effect on human health. Low calcium, serves as control on water pH [11].

The physiochemical parameters of the hand dug wells samples, shows that the pH in the three locations ranges from 7.34, 8.21, and 7.35 respectively and it indicates that they are within the WHO drinking water standard, the acceptable WHO standard for pH is from 6.5-8.5. The pH result is neutral when observed in the samples and it may be an indication of contamination. The result obtained in this work is in agreement with what was recorded by [16]. Result of Turbidity in Otuoke 3.47 NTU sample were low, Emeyal 5.75 NTU sample was above the WHO drinking water standard and Onuebum 7.54 NTU sample was too high above the drinking water standards with Otuoke 210.87 mg/L having the highest value which is very high above the WHO limit, Onuebum 176.40 mg/L and Emeyal 122.87 mg/L. The acceptable WHO standard for T.A is 100 mg/L. The result for Calcium (Ca) for Onuebum is 77.10 mg/L which is the highest value among the three locations. Emeyal 53.77 mg/L and Onuebum 46.03 mg/L are below the WHO standard, and the acceptable WHO standard for Ca is 75 mg/L. The results of Nitrates range from 0.20 mg/L to 1.72 mg/L,

respectively among the three locations and it indicates that they are all below the WHO drinking water standard for Nitrates [8].

Frequency of Occurance of Bacteria isolates indicates the organisms that appeared in the samples when analysed from the three different locations namely: *Staphylococcus* spp, *Serratia* spp, *Citrobacter* spp, *Bacillus* spp, *Streptococcus* spp, *Salmonella* spp, *Shigella* spp, *Pseudomonas* spp, *Proteus* spp, *Micrococcus* spp, *Arthrobacter* spp, *Klebsiella* spp, *Enteobacte.* The highest bacteria specie recorded is *Escherichia*. The WHO drinking water standard for microorganisms is 0.00 and this implies that the water samples are not safe for drinking but can be treatable because it is caused by different activities [11]. High count of indicator bacteria suggests heavy pollution from different anthropogenic sources [17].

CONCLUSION

The result of the study obtained from the three different locations namely Otuoke, Onuebum and Emeyal bacteriological water analysis reveals that all the boreholes and hand dug wells were not free from total heterotrophic and coliform bacteria. High level of coliform was recorded in this work. This is suspected to have risen as a result of poor refuse and sewage disposal system, inadequate water treatment and pollution from industrial activities. The bacteriological quality of underground water sources for the three locations shows poor quality as reflected by the overall mean value for both heterotrophic and Coliform bacteria. According to [18][19] guide lines for drinking water, underground water sources (boreholes and wells) are supposed to be at least 30m away from sewage and refuge sites. From the results of this research, it can be construed that the water obtained from the research area are not safe for consumption due to high level of microorganisms and minerals present in the samples, unless proper treatment is carried out. It is therefore pertinent that continuous monitoring as well as water treatment measures be taken for the people of these three locations to ensure maximum safety and healthy living for all. Regular washing of tanks with disinfectant and maintenance of public and private environmental sanitation should be done to reduce the rate of contamination of ground water and formation of biofilms in storage materials. Regulatory bodies should be empowered and made to employ the polluted pay principle and good practice should be adopted, in order to effectively achieve the expected goal and global sustainability demand.

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