# *Original Research Article*

# Drinking Wells and River Water Quality Assessment in Oproama Community, Rivers State, Nigeria




## ABSTRACT

**Aims:** The hand-dug wells and river water in Oproama Community, Rivers State, Nigeria was assessed for its quality.
**Study design:** The study involved ten (10) sampling stations consisting of seven (7) hand-dug wells and three (3) points along the Oproama River.
**Place and Duration of Study:** Oproama Community in Asari-toru Local Government Area of Rivers State, Nigeria between January and December, 2011 to cover both dry and wet seasons.
**Methodology:** The parameters assessed were *Vibrio* (bacteria), salinity, calcium, magnesium concentrations as well as saltwater intrusion status employing standard laboratory procedures and estimation model.
**Results:** The results reveal that *Vibrio* counts ranged from 2 $x10^2$ to 1.375 $x10^4$ cfu/100ml and the bacteria species identified from the water sources were *Vibrio cholera* and *Vibrio parahaemolyticus*. The study also reveals that salinity ranged from 11.97 to 13,772mg/l, calcium, 0.15 to 126.33mg/l and magnesium, 0.09 to 43.02mg/l. All parameters assessed exhibited seasonal variation during the study period; Calcium/magnesium (Ca/Mg) ratios for each well water sample ranged from 1.67 to 12.33 and indicate absence of saltwater intrusion which stands at a Ca/Mg limit of 1.
**Conclusion:** Salinity (particularly well water samples), calcium and magnesium concentrations were within recommended limit; *Vibrio* counts were high and its presence in drinking water has public health risk; therefore, the use of sanitary buckets and point-of-use (households use) treatment and safe storage practices of water is strongly advocated.


*Keywords: Calcium, Magnesium, Oproama, Saltwater intrusion, Water Quality*

## 1. INTRODUCTION

Water which is a basic necessity of life, when absent, affects the survival rate of higher animals [1]. There are many uses of water which include washing, cooking, processing of food, recreational activities like swimming, etc., of which water for drinking seems very sensitive since it can have negative health effects on humans. Consequently, water for drinking should be potable, free of harmful pathogens and toxic substances [2]. Many disease-causing microorganisms such as *Escherichia coli*, *Salmonella* species, *Vibrio cholera* among others have contaminated drinking water due to lack of potable water as well as poor sanitation measures; and when present, they cause waterborne diseases which include cholera, typhoid, nausea, cramp and diarrhea in humans as well as their animal host [3]. WHO [4] reported that the lives of millions of people particularly children below the age of five and those with immune-compromised systems are at risk as a result of pathogens found in water. This result in over 2 million lives of mostly children under five years are lost yearly due to diarrhea in developing countries.

Vibrios are pathogenic, and are always a threat to the public due to the infection they cause resulting from the consumption of undercooked seafood products or water contaminated with the organism [4]. Water is considered as an important vehicle for transmission of cholera [5] which is caused by *Vibrio cholera*, a Gram-negative bacterium of the family Vibrionaceae [6]. Furthermore, the effect on health due to water is linked to faecal matters (from human or animals) which introduce these pathogenic organisms into the water sources [7], confirming that the quality of drinking water is closely associated with human health; hence the provision of potable has become a top health concern [8]. FGN [9] had reported that within the Niger Delta area, rivers/creeks/streams/ponds, hand-dug wells and harvested rain water are the known water sources for many urban as well rural settings, which implies that availability of safe drinking water is a key setback, an attribute of a developing country like Nigeria [10]. So according to Jain et al [11] the dwellers directly use the water as presumed potable water, believing that natural groundwater filtration have rendered it suitable for human consumption.

Groundwater contamination is a significant environmental issue widely discussed today [12], and heavy metals contamination in the midst of various contaminants is receiving wider attention due to their toxicity level even when their concentration is very low [13]. These metals such as calcium, magnesium, potassium and sodium are necessary for life sustenance while others like cobalt, copper, iron, manganese, molybdenum and zinc are needed for catalyzing enzyme activities [14]. Saltwater intrusion which is described as the entering of saline water into aquifers of freshwater origin is yet another contaminant of groundwater. Mainly, it arises due to pumping from coastal wells, where navigational channels or oil-fields are constructed. These channels and canal create passages for saline water being introduced into freshwater. Wikipedia [15] also reported that natural processes such as storm surges resulting from hurricanes is a source of saltwater intrusion; however, too much pumping of groundwater creates an environmental problem whereby the aquifer depresses drawing saline water into new areas [16]. When freshwater is drawn faster than it can be replenished, it results to a draw-down thereby reducing the hydrostatic pressure, and especially if it happens at ocean coastal area, saline water intrusion occurs, and this process is currently happening in many coastal areas [17, 18]. Wikipedia [15] reported that documented cases exist, particularly the well-known groundwater pollution involving the Ganges Plain of Northern India and Bangladesh where naturally occurring arsenic was introduced into two regional water aquifers by the action of microorganisms thereby affecting 25% of water wells. In Oproama, the major drinking water source is hand-dug wells of various depths, depending on availability and the level of groundwater; therefore, to establish the baseline status of the quality of the wells and river water, the present study was carried out to ascertain the *Vibrio* spp., salinity, calcium, magnesium concentrations and saltwater intrusion status of the hand-dug wells and the river water in the Community.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study area is Oproama Community, Asari-Toru Local Government Area, Rivers State, Nigeria. Oproama lies on $4^{o}$ 47' and $4^{o}$ 56' North and longitudes $6^{o}$ 50' and $6^{o}$ 41' East, with a combination of tropical rain and predominant mangrove forest zone. Oproama has a soil texture which is clay-sandy and is dominated by dry season (November-March) and rainy seasons (April-October). The inhabitants are predominantly fisherman, which is their basic source of livelihood.

## 2.2 Sampling Stations and Duration

Ten (10) sampling stations were selected which includes seven (7) hand-dug wells which are used for drinking and other domestic purposes and three (3) points along the Oproama River. The water samples were collected monthly between January to December, 2011 to cover both dry and wet seasons.

## 2.3 Collection of Water Samples

Seven (7) clean plastic buckets were used to fetch water from each of the seven hand-dug wells in the community using '*okowa'* (stick with hook) and transferred immediately into already labelled 2 litre plastic containers. The water samples from the river were collected by wading to somewhat above knee level in the river, then dipping the neck of a labelled clean and sterile 2 litre plastic containers down to about 30cm under the water surface, slightly tilting up towards upstream allowing it fill up, leaving a space of 1.5 com for mixing. The cap for each container was replaced under water. All the water samples were collected in triplicates for *Vibrio* species, salinity and metal analysis and taken to the Environmental Microbiology Laboratory, University of Port Harcourt, Choba, in a cold box within 2 hours.

## 2.4 Microbiological Analysis

### 2.4.1 Isolation of *Vibrio* spp. in Water Samples

The isolation of *Vibrio* spp. was carried out using Membrane filtration technique as described in 9260H (APHA, 1998). Ten milliliters (10ml) of $10^{-1}$ dilution (from a ten-fold serial dilution) of each water sample was used. After the filtration, the filter (membrane filter of 0.45µm, HAWG, Millipore Corporation, Bedford, USA) was then placed on Thiosulphate Citrate Bile Salts Sucrose (TCBS) Agar in Petri dishes, which was prepared according to manufacturer's instruction. All the plates in duplicates were incubated at 35$^{o}$C for 24 hours.

### 2.4.2 Purification and Storage of isolates

Freshly prepared Nutrient Agar plates were inoculated using streak plate technique to subculture distinct colonies. Thereafter, stock cultures were prepared on Nutrient agar in already coded Bijou bottles and then stored in a refrigerator at 4$^{o}$C for further tests.

### 2.4.3 Characterisation and Identification of Bacterial Isolates.

The identification of the isolates was done based on cultural, colonial and physiological characteristics as described by Cheesborough [19]. The following tests were carried out: Gram staining and Biochemical tests which include catalase, oxidase, coagulase, citrate utilisation, indole, methyl red, Voges Proskauer, Hydrogen Sulphide, Urease, motility, salt tolerance and sugar fermentation test.

## 2.5 Determination of Salinity

Water samples for the determination of salinity were analysed using a digital meter (consort p107). The procedure involves dipping the probe end of the meter in the water sample and reading off and recording the value at the pointer.

## 2.6 Metal Analysis

The analysis for metals (magnesium and calcium) in the water samples were carried out employing atomic absorption spectrophotometer (AAS) (HACH DR 2400). First, the AAS was calibrated with standards of known concentrations to obtain a calibration curve for the individual metal. Thereafter, for the analysis, the water samples were directly aspired into an air/acetylene or nitrous oxide/acetylene flame in the presence of energy at a specific wavelength which was generated by hollow cathode lamp with peculiarity to each metal under investigation.

## 2.7 Statistical Analysis

Statistically, the data generated from the study were analysed using two factors analysis of variance (ANOVA).



# 3. RESULTS AND DISCUSSION

## 3.1 *Vibrio* sp. Counts

The seasonal changes in *Vibrio* counts of the various sampling stations (wells and river) in Oproama Community are presented in Figure 1. The results shows that generally, there was apparent seasonality as shown in *Vibrio* counts especially in well water sources (stations 1-7). Also, Stations 6 (well) and 9 (river) recorded the highest value of $1.53x10^1$ cfu/ml ($log_{10}$ 2.1846) and $8.99x10^1$ cfu/ml ($log_{10}$ 1.9537) for wet season amongst the well and rivers samples respectively while dry season values shows that station 6 (well) and station 8 (river) recorded the highest values of $1.66x10^1$ cfu/ml ($log_{10}$ 1.2201) and $2.32x10^2$ cfu/ml ($log_{10}$ 2.3654) for well and river samples respectively. The analysis of variance (ANOVA) results shows that there was significant difference in the counts obtained within stations and months (wet and dry seasons) over the monitoring period at $P$ = .05.
The bacterial isolates identified from water samples include *Vibrio cholerae* and *Vibrio parahaemolyticus*.

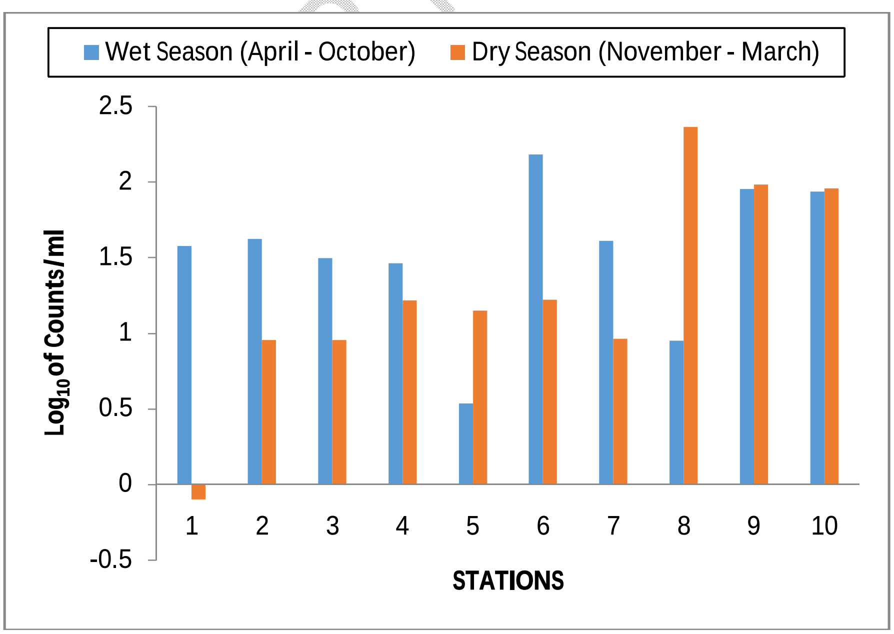


**Figure 1** ***Vibrio* Counts of Water Samples from Oproama**

**Community covering the wet and dry seasons**

## 3.2 Salinity Concentration

The salinity concentrations of both wells and river water samples during the study period are presented in Figure 2. The results show that stations 8, 9 and 10 (river sources) exhibited the highest salinity levels both for the wet and dry seasons. Meanwhile, stations 1-7 which are well water sources were generally low compared to the river stations all through the seasons. During the wet season, the salinity of stations 1-7 ranges from 12.60-31.24 mg/l and 11.97-35.9 mg/l for the dry season. Generally, higher values were recorded in dry season than the rainy season especially with stations 8, 9, and 10 which are river water samples. With the analysis of variance, there was significant difference (P = .05) observed in salinity values obtained for the stations, while there was no significant difference within the months (wet and dry seasons) during the study period.

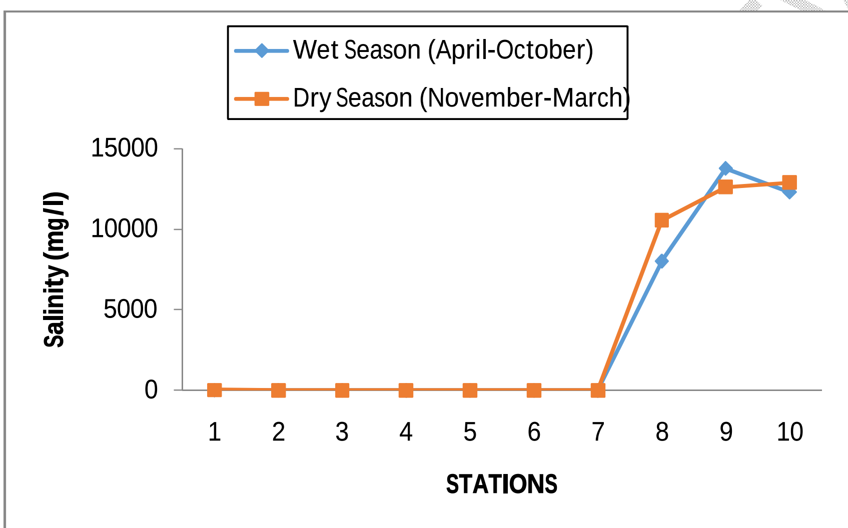


**Figure 2 Salinity of Water Samples from Oproama Community covering wet and dry season**



## 3.3 Calcium Concentration

The calcium concentrations of water samples from Oproama Community covering wet and dry seasons are presented in Figure 3. The results reveal that higher values of calcium concentration were observed in the dry season during the monitoring period with the highest value of 126.33 ppm recorded in station 8, 122.83 mg/l in station 9 and 98.01 ppm in station 10. Also, during the wet season, station 9 recorded the highest value of 51.66 ppm followed by station 10 (50.45 ppm) and station 8 (47.33 ppm). Relatively low levels of calcium concentration were observed in stations 1, 2, 3, 4, 5, 6 and 7 which are all well water samples when compared to the river stations (8, 9, and 10). Generally, higher values were recorded during the dry season than wet season. With the analysis of variance (ANOVA), there was significant difference ($P$ = .05) in calcium concentration for the stations and months (wet and dry seasons) during the sampling period.

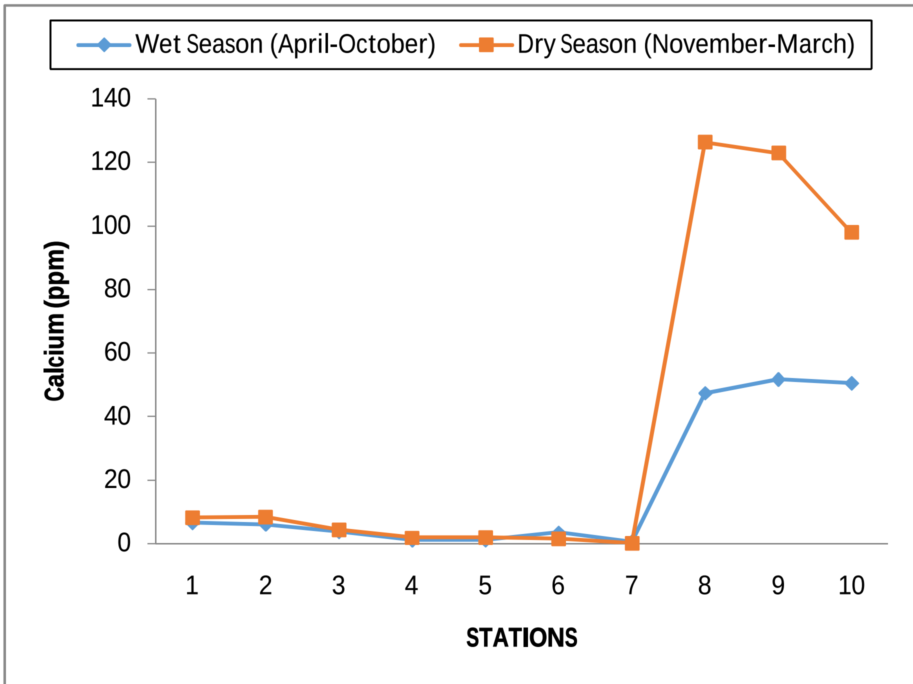


**Figure 3** **Calcium Concentration of Water Samples from Oproama Community covering wet and dry seasons**

### 3.3 Magnesium Concentration

The magnesium concentrations of water samples obtained from Oproama Community covering wet and dry seasons are presented in Figure 4. The results reveal that stations 8, 9, and 10 showed higher values compared to other stations for both wet and dry seasons. The result further reveals that station 10 recorded the highest value of 43 ppm while stations 4 and 7 recorded the lowest value of 0.09 ppm for the wet season; for the dry season, station 8 recorded the highest value of 31.18 ppm while station 7 recorded the lowest value of 0.09 ppm. Again, the values recorded for stations 1-7 for the dry season were generally higher than those recorded for wet season. However, for stations 8-10, higher values were recorded for wet season than dry season and there is apparent seasonal variation. With the analysis of variance (ANOVA), there was significant difference ($P$=.05) in magnesium concentration for the stations and months (wet and dry seasons) during the study period.

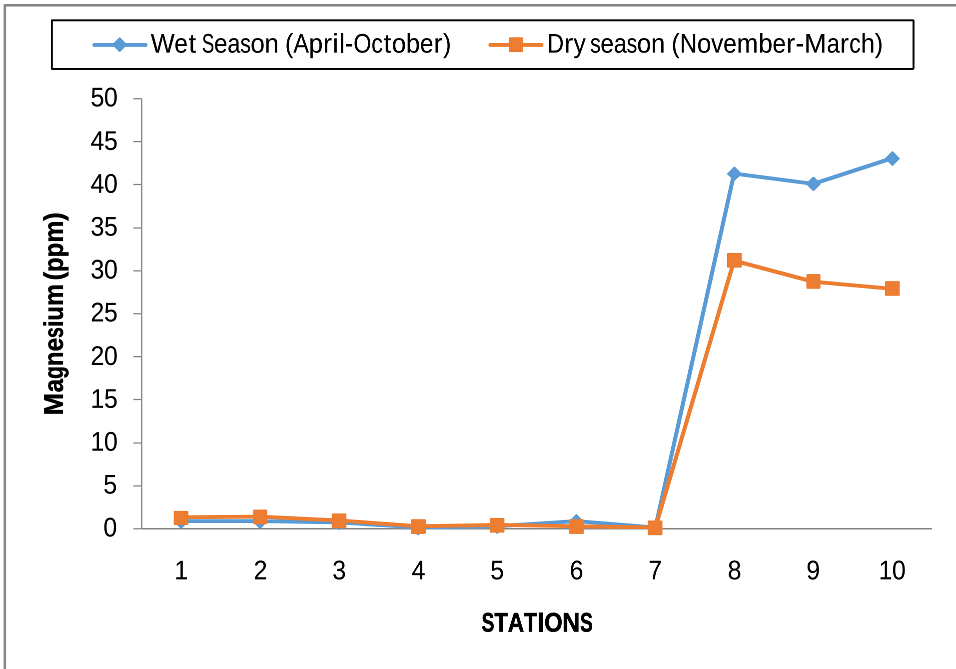


**Figure 4** **Magnesium Concentrations of Water Samples from Oproama Community covering wet and dry seasons**



### 3.4 Calcium/Magnesium Ratio for Well Water Samples

The mean seasonal ratio of calcium/magnesium for water samples obtained from hand-dug wells is presented in Table 1. The ratio obtained for all the stations revealed a range of 4.95-12.33 and 1.67-8.54 for wet and dry season, respectively. All the ratios obtained were above 1.

**Table 1** **Mean Seasonal Ratio of Calcium/Magnesium (Ca/Mg) for Well Water Samples**

| | Wet Season | | | Dry Season | | |
|---|---|---|---|---|---|---|
| **Station** | **Ca** | **Mg** | **Ratio** | **Ca** | **Mg** | **Ratio** |
| 1 | 6.56 | 0.82 | 8 | 8.26 | 1.25 | 6.55 |
| 2 | 6.05 | 0.82 | 7.37 | 8.4 | 1.35 | 6.26 |
| 3 | 3.78 | 0.68 | 5.55 | 4.31 | 0.89 | 4.84 |
| 4 | 1.11 | 0.09 | 12.33 | 1.88 | 0.22 | 8.54 |
| 5 | 1.09 | 0.22 | 4.95 | 1.97 | 0.40 | 4.93 |
| 6 | 3.53 | 0.86 | 4.10 | 1.57 | 0.24 | 6.54 |
| 7 | 0.54 | 0.09 | 6 | 0.15 | 0.09 | 1.67 |

**Ravi and Krishna (1996) Standard Ratio: <1 indicates Saltwater Intrusion**

### 3.4 Discussion

Most of the population in developing countries lacks inadequate supply of drinking water from well-protected and managed water supply network; hence the use of unsafe water from sources such as wells, springs and streams which already are contaminated via natural interference is inevitable [20].

The finding of the study reveals that *Vibrio* counts exhibited seasonal variation except at stations 8, 9 and 10. The *Vibrio* counts obtained in this study were found to be at higher concentration in the well water samples particularly during the wet season, and these observations are in line with [21, 22], however, the counts were lower than the count reported by Osarenminda and Idaehor [23]. The overall reduction in *Vibrio* count during the dry seasons particularly in the month of November, December and January was noted at stations 1-7 (well water), and this might be due to the *Vibrio* species entering the viable but nonculturable (VBNC) state, which is a survival strategy used by organisms to counter temperature stress [24]. Nonetheless, their presence in water meant for consumption portends a serious health risk even as WHO [25] had reported that about 100,000 to 120,000 die in the annual globally estimated 3-5 million cholera cases that occur.

Salinity concentration of the water samples was observed with apparent seasonality in occurrence as higher values were recorded during the dry season than the wet season. The well water samples were within the acceptable limits of 250 mg/l as stipulated by WHO [26]. Brian [27] reported that the land or geology, rainfall as well as the release of substances contained in underlying sediments determines the quantity of materials that will enter any body of water. This might be the reason for the observed salinity levels in the well water samples. However, the very high salinity concentration for the river samples is because they are seawater in origin while the lower values may be due to dilution as confirmed by McLusky [28] that rainfall is capable of causing dilution of estuaries thereby resulting in salinity reduction while evaporation will result in increase salinity. Akinrotim et al. [29] in their study further confirmed that the highest values (16.18-21.11%) were recorded during the dry months while sampling the Buguma Creek.

Calcium and magnesium concentrations in this study reveal that the dry season sampling had higher values. This could as a result of decreased water levels in the well due to prolonged period of sunshine while the low concentrations during the wet season may be attributed to the dilution effect of rain water. The metals presence in the water samples confirm the report by Barbieri et al. [30] that in groundwater, metal ions such as $Mg^{2+}$ and $Ca^{2+}$ are present naturally, adding that they could even be at abnormally high concentration due to the groundwater being contaminated by natural and anthropogenic inputs. The higher values observed in both wet and dry seasons were in the river samples, while the lower values were observed in the well water samples. However, samples from the wells (Stations 1, 2, and 3) closer to the river were higher than other well samples for both seasons. This might be as a result of their proximity to the river bank as WHO [31] reported that both calcium and magnesium which are usually highly soluble in water could be leached from the environment into ground and surface water; again, these metals alongside their carbonates sulphates and chlorides are also known to cause temporary and permanent hardness of water. Meanwhile, values obtained were below the recommended limit of 75-200mg/l for calcium and 30-150mg/l for magnesium recommended by WHO [26] for drinking water as well as the 183.75 mg/l and 91.30 mg/l average values for calcium and magnesium respectively reported by Xu et al. [32].

Babu et al. [33] have reported that in recent years, the issue of saltwater intrusion has received greater attention due to overwhelming demands for groundwater to meet up the increasing needs of the populace in urban areas and agricultural activities within coastal areas of the world. According to Ravi and Krishna [34], low Ca/Mg ratio is an indication of saltwater contamination. Calcium/magnesium ($Ca^{2+}$ /$Mg^{2+}$) ratio is employed because of the greater concentration of magnesium in seawater than calcium. The finding of this study confirmed that none of the well water samples has saltwater contamination which is in agreement with Babu et al. [33], even as the community dwellers also attest to the fact that the water does not taste salty during consumption.

## 4. CONCLUSION

The microbiological investigation reveals that *Vibrio cholera* and *Vibrio parahaemolyticus* were isolated from the water sources which could be potential pathogens and harmful to human health. Salinity, magnesium and calcium concentrations of the well water samples were within the recommended range for drinking water while the samples from the river were above the recommended levels for the parameters analysed during the study period. The calcium/magnesium ratios obtained from this study revealed that they are above 1 which suggests that there is no saltwater intrusion in the study area. The study also concludes that that there is an apparent seasonal influence on the microbiological and physicochemical parameters of the various water samples. The study therefore recommends that open defecation by humans (including use of jetty latrines) and animals as well as dumping of waste close to these water-points should be discouraged. Furthermore, proper drainage channels should be constructed around these water-points which will take water away immediately. Finally, the use of sanitary buckets and point-of-use (households use) treatment and safe storage practices of water should be advocated.

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