Assessment of Selected Physicochemical and Microbial Parameters of Water Sources along Oproama River in Oproama Community in Rivers State, Nigeria

Asiton-a Asifamabia Dick, Leera Solomon and Susan Okparanta

Department of Science Laboratory Technology, School of Science and Technology, Captain Elechi Amadi Polytechnic, Rumuola, P. M. B. 5936, Port Harcourt, Rivers State
asitona2016@yahoo.com

Abstract: Assessment of selected physiochemical and microbial parameters collected from seven hand-dug wells and three points along the Oproama River in Oproama community were studied to provide guidance and baseline data for future reference. The hand-dug wells and river water samples were collected to analyse the total heterotrophic bacteria, total coliform, salinity, chloride, electrical conductivity, total dissolved solids, calcium and magnesium. Bacteriological analysis showed that the groundwater quality was poor, with total coliform exceeding the WHO permissible limit for drinking. Bacteria species identified were *Escherichia coli*, *Enterobacter aerogenes*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus mirabilis*, *Klebsiella* sp., *Salmonella* sp., *Vibrio* sp., *Serratia marcescens, Shigella* sp., *Chromobacterium* sp., *Flavobacterium* sp., *Citrobacter* sp., *Alcaligenes* sp., *Bacillus* sp., *Streptococcus faecalis* and *Aeromonas* sp. Conductivity, salinity, chloride, total dissolved oxygen, calcium, and magnesium were within recommended limit. Calcium/magnesium (Ca/Mg) for each well sample ranged from 1.67 to 12.33 and indicates absence of saltwater intrusion which stands at a limit of 1. The implication of this is the shallow hand-dug wells were contaminated with microbes and could result in health hazard.

[Asiton-a Asifamabia Dick, Leera Solomon and Susan Okparanta. **Assessment of Selected Physicochemical and Microbial Parameters of Water Sources along Oproama River in Oproama Community in Rivers State, Nigeria.** *World Rural Observ* 2018;10(1):69-74]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 9. doi:10.7537/marswro100118.09.

Key words: Hand-dug wells, Oproama River, Saltwater intrusion, Total coliform

1. Introduction

In most urban and rural settings in the Niger Delta area, major sources of water for drinking and domestic purposes are: rivers/creeks/streams/ponds, hand-dug wells and harvested rain water (FGN, 2000). The provision of potable water has been a major problem in Nigeria, a characteristic feature of developing countries (Ashbolt, 2004). However, groundwater quantity is as important as its quality. This is because the health profile of any community is dependent on quality of the water they use.

The consumption of non-potable water could lead to water borne such as typhoid fever, cholera and dysentery. Wells located at the coastal regions are liable to contamination with pathogenic bacteria. Bacterial contamination of groundwater is a function of geological structure of the area (CPCB, 2001). In coastal areas, freshwater aquifers are in direct contact with the ocean. The dense saltwater typically circulates inland, creating a saline zone or “wedge” below the less dense overlying freshwater aquifer (Bear *et al*., 1999). Saltwater intrusion occurs when saltwater moves into water a freshwater aquifer (technically, this is sea water intrusion) because “Saltwater” can be derived from different source (Klassen *et al*., 2014).

Seawater intrusion is a natural process; it becomes an environmental problem when excessive pumping of groundwater from the aquifer reduces the water pressure thereby drawing saltwater into new areas (Amadi *et al*., 2012).

The clearest indication of seawater intrusion is an increase in Cl^- concentration as a proxy for salinity, although other processes may lead to a similar phenomenon (FAO, 1997). Along the coastline, high values of electrical conductivity (EC) are usually attributed to salinisation by seawater intrusion (Stamatis and Voudouris, 2003).

Cation exchange is another factor modifying groundwater quality and is one of the most important geochemical processes taking place in aquifers. In coastal aquifer, where the relationship between seawater and fresh water is complex, cation exchange contributes significantly to the final composition of groundwater (El-Fiky, 2010). Salinity arising from seawater intrusion is the most common and widespread form of groundwater contamination in coastal areas, leading to abandonment of water wells in many instances (Frank-Briggs *et al*., 2006).

The occurrence of groundwater with very high salinity has been documented in some parts of Nigeria. In this paper, an attempt was made to assess and evaluate the microbial, some physiochemical parameters and saltwater status of the hand-dug wells in Oproama Community as a baseline study.

2. Materials and Methods

2.1 The Study Area

The study was carried out in Oproama Community in Asari-toru Local Government Area of River State. The community lies on latitudes 4° 47' and 4° 56' North and longitudes 6° 50' and 6° 41' East. The study area is surrounded by Oproama River and tidal creeks and only accessible by sea.

The Oproama River is salty, tidal and a tributary that originates from the New Calabar River. All the inhabitants rely on the hand-dug wells as there is no pipe-borne water supply in the area. For the purpose of this study, ten (10) sampling stations were selected. Seven (7) hand-dug wells which are being used extensively for drinking and other domestic purposes and three (3) source points along the Oproama River were sampled monthly for twelve months to cover both wet and dry seasons.

Stations 1-7 are hand-dug wells, while Stations 8-10 are points along the Oproama River. The samples were collected in triplicate for microbiological, physiochemical (conductivity, salinity, chloride, total dissolved solids) and metals (calcium and magnesium) analysis. All the samples were then taken to the laboratory in a cold box for analysis within 24 hours. The total coliform and *Escherichia coli* counts were estimated employing membrane filtration technique.

All isolates were characterised and identified according to Chesseborough (1984). Salinity of the water samples was determined using a digital meter (Consort P107). The probe end of the meter was dipped into the water sample while the value at the pointer was read off and recorded. Chloride was determined trimetrically in accordance with section 4500Cl-B.

The method requires titration of an aliquot portion of the sample in the presence of potassium chromate and Volhard solution as indicators respectively to a brick-red endpoint with silver nitrate ($AgNO_3$). Conductivity was assessed by putting on the Suntex Conductivity meter, adjusting the reading portion and dipping the electrode into water sample and appropriate reading taken.

Total dissolved solids (TDS) concentration of the water samples was determined from conductivity measurement using the relationship: TDS mg/l = Conductivity (µS/cm) x 0.65 (water sample), where mg/l is milligramme per litre of water sample and µS/cm is microsiemen per centimetre.

The water samples were analysed for the presence of calcium and magnesium using atomic absorption spectrophotometer (AAS) (HACH DR 2400). Prior to analysis, the AAS was calibrated with standards of known concentrations to obtain a calibration curve for the individual metal.

3. Results

There were seasonal changes in total coliform of the different sampling stations (wells and river) in Oproama Community (Fig. 1). Station 5 (well) and station 10 (river) recorded the highest values of $1.03x10^3$ cfu/ml (log_{10} 3.0161) and $1.381x10^3$ cfu/ml (log_{10} 3.1401) for wet season amongst the well and rivers samples respectively, while dry season values show that station 3 (well) and station 9 (river) recorded the highest values of $2.42x10^3$ (log_{10} 3.3852) and $1.45x10^3$ cfu/10ml (log_{10} 3.1619) for well and river samples, respectively.

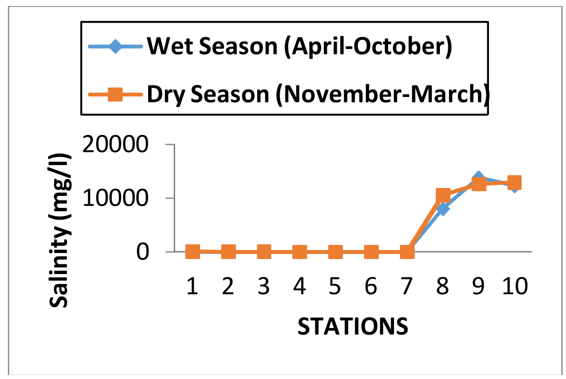

Fig. 1: Total Coliform counts of water

There were seasonal changes in *Escherichia coli* of the different sampling stations (wells and rivers) in Oproama Community (Fig. 2). Generally, apparent seasonality was shown especially in well water sources (stations 1-7).

Station 5 (well) and station 10 (river) recorded the highest values of $2.62x10^2$ cfu/ml (log_{10} 2.4183) and $3.32x10^2$ cfu/ml (log_{10} 2.5211) for wet season amongst the well and river samples respectively, while dry season values show that station 1 (well) and station 10 (river) recorded the highest values of $5.6x10^1$ cfu/ml (log_{10} 1.7481) and $3.4x10^2$ cfu/ml (log_{10} 2.5314) for well and river samples respectively.

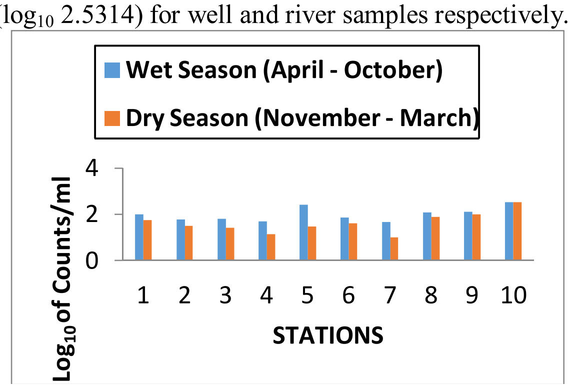

Fig. 2: *Escherichia coli* counts of water samples covering wet and dry season samples covering wet and dry season

The salinity of the water bodies during the sampling period are presented in Fig. 3. Stations 8, 9 and 10 (river sources) exhibited the highest salinity levels both for the wet and dry 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.

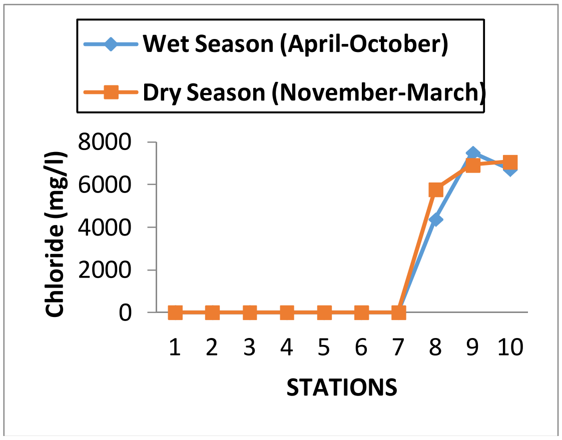

Fig. 3: Salinity of water samples covering wet and dry seasons

The results of the chloride concentrations of the water samples are shown in Fig. 4. Station 9 recorded the highest value of 7,500.05 mg/l while station 5 recorded the lowest value of 7.14 during the wet season. During the dry season, station 10 recorded the highest value of 7080.21 mg/l while station 5 recorded the lowest value of 6.57 mg/l.

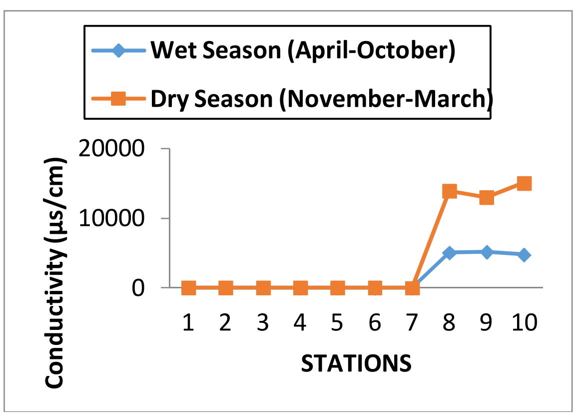

Fig. 4: Chloride of water samples covering wet and dry seasons

The conductivity values of the water samples are presented in Fig. 5. The river water stations recorded the highest values of 5071.42 µS/cm (station 8), 5192.85 µS/cm (station 9) and 4775.71µS/cm (station 10) for the wet season and 13910 µs/cm (station 8), 13030 µs/cm (station 9) and 15060 µS/cm (station 10) for dry season.

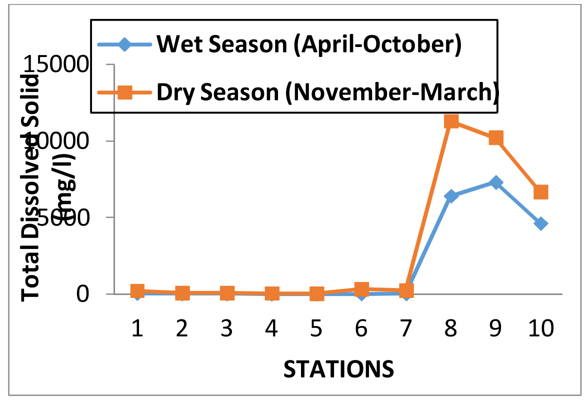

Fig. 5: Conductivity of water samples covering wet and dry seasons

Readings of Total Dissolved Solid are shown in Fig. 6. Station 9 recorded the highest concentration of 7305.71 mg/l while station 5 recorded the lowest concentration of 17.28 mg/ during the wet season. During the dry season, the highest concentration of 11,290 mg/l was recorded for station 8 while station 5 recorded the lowest concentration of 34.8 mg/l.

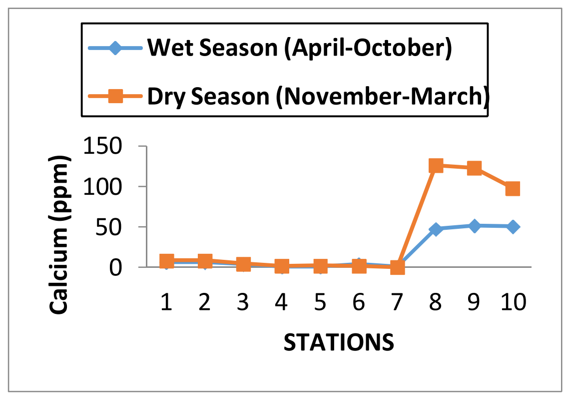

Fig. 6: Total dissolved solid of water samples covering wet and dry season

The results of calcium concentrations of the water samples are shown in Fig. 7. There were higher values of calcium concentration observed in the dry season during the monitoring period with the highest value of 126.33 ppm recorded in station 8 and during the wet season, station 9 recorded the highest value of 51.66 ppm.

The results of Magnesium concentrations of the water samples are indicated 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. During the dry season, station 8 recorded the highest value of 31.18 ppm while station 7 recorded the lowest value of 0.09 ppm.

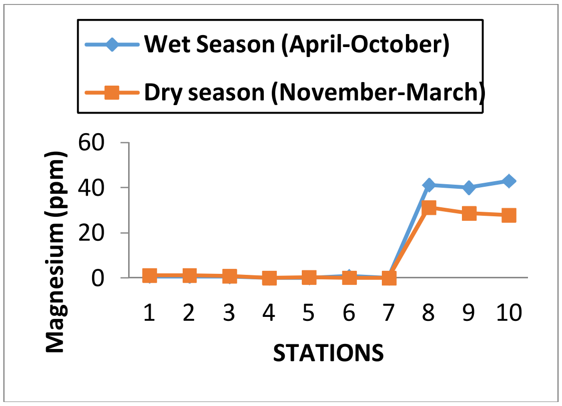

Fig. 7: Calcium concentration of water samples covering wet and dry seasons

4. Discussion

The present study has revealed some microbiological, physicochemical and metal quality of water sources in Oproama as well the saltwater intrusion level. The guideline value for total coliform is 0/100 ml (WHO, 1993) for water intended for drinking. This guideline value was not met in any of the sampled stations.

This indicates that the ground water has been polluted by microbes sourced possibly from animals and humans. The presence of coliform, however indicates the possibility of the presence of pathogenic microorganisms (Hosetti and Kumar 2002). High coliform counts appear to be characteristic of rural ground water quality in Nigeria (Adekunle *et al*., 2007). The presence of *Escherichia coli* in water supply indicates human faecal contamination. In Oproama, the wells are not close to soak away pits (indicative of a rural setting); however, pier latrine is prominent.

Medically, *Escherichia coli* have been reported to be the leading cause of diarrhoea diseases in addition to pathogens such as *Salmonella*, *Shigella*, *Yersinia*, *Vibrio*, *Campylobacter* species, *Entamoeba histolytica*, and *Giardia lamblia* in developing countries (Prescott *et al*., 2002). Groundwater in Oproama Town has low mineralisation which can be explained by the electrical conductivity (EC) measurement that varies from 13.85 – 56.4 µS/cm (wet season) and 18.8 – 74 µS/cm during the study period.

This noticeable variation in the measured Electricity Conductivity (EC) is probably due to the dilution of groundwater by heavy precipitation (Mondal *et al*., 2007). The study revealed that all the well water samples (Station 1-7) are within the WHO (2004) limit of 1400 µS/cm. Salinity concentration analysis showed that for both seasons, the well water samples were within the acceptable limits of 250 mg/l (WHO, 2004b).

It has been reported that the amount of a substance entering a water body depends on land or geology and rainfall and release of substances from underlying sediment into the water (Brian, 1980). This may be responsible for salinity levels recorded in the drinking water wells (Station 1 – 7) in Oproama. The lower values recorded during the wet season may be due to dilution and far below the values of 1100 – 9400mg/l recorded for hand-dug wells in Buguma.

The presence of chloride in slightly higher amounts in these stations may be due to the passage of water through natural salt formations in the earth (Renn, 1970). High chloride concentration may also be due to the proximity of the well to a tidal channel and the poor muddy sediments present in the aquifer system which further infers saline intrusion (Lin *et al*., 2010).

Generally, high chloride content is generally taken as an index of impurity of groundwater. Tremblay *et al.* (1973) stipulated 40mg/l to indicate salt water intrusion; hence, there is no salt water encroachment into the aquifers of Oproama. Also, no adverse health effects on human have been reported from intake of water containing even higher concentrations of chloride (Alexander, 2008).

As a general observation, lower TDS values were observed during the wet season while higher TDS values were observed during the dry season which explains the possibility of dilution effect during the wet periods. These data are supported by the overall decrease in salinity and electrical conductivity values during the wet season.

However, the lower values observed during the study were found in well water samples which were within the stipulated value of 1000 mg/l by WHO (2004) for drinking water, hence, the water is not harmful in view this parameter. High values of TDS in groundwater are generally not harmful to human beings but high concentration of these may affect persons, who are suffering from kidney and heart diseases (Gupta *et al*., 2004).

Water containing high solids may cause laxative or constipation effects. Calcium and Magnesium concentration exhibited the same trend in the water samples analysed. Generally, the dry season samples had higher values of these parameters for all the water samples.

This probably may be due to decrease in well water level following extended period of sunshine which resulted in increased concentration of calcium level while the low concentrations during the wet season may be attributed to the dilution effect of rain water.

Also, WHO (1996) reported that calcium and magnesium salts which are generally highly soluble in water are leached from the terrestrial environment to ground and surface water. However, the concentrations of these parameters in the water samples analyzed were found to be within the acceptable limit of 75-200mg/l for calcium and 30-150mg/l for magnesium recommended by WHO (2004a) for drinking water as well as the 40-92mg/l and 4-12.5 mg/l values for calcium and magnesium reported by Adejuwon and Mbuk (2011) for shallow wells in Ikorodu Town, Lagos.

Calcium toxicity is rare, but over consumption may lead to deposit of calcium phosphates in soft tissue of the body; also, Calcium intoxication causes depression (Chapman-Nowaskofski and Tussing, 2001). The study reveals that none of the Ca/Mg ratio of well (groundwater) water sample is indicative of saltwater intrusion which can be confirmed by the local dwellers based on their consumption.

A low Ca/Mg ratio may also be indicative of saltwater contamination (Ravi and Krishna, 1996). If the ratio is less than 1, then the area is considered to be highly affected by saltwater intrusion.

5. Conclusion

The microbiological investigation indicates that the bacteria of the water sources included various potential pathogens which could be hazardous to health. If microbiological parameters are taken into account, such as total coliform and *Escherichia coli*, then the analyzed groundwater would not be suitable for human consumption without prior treatment as none of the wells studied met the WHO requirements for water intended for drinking.

The study also revealed that the selected parameters such as salinity, chloride, conductivity, total dissolved solids, calcium and magnesium were within recommended limits. Generally, the study revealed an apparent seasonal influence on the microbiological and physicochemical parameters of the various water samples.

The calcium/magnesium ratios obtained from this study revealed that they are above 1. This suggests that there is no saltwater intrusion in the study area. Since this is a baseline study and rural communities like Oproama still rely exclusively on untreated groundwater as source of drinking water.

5.1 Recommendations

This study recommends that hand-dugs wells in the Community should be well constructed with concrete casing and well-covers. Water chlorination is also advocated. Finally, this study strongly recommends the urgent completion of the abandon water scheme project in the Community.

Corresponding author
Asiton-a Asifamabia Dick, Ph.D.
Department of Science Laboratory Technology, School of Science and Technology, Elechi Amadi Polytechnic, Rumuola, P. M. B. 5936,
Port Harcourt, Rivers State
E-mail: asitona2016@yahoo.com

References

1. Adejuwon, J. O. And Mbuk, C. J. (2011). Biological and physiochemical properties of shallow wells in Ikorodu town, Lagos Nigeria. *Journal of Geology and Mining Research*, 3(6): 161-168.
2. Adekunle, M., Adetunji, M. T., Gbadebo, A. M. and Banjoko, O.B. (2007). Assessment of Groundwater Quality in a Typical Rural Settlement in Southwest Nigeria. *International Journal of Environmental Research and Public Health*. 4(4): 307-318.
3. Alexander, P. (2008). Evaluation of ground water quality of Mubi Town in Adamawa State, Nigeria. *African Journal of Biotechnology*, 7(11): 1712-1715.
4. Amadi, A. N., Nwankwoala, H. O., Olasehinde, P. I. Okoye, N. O., Okunbola, I. A. and Alkali, Y. B. (2012). Investigation of Aquifer Quality in Bonny Island, Eastern Niger Delta, Nigeria using Geophysical and Geochemical Techniques. *Journal of Emerging Trend in Engineering and Applied Sciences*, 3(1): 183-187.
5. Ashbolt, N. J. (2004). Microbial contamination of drinking water and disease outcomes in developing region. *Toxicology*, 20: 229 – 238.
6. Bear, J., Cheng, A. H. D., Sorek, S., Quazar, D. and Herrera, I. Eds. (1999). Seawater intrusion in coastal aquifers-concepts, methods and practices. Dordrecht, The Netherlands, Kluwer Academic Publishers. p625.
7. Brian, M. (1980). *Ecology of Freshwater*. 1st edition. Blackwell Scientific Publications, London. pp312.
8. Chapman-Nowaskofski, K. and Tussing, L. (2001). Calcium, University of Illinois Co-operative Extension. http://www.McKinley.Uiuc.edu/handouts/calcium.html.
9. Central Pollution Control Board (2011). Pollution Control Acts, Rules and Notifications. Issued there under, Fourth Edition. New Delhi: Central Pollution Control Board. Ministry of Environment and Forests, Government of India.
10. Chessebrough, M. (1984). *Medical Laboratory Manual for Tropical Countries*. 2nd Edition. Butterworths-Heinemann Limited, London.

11. El-Fiky, A. A. (2010). Hydrogeochemical characteristics and Evolution of groundwater at the Ras Sundr-Abu Zenima Area, Southwest Sinai, Egypt, JKAU. *Earth Science*, 26(1): 79-109.
12. Federal Government of Nigeria (FGN) (2000). Annual report on water resources in Nigeria. A yearly publication of Federal Ministry of Water Resources.
13. Food and Agricultural Organisation, FAO (1997). Seawater intrusion in coastal aquifers. Guidelines for study, monitoring and control, 7(23): 124-150.
14. Frank-Briggs, I. N., Akpokodje, E. G. and Mbeledogu, I. U. (2006). A regression model for analysising freshwater/saltwater interface behavior in sandy islands of the Eastern Niger Delta. *Scientia Africana*, 5(1)5-10.
15. Gupta S., Kumar, A., Ojha, C. K. and Singh, G. (2004). Chemical analysis of groundwater of Sanganer area, Jaipur in Rajasthan. *Journal of Environmental Science and Engineering*, 46(1)**:** 74-78.
16. Hosetti, B. B. and Kumar, A. (2002). *A Textbook of Applied Aquatic Biology*. Daya Publishing House, Delhi. p.35.
17. Klassen, J., Allen, D. M. and Kirste, D. (2014). Chemical indicators of Saltwater intrusion for the Gulf Islands, British Columbia. Final Report submitted to BC Ministry of Forests, Lands and Natural Resource Operations and BC Ministry of Environment. p43.
18. Mondal, N. C., Singh, V. S., Saxena, V. K. and Prasad, R. K. (2007). Improvement of Groundwater Quality due to Fresh Water Ingress in Potharlanka Island, Krishna Delta, India. *Environmental Geology*, 434-439.
19. Prescott, L. M., Harley, J. P. and Donald, A. K. (2002). *Microbiology*. Fifth Edition. McGraw Hill, Companies, USA. pp935-937.
20. Renn, C. E. (1970). *Investigating Water Problems*. Educational Products Division, LaMotte. Chemical Products Company, Maryland.
21. Tremblay, J. J., Cryz, D. and Auger, H. (1973). Saltwater intrusion in the Summer Side Area. P. E. I. Groundwater II: 4.
22. World Health Organisation, WHO (1993). Guidelines for Drinking Water Quality. World Health Organisation, Geneva, Switzerland.
23. World Health Organisation (1996). Guidelines for Drinking Water Quality (Vol. 2): Health Criteria and Other Supporting Information, Geneva, Switzerland.
24. World Health Organisation (2004a). *Guideliness for Drinking-water quality*. Volume 1 Recommendations. 3rd Ed. World Health Organisation, Geneva.
25. World Health Organisation (2004b). *Seminar Pack. Microbiological Aspects* http://www.who.int/inf-fs/en/fact097.html.

3/22/2018