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**Research Article**

# Surface and Groundwater Quality in Some Oil Field Communities in the Niger Delta: Implications for Domestic Use and Building Construction

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**Abstract:** The aim of this study was to determine surface and groundwater quality in some communities in the Niger Delta and to evaluate the implications for domestic use and building construction. Surface water samples were collected along the Nun River and Taylor creek in the greater Gbaran area; groundwater samples were collected from seven communities in that Gbarain and Ekpetiama kingdoms of Bayelsa State, Nigeria. The surface water turbidity values (24.18 to 130.42 NTU) were above the Nigerian drinking water limits. TDS values were low (27-32 mg/L); pH (7.0 to 7.5), conductivity (54.00 to 63.00 µS/cm), nitrate (0.09-0.61 mg/L). The measured values of conductivity, pH and TDS and nitrate fell within the NIS limits for drinking water in Nigeria. About 50% of the surface water samples had values of iron higher than the Nigerian standard for drinking water. Most of the samples gave values of chromium within the limit for drinking, with a few exceptions. pH of groundwater (6.3-7.8) mostly fell within the Nigerian drinking water limits (6.5-8.5). Mean electrical conductivity values of groundwater was 129.67 µS/cm, the TDS values (51.00 to 81.00 mg/L). The turbidity values ranged from <0.01 NTU to 38.11 NTU. Heavy metals concentrations were generally low; copper values ranged from <0.001 to 0.407 mg/L, chromium (0.020-0.059 mg/L), iron (0. 162 to 0.558 mg/L). The measured physicochemical variables of surface water and groundwater from the study area showed water quality values that were generally within the Nigerian standards for drinking water, apart from turbidity, iron and chromium in both surface and groundwater. However, all the measured parameters showed valued that are within acceptable limits for construction.

**Keywords:** Bayelsa state, cement bonding, Nun River, Nigeria water quality, potable

## INTRODUCTION

Water quality affects the abundance, species composition/diversity; stability, productivity and physiological condition of indigenous populations of the aquatic organisms (Chindah, 1998; CCME, 1999). The introduction of industrial and urban sewage to the water system cause changes to the structure of the inhabiting organisms hence the analysis of these changes constitute an important tool in interpreting and evaluating the effects of contaminants in a particular ecosystem both in space and time (Heip, 1992; Daka *et al*., 2007; Daka and Moslen, 2013). There are also critical imperatives for water use in rural communities where surface water bodies provide the sources of potable water (RPI, 1985). The Niger Delta comprises a complex network of rivers with an intercalation of creeks; water from these sources support a variety of uses (NEDECO, 1961).

The challenge of collapsed buildings has been widely reported in the national media in recent times and efforts and policies towards addressing this problem have focused largely on structural integrity. The possible effects of water quality used for construction on the bonding properties of concrete and failure have been largely ignored. In this study, we report the quality of surface water of the Nun River and Taylor Creek and groundwater from some oil field communities in Bayelsa State, Nigeria. The implications of the observed water quality on portability and suitability for construction are discussed.

## MATERIALS AND METHODS

A total of nine sampling points were selected for this study (six in the Taylor Creek and three in the Nun River) for the determination of surface water quality. Groundwater was obtained from nine sampling points from existing boreholes in the following communities: Obunagha, Polaku, Koroama, Okolobiri, Okotiama, Ogboloma, Gbarantoru, Tombia and Zarama in Yenagoa Local Government Area of Bayelsa State of Nigeria. Samples were collected and analyzed in November 2010. *In-situ* measurements were taken for pH, Electrical Conductivity (EC), Total Dissolved Solids

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(TDS) and temperature for each of the nine samples collected.

Samples for physicochemistry were collected in 1 L plastic containers, DO and BOD samples were collected in Winkler bottles. A set was fixed on the spot for DO using Winkler Reagents I and II and kept in ice box while the second set was sent to the laboratory and incubated at room temperature for 5 days before fixing for BOD analysis; samples for heavy metals, sodium and calcium analysis were taken in plastic containers and preserved with appropriate reagents ($H_2SO_4$, $HNO_3$). All analyses were carried out in Thermosteel Nigeria Limited Laboratories using standard methods. The methods of analyses used in this study were those specified in EGASPIN (2002) and other internationally accepted analytical procedures. To reduce error, measurements were replicated and numbers of spatially distributed samples were composited before sub-sampling for analyses. To avoid samples contamination and deterioration, sampling tools and containers were pre-sterilized, pre-treated and preserved in transit in ice-cooled chest and transported to the laboratory. They were stored in refrigerator pending subsequent analyses. Details of analyses for the parameters studied are as follows:

Phosphate was determined by the stannous chloride method (APHA, 1989) Phosphate in water reacts with ammonium molybdenum blue complex in the presence of stannous chloride. The intensity of colour was measured at 690 nm using a Spectronic 20 spectrophotometer. Chloride was measured titrimetrically (Argentometric Method) in slightly alkaline solution with silver nitrate ($AgNO_3$) solution in the presence of potassium chromate as indicator (APHA, 1989). Heavy metals (Fe, Cu and Cr) were analysed using Unicam Atomic Absorption Spectrophotometer Model 929.

Biochemical Oxygen Demand (BOD) is dependent on oxygen uptake by bacteria and was determined using the dilution method according to APHA (1976). The amount of oxygen consumed during a fixed time period (usually 5 days) is related to the amount of organic matter present in the original sample. Dissolved oxygen of the samples was first determined using the Schott Geräte Dissolved Oxygen meter and then incubated for 5 days at 20°C. DO was again measured after a period of five days and BOD in mg/L was determined from the following calculation and reported accordingly:

$$BOD\ (mg/L) = [DO_B - DO_A] - [DOS_B - DOS_A]$$

where,
D = Dilution factor usually 0.5
$DO_B$ = DO of sample before incubation
$DO_A$ = DO of sample after incubation
$DOS_B$ = DO of sample blank before incubation
$DOS_A$ = DO of sample blank after incubation

Chemical Oxygen Demand (COD) was used as a measure of the oxygen equivalent of the organic matter content of the sample which was susceptible to oxidation by a strong chemical oxidant. COD was determined using the open reflux method where a sample was refluxed and digested in a strongly acidic solution with a known excess of potassium dichromate ($K_2Cr_2O_7$). After digestion, the excess un-reacted potassium dichromate was read with a spectrophotometer at 600-nm and results reported in mg/L (APHA 508). Results were also verified by titrating with a standard solution of ferrous ammonium sulphate.

Descriptive statistical analyses were used to summarize the data and these were compared with Nigerian drinking water standards (NIS, 2007) as well as the Bureau of Indian Standards IS 456 2000 (IS 456, 2000) for construction. The significance of the differences between the medians for each variable of surface and groundwater quality ware determined using Mann Whitney tests (Zar, 1984). Analyses were performed using MINTAB for Windows V16.

## RESULTS AND DISCUSSION

The summary of the results of physico-chemical analysis of the surface water samples from the study area are presented in Table 1 and Fig. 1. The surface water turbidity values ranged from 24.18 to 130.42

Table 1: Summary of the physico-chemical parameters of the surface water samples from the study area (Nun River and Taylor Creek)

| | Min | Max | Mean | S.D. | *NIS (2007) | **IS 456 (2000) |
|---|---|---|---|---|---|---|
| pH | 7.0 | 7.5 | 7.2 | 0.2 | 6.5-8.5 | ≥6 |
| Conductivity (µS/cm) | 54.00 | 63.0 | 58.00 | 2.50 | 1000 | |
| Dissolved oxygen (mg/L) | 5.20 | 6.80 | 5.69 | 0.54 | | |
| Biochemical oxygen demand (mg/L) | 2.50 | 4.80 | 4.24 | 0.69 | | |
| Chemical oxygen demand (mg/L) | 4.00 | 6.48 | 5.28 | 0.86 | | |
| Turbidity (NTU) | 24.18 | 130.42 | 58.96 | 36.81 | 5 | |
| Chloride (mg/L) | 5.24 | 8.64 | 6.29 | 1.03 | 250 | 2000 |
| Nitrate (mg/L) | 0.09 | 0.61 | 0.31 | 0.18 | 50 | |
| Phosphate (mg/L) | <0.01 | 0.29 | 0.15 | 0.12 | | |
| Total dissolved solids (mg/L) | 27.00 | 32.0 | 28.90 | 1.50 | 500 | |
| Sodium (mg/L) | 4.490 | 9.340 | 7.422 | 1.528 | 200 | |
| Calcium (mg/L) | 2.880 | 4.800 | 3.781 | 0.624 | | |
| Iron (mg/L) | 0.244 | 0.759 | 0.395 | 0.196 | 0.30 | |
| Copper (mg/L) | <0.001 | 0.265 | 0.175 | 0.106 | 1.00 | |
| Chromium (mg/L) | 0.024 | 0.057 | 0.043 | 0.011 | 0.05 | |

*: Nigerian standard for drinking water quality (NIS 554: 2007); **: Indian Standard plain and reinforced concrete – code of practice (IS 456, 2000)

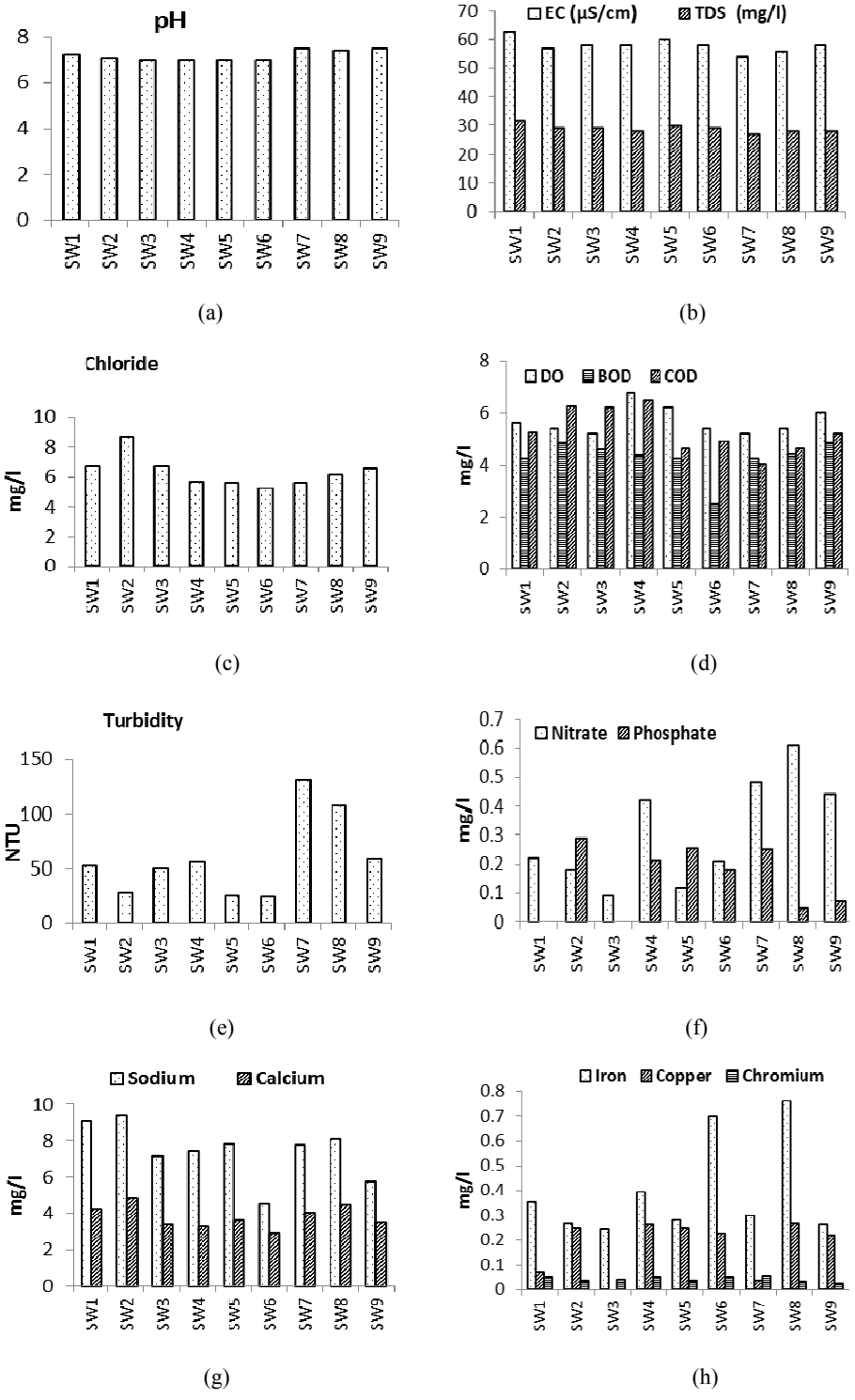


Fig. 1: Physicochemical variables of surface water in the study area

NTU with an average of 58.96 NTU. This is relatively high and above the recommended limit of 5 NTU for potable water. The TDS values surface water were low (27-32 mg/L) with a mean of 28.89, reflecting the typical values in the freshwater environment. The surface water pH values varied from 7.0 to 7.5 with a mean of 7.2 reflecting about neutral range. Conductivity values were in the range of 54.00 to 63.00 µS/cm and a mean of 58.00 µS/cm in the surface water. These values are typical of the freshwater environment. The measured values of conductivity, pH and TDS fell within the NIS limits for drinking water in Nigeria.

Table 2: Summary of the physico-chemical parameters of the groundwater samples from the communities in the study area

| | Min | Max | Mean | S.D. | *NIS (2007) | **IS 456 (2000) |
|---|---|---|---|---|---|---|
| pH | 6.3 | 7.8 | 6.7 | 0.5 | 6.5-8.5 | ≥6 |
| Conductivity (µS/cm) | 104.0 | 160.0 | 129.70 | 19.10 | 1000 | |
| Dissolved Oxygen (mg/L) | 0.50 | 2.44 | 1.70 | 0.63 | | |
| Biochemical oxygen demand (mg/L) | 0.46 | 1.84 | 1.14 | 0.48 | | |
| Chemical oxygen demand (mg/L) | 1.22 | 2.56 | 2.09 | 0.44 | | |
| Turbidity (NTU) | 0.01 | 38.11 | 11.96 | 16.15 | 5 | |
| Chloride (mg/L) | 6.24 | 24.44 | 11.38 | 5.43 | 250 | 2000 |
| Nitrate (mg/L) | 0.09 | 0.90 | 0.49 | 0.25 | 50 | |
| Phosphate (mg/L) | <0.01 | 0.07 | 0.02 | 0.03 | | |
| Total dissolved solids (mg/L) | 51.00 | 81.00 | 64.70 | 10.10 | 500 | |
| Sodium (mg/L) | 6.580 | 16.52 | 13.754 | 3.136 | 200 | |
| Calcium (mg/L) | 2.900 | 7.960 | 4.393 | 1.554 | | |
| Iron (mg/L) | 0.162 | 0.558 | 0.325 | 0.139 | 0.30 | |
| Copper (mg/L) | <0.001 | 0.407 | 0.223 | 0.133 | 1.00 | |
| Chromium (mg/L) | 0.020 | 0.059 | 0.039 | 0.014 | 0.05 | |

*: Nigerian standard for drinking water quality (NIS 554:2007); **: Indian Standard plain and reinforced concrete-code of practice (IS 456, 2000)

The mean value dissolved oxygen of 5.69 mg/L (range 5.2-6.8 mg/L) shows comfort respiratory zone for living organisms. The mean $BOD_5$ value of 4.24 mg/L for the surface water sampled indicates low organic pollution, tolerable and manageable within natural purification schemes and not requiring remediation intervention. The COD values ranged from 14.30 to 20.6 mg/L with a mean of 16.40 mg/L.

The phosphate content as phosphorus was low, varying between <0.001 and 0.257 mg/L with a mean of 0.123 mg/L. At this concentration, eutrophication potential is low. Nitrate varied between 0.09 and 0.60 mg/L and a mean of 0.31 mg/L in the study area, $nitrate^-$ was low, indicating minimum anthropogenic biological pollution and organic matter decomposition. The values are lower than the NIS limit of 50 mg/L for drinking water.

Levels of all physicochemical parameters measured in the Taylor Creek and Nun River are within concentrations commonly encountered in Rivers of Southern Nigeria (Akpan, 1998; Akpan *et al*., 2002) and considered adequate for aquatic life (McNeely *et al*., 1979; Chapman, 1996). Dissolved oxygen levels are low and this is mainly attributed to natural input of decaying organic matter from associated forest ecosystems (Ajayi and Osibanjo, 1981). About 50% of the surface water samples had values of iron higher than the Nigerian standard for drinking water. Most of the samples gave values of chromium within the limit for drinking, with a few exceptions (Fig. 1). Daka and Chinedu-Agunobi (2013) recorded higher concentrations of iron in the Nun River, which were higher than the Nigerian drinking water limit.

The physico-chemical and heavy metals composition of the groundwater samples in the study area are presented in Table 2 and Fig. 2. pH of the groundwater in the study area was mainly slightly acidic except in sample stations GW 7and GW 9 that gave neutral and slightly alkaline pH values respectively (Fig. 2). On the overall the results fall within the Nigerian drinking water limits (6.5-8.5) for acceptability of water for domestic purpose.

Electrical conductivity values of groundwater in the study area were moderate with a mean of 129.67 µS/cm drawn from a range of 104-160 µS/cm. All values were within the NIS limits of 1000 µS/cm for drinking water. Similarly, the TDS values (51.00 mg/L at GW 9 to 81.00 mg/L at GW 7 with mean value of 64.67 mg/L) fell within the NIS limit of 500 mg/L.

The turbidity values ranged from <0.01 NTU at GW 1, 2 and 6 to 38.11 NTU at GW 3, with a mean value of 11.96 NTU. The groundwater samples from the study area had turbidity values above the Nigerian drinking water limit of 5 NTU for acceptability of water for domestic purpose. The COD and $BOD_5$ values of groundwater at the study area were low. The COD values ranged from 1.22 at GW 8 to 2.56 mg/L at GW 6 with a mean value of 2.10 mg/L. The $BOD_5$ values ranged from 0.46 at GW 8 to 1.84 mg/L at GW 4 with a mean value of 1.14 mg/L. DO values were also low having a range of 0.5-2.44 mg/L and a mean of 1.70 mg/L. These parameters are oxygen functions and ground water exist in an anoxic condition. Hence the DO is low. Low BOD and COD simply indicate low level of organic matter in the ground water.

Chlorides, expectedly is the dominant anion in groundwater amongst those assayed at the study areas site while nitrate and phosphate closely follow in that order. Chloride values ranged from 6.24 mg/L at GW 2 to 24.44 mg/L at GW 6 with an average of 11.38 mg/L. Nitrate ranged from 0.09 mg/L at GW 7 to 0.90 mg/L at GW 3 with an average of 0.49 mg/L. The values of chloride and nitrate are lower than the Nigerian limit for drinking water. Phosphate ranged from <0.001 mg/L at GW 1, 5, 6 and 9 to 0.065 mg/L at GW 2 with an average of 0.02 mg/L.

The mean concentrations of calcium and sodium were 4.39 ($\pm$1.55) and 13.75 ($\pm$3.13) and all concentrations of sodium were within the NIS limit of 200 mg/L for drinking water. Heavy metals concentrations were generally low; copper values ranged from <0.001 to 0.407 mg/L, chromium (0.020-0.059 mg/L), iron which was the highest had values ranging from 0. 162 to 0.558 mg/L with mean of 0.325

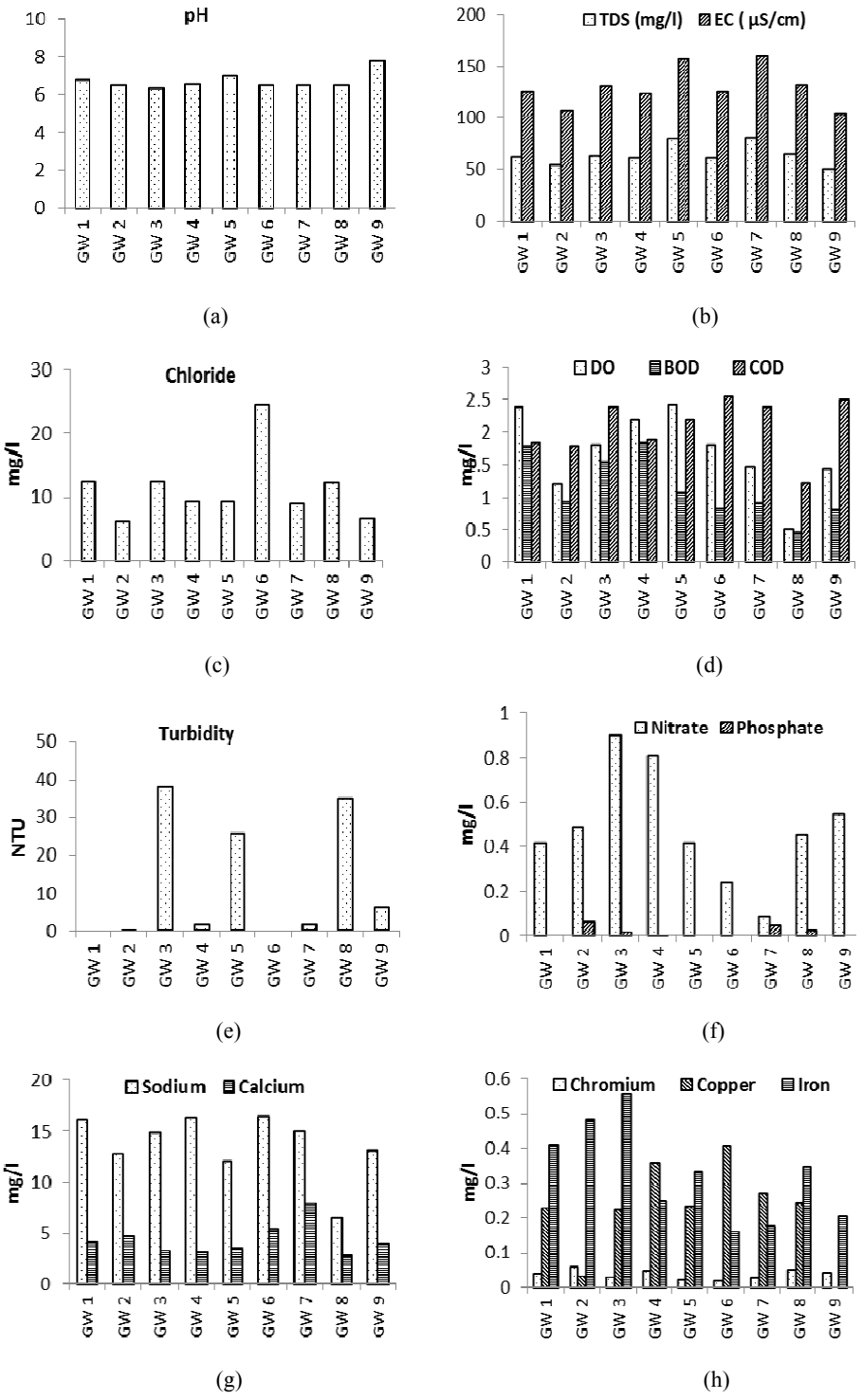


Fig. 2: Physicochemical variables of groundwater in the study area

mg/L. Some of the measured values of chromium and iron were higher than the Nigerian drinking water standard of 0.3 mg/L. High iron content of ground water in the study area may be attributed to the geologic materials and geochemical condition prevailing the Niger-Delta region. Despite high iron content, the pH of water samples for surface and groundwater were about neutral. Cement used for construction contains considerable iron oxide and becomes highly alkaline on mixing with water. The iron contents of the water samples in the study area should therefore not be of concern for construction.

Table 3 is a presentation of the Mann-Whitney tests for comparison of the median values of the physic-

Table 3: Mann-Whitney tests for significance differences between Surface Water (SW) and Groundwater (GW) samples from the study area

| Variable | Median | | Point Estimate for ETA1-ETA2 | 98.5 CI for ETA1-ETA2 | Test Statistic-*W* | P-value (adjusted for ties) |
|---|---|---|---|---|---|---|
| | SW | GW | | | | |
| pH | 7.1000 | 6.5000 | 0.5000 | 0.2001, 0.90020 | 115.0 | 0.0092 |
| Conductivity (μS/cm) | 58.000 | 126.00 | -69.00 | -93.99, -53.0000 | 45.00 | 0.0004 |
| Dissolved oxygen (mg/L) | 5.4000 | 1.8200 | 3.9400 | 3.380, 4.700000 | 126.0 | 0.0004 |
| Biochemical oxygen demand (mg/L) | 4.4000 | 0.9400 | 3.2800 | 2.600, 3.740000 | 126.0 | 0.0004 |
| Chemical oxygen demand (mg/L) | 5.2000 | 2.2000 | 3.0200 | 2.394, 4.000000 | 126.0 | 0.0004 |
| Turbidity (NTU) | 52.380 | 1.5000 | 46.380 | 20.18, 68.890000 | 118.0 | 0.0047 |
| Chloride (mg/L) | 6.1600 | 9.3600 | -3.8100 | -6.858, -1.040000 | 51.00 | 0.0026 |
| Nitrate (mg/L) | 0.2200 | 0.4600 | -0.2000 | -0.3700, 0.060100 | 68.50 | 0.1441 |
| Phosphate (mg/L) | 0.1800 | 0.0040 | 0.15800 | -0.0001, 0.237000 | 110.0 | 0.0309 |
| Total dissolved solids (mg/L) | 29.000 | 63.000 | -34.000 | -48.00, -27.00000 | 45.00 | 0.0004 |
| Sodium (mg/L) | 7.7600 | 14.930 | -7.1200 | -8.689, -4.339000 | 52.00 | 0.0036 |
| Calcium (mg/L) | 3.5700 | 4.0400 | -0.2200 | -1.400, 0.5810000 | 77.5 | 0.5067 |
| Iron (mg/L) | 0.2980 | 0.3330 | 0.0560 | -0.1119, 0.215000 | 94.0 | 0.4799 |
| Copper (mg/L) | 0.2260 | 0.2395 | -0.0305 | -0.1920, 0.020900 | 70.0 | 0.3123 |
| Chromium (mg/L) | 0.0410 | 0.0420 | 0.0040 | -0.00900, 0.01901 | 93.0 | 0.5363 |

chemical variables between surface and groundwater in the area. Significant differences existed for the pH, conductivity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, turbidity, chloride, phosphate, total dissolved solids and sodium; no significant difference was found for nitrate, calcium, iron, copper and chromium.

## CONCLUSION

The measured physicochemical variables of surface water and groundwater from the study area showed water quality values that were generally within the Nigerian standards for drinking water, apart from turbidity, iron and chromium in both surface and groundwater. These sources therefore require treatment to make them potable. All parameters showed values that are within acceptable limits for construction, so building failures in the study area may not be associated with water quality.

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## REFERENCES

Ajayi, S.O. and O. Oshibanjo, 1981. Pollution studies on Nigerian rivers ii, water quality of some Nigerian rivers. Environ. Pollut., 12: 87-95.

Akpan, E.R., 1998. Possible environmental impact of channelization dredging on the ecology of the cross river estuary system-Nigeria. Trop. Freshwater Biol., 7: 53-61.

Akpan, E.R., J.O. Offem and A.E. Nya, 2002. Baseline ecological studies of the great Kwa River, Nigeria 1: Physicochemical studies. Afr. J. Environ. Pollut. Health, 1: 83-90

APHA, 1976. Standard Methods for the Examination of Water and Waster Water. 14th Edn., American Public Health Association, Inc., New York.

APHA, 1989. Standard Methods for the Examinations of Water and Wastewaters. 17th Edn., American Public Health Association Inc., New York.

CCME (Canadian Council of Ministers of the Environment), 1999. Canadian Water Quality Guidelines for the Protection Aquatic Life: Introduction. In: Canadian Environmental Quality Guidelines. Winnipeg, pp: 159.

Chapman, D., 1996. Water Quality Assessment: A Guide to Use of Biota, Sediments, Water in Environmental Monitoring. 2nd Edn., UNEP UNESCO and WHO, E and FN Spon, London.

Chindah, A.C., 1998. The effect of industrial activities on the periphyton community at the upper reaches of new Calabar River, Niger Delta, Nigeria. Water Res., 32: 1137-1143.

Daka, E.R. and A. Chinedu-Agunobi, 2013. Monitoring of surface water quality during the construction of riverbank protection at a section of the Nun River in the Niger Delta, Nigeria. Afr. J. Environ. Pollut Health, 10: 23-29.

Daka, E.R. and M. Moslen, 2013. Spatial and temporal variation of physico-chemical parameters of sediment from Azuabie Creek of the upper bonny estuary, Niger Delta. Res. J. Environ. Earth Sci., 5: 219-228.

Daka, E.R., M. Moslen, C.A. Ekeh and I.K.E. Ekweozor, 2007. Sediment status of two creeks in the upper bonny estuary, Niger Delta, in relation to urban/industrial activities. B. Environ. Contam. Tox., 78: 151-521.

EGASPIN, 2002. Environmental guidelines and standards for the petroleum industry in Nigeria. Rev Edn., Department of Petroleum Resources, Lagos.

IS 456, 2000. Plain and Reinforced Concrete-code of Practice. 4th Revision, Bureau of Indian Standards (BIS 2000), 5th Reprint August 2002.Heip, C., 1992. Benthic studies summary and conclusions. Mar. Ecol-Prog. Ser., 19: 265-269.

McNeely, R.N., V.P. Neimanis and I. Dyer, 1979. Water quality sourcebook, a guide to water quality parameters. Environnement Canada. Dir Generale des Eaux Interieures, Ottawa.

NEDECO, 1961. The waters of the Niger Delta. The Netherlands Engineering Consultants, Hague.

NIS, 2007. Nigerian Industrial Standards NIS 554: 2007, Nigerian Standard for Drinking Water. Approved by Standard Organization Nigeria (SON), ICS 13.060.20, pp: 1-30.

RPI, 1985. Environmental baseline studies for the establishment of control and standards against petroleum related pollution in Nigeria. Research Planning Institute, South Carolina, USA RIP/R/84/14/15-7.U.S.A I-xiii, pp: 45.

Zar, J.H., 1984. Biostatistical Analysis. Prentice-Hall, New Jersey.