JASEM ISSN 1119-8362

Full-text Available Online at www.bioline.org.br/ja

J. Appl. Sci. Environ. Mgt. 2005
Vol. 9 (1) 191 - 195

Seasonal Variations of Physico-chemical Characteristics in Water Resources Quality in Western Niger Delta Region, Nigeria

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ABSTRACT: The influence of seasonal changes on the physico-chemical characteristics of water resources quality in the western horn of the Niger Delta region of Nigeria has been investigated. The water resources investigated were rain, open well and borehole water. The seasonal temperature variations show the waters to be in a heterothermal phase, but values are not significantly different ($P< 0.05$). The pH of the water resources is acidic in nature with pH values < 5.50 at all seasons. In general, the data revealed that maxima and minima concentrations of the priority physico-chemical water quality parameters examined in the three water resources are either above or below the target water quality range (TWQR) for domestic use, making these three water resources available in the area a potential health hazards to inhabitant. The overall implication of this observation calls for an urgent water resources management strategy in the area in order to circumvent the fast deteriorating water resources quality, which may pose associated health risk and environmental hazards. @JASEM

A water resource (rain, river, sea and ground water) is one of the major components of environmental resources that are under threat either from over exploitation or pollution, exacerbated by human activities on the earth's surface (Efe, 2001a). Generally, water resource problems are of three main types: too little water, two much water and polluted water (Ayoade, J. O; 1988 and Adebola, 2001). In the Niger Delta region of Nigeria, the problem of water resource is getting good quality (potable) water because of environmental pollution and degradation (Efe, 2002b). In most cities, towns and villages in this region, valuable man-hours are spent on seeking and fetching water, often of doubtful quality, from distant sources. The studies in Nigeria have shown that water resources are easily contaminated from anthropogenic activities in most cities (Akintola and Nyamah, 1978, Ayoade, 1988 and 1994, Ayoade and Oyebande, 1983, Kaizer et al, 2001, Obasi and Balogun, 2001 and Ovrawah and Hymore, 2001). These studies are however, concentrated on only one source of water.

Infact, studies such as this which is concentrated on rain, well and borehole water quality as a combined work, are lacking in literatures, especially borehole water quality assessment which is usually neglected in this area because of the general belief that it is pure through the natural purification process (Efe, 2002b). This neglect, according to Ayoade and Oyebande (1983) has impaired adequate information or knowledge of the quantity, quality and pattern of distribution of Nigeria's water resources. This was also observed by the Federal Ministry of Environment when considering the 1995 State Report on the Nigeria Environment and called for regular monitoring of rain and ground water resources vis-à-vis their contamination and/or pollution. Rainwater and ground water are vital components of the hydrologic cycle. Generally, rainwater charges ground water resources; hence, deterioration of rainwater quality as a result of man's activities may adversely affect the quality of underground water resources. Majority of the inhabitants of the Western Niger Delta Region such as Warri metropolis, consume water that does not undergo any form of treatment.

The geology of the western Niger Delta region is of the sedimentary type with a lithology of top layer (4-6m) of silty clay and sand followed by a thick (up to 17m) sand layer, silty at the top but becoming coarse and pebbly with depth (Okoye et al, 1987). This is coupled with the tropical equatorial climate (with mean annual rainfall of 3,000mm), which allows rapid drainage of the abundant rainfall that leaches pollutants into the subsurface water system (boreholes and open wells). Physico-chemical characteristics are very vital water quality monitoring parameters due to their instability once water is extracted from its source. Significant variations in physico-chemical parameters affect the quality of a water resource. Hence, it is necessary to obtain information on the variations of seasonal physico-chemical characteristics of water resources in order to decide on the type of water treatment process to be adopted. Therefore, this study is aimed at examining the influence of seasonal variation on the physico-chemical characteristics of water quality from rain, open hand-dug wells and boreholes in the Warri

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metropolis. It is also aimed at offering possible water management measures that would enhance good quality of these water sources.

EXPERIMENTAL

Materials

A reconnaissance survey was embarked upon to establish the land-use and the importance of water from rain, open-wells and boreholes in the study area. The sampling stations were chosen on the basis of land-use proximity to sources of pollution (such as refuse dumps, septic thanks and pit latrines for open-well and borehole samples and refinery as well as areas with dense traffic for rain water samples). Samples were collected from a " control sampling station" which is located in a rural area (Otorho Abraka), which is about 80km from Warri.

Sampling and Sample Preservation

Fourteen (14) plastic buckets were used to collect the well and borehole water samples. They were thoroughly washed and sterilized to avoid extraneous contamination of the samples. The open-well and borehole water samples were transferred to fourteen (14) clean and sterilized plastic containers. Six (6) sterilized hard plastic bottles were used to collect rainwater samples during specific rainfalls. These plastic bottles were raised from the ground by placing them on top of 1m blocks in order to avoid sand splash and other ground based pollution from contaminating the rainwater samples.

1.5 litres of water samples were collected from each of the three sources of water for subsequent analysis. Two sets of water samples (dry seas on and raining season samples) were collected from each sampling station during the months of January and June 2004 respectively. The January samples represent the dry season samples while the June samples are representative of the wet season samples respectively. The water samples for chloride, total dissolved solids (TDS), turbidity etc analysis were collected into plastic containers without any form of preservation. The samples were taken to the laboratory and stored in a refrigerator at $4^{O}C$ to avoid sample loss through evaporation and subsequent concentration of the different parametric indices analysed.

Analysis of Rain, Well and Borehole Water Samples

Unstable parameters such as pH, temperature, dissolved oxygen and conductivity were measured *in-situ* at the point of sample collection; a thermometer was used to determine the temperature of the samples while Hach 2000 pH meter was used to measure the pH of the samples. CIBA-CORING conductivity meter was used to measure electrical conductivity. Total suspended solids (TSS) were determined by filteration and gravimetry. TDS was measured by gravimetry while dissolved oxygen (DO) and biochemical oxygen demand (BOD_5).

Data Analysis

To maintain quality assurance, triplicate determinations were made and the data presented as the mean.

RESULTS AND DISCUSSION

The quality of a water resource depends on the management of anthropogenic discharges as well as the natural physico-chemical characteristics of the catchments areas. The study zone was chosen because it presents the main industrial and human centre of the western Niger Delta region of Nigeria, and therefore has a great probability for the existence of deteriorating water quality resources.

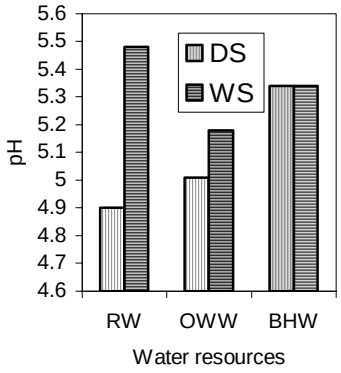

Fig 1. Seasonal variation of pH

The results of seasonal variation of some physico-chemical parameters and selected priority heavy metals in rainwater, open-well water and borehole water resources of the study area for dry and wet seasons are preserved in Tables 1 and 2 respectively. The mean pH values of rainwater, open-well water and borehole water resources are 4.90, 5.01 and 5.34 for dry season samples and 5.48, 5.18 and 5.34 for wet season samples. The result indicated that the three water resources available to the inhabitants of the area is acidic and that dry season intermittent rain drops are more acidic than rainy season (Fig 1). The Target Water Quality Range (TWQR) for pH in water for domestic use varied from 6 - 9 (DWAF, 1996a). The data revealed that the maximum and minimum pH values in the three water resources from all the sampling sites fall below the TWQR level and therefore making these sources of water available to inhabitant of the area as a low quality water. According to Fatoki et al (2002), the pH of a water body is very important in that it may affect the

solubility and toxicity of metals in the aquatic system, these pH ranges were therefore used to access the metal toxicities in the three water resources under consideration.

Table 1. Physico-chemical characteristics of water resources in the study area during the dry season. Results are given in range ± mean.

Parameters	Rainwater (RW)	Open-well water (OWW)	Borehole water (BHW)
pH	4.8 – 5.1 ± 4.90	5.02 – 5.42 ± 5.01	5.24 – 5.41 ± 5.34
Turbidity, TU	5.8 – 6.9 ± 6.58	16.1 – 16.4 ± 16.24	1.00 – 3.02 ± 2.01
Conductivity, Scm^{-1}	66.80 – 68.4 ± 67.32	56.4 – 65.6 ± 59.84	60.0 – 67.0 ± 61.4
TSS, mg/L	506 – 518 ± 510.2	504 – 516 ± 508	4.70 – 11.02 ± 6.25
TDS, mg/L	29.0 – 30.0 ± 29.62	248 – 378 ± 276.8	8.22 – 11.05 ± 9.10
DO, mg/L O_2	5.42 – 5.61 ± 5.5	3.41 – 3.43 ± 3.42	1.05 – 2.40 ± 1.54
BOD, mg/L O_2	0.02 – 0.04 ± 0.024	1.02 – 1.04 ± 1.032	0.80 – 1.10 ± 0.98
Chloride, mg/L Cl_2	24.8 – 30.2 ± 28.04	520 – 740 ± 638	221.0 – 5.12.0 ± 347.6
Nitrate, mg/L N	51 – 54 ± 52.4	51 – 53 ± 52	12.1 – 16.0 ± 14.62
Sulphate, mg/L SO_4	15.0 – 18.40 ± 16.51	5.5 – 6.4 ± 6.08	3.4 – 6.4 ± 5.18
Total hardness, mg/L $CaCO_3$	160 – 160.2 ± 160.12	370 – 476 ± 452.6	381 – 480 ± 456.4

However, no significant difference exists ($P \leq 0.05$) between the pH of dry and wet seasons for rain, open-well and borehole waters but pH of rainwater in dry season was relatively higher than open-well and borehole and the direct opposite of this trend was observed during the wet season. This indicates that rainwater in dry season is more acidic than open-well and borehole, which later charges ground water resources during the wet season. This increased acidity may be attributable to the oxidation of reduced sulphur compounds in the soils of the catchments areas. On seasonal variability the dry season water samples from the three water resources are more turbid than the wet season samples. This is an indication of concentration build –up during the dry season, which is supported by the high conductivity values observed at all sites during the dry season.

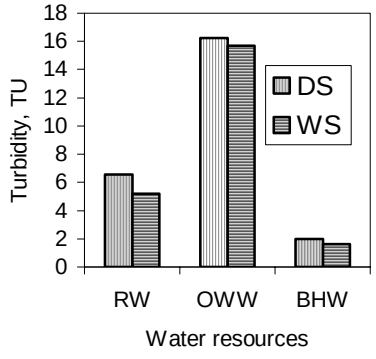

Fig 2. Seasonal variation of turbidity

Among the water resources, open-well water was found to be more turbid than rainwater and borehole water, while conductivity follow the order open-well > borehole > rainwater for both dry and wet seasons. Significant difference exists between the turbidity of water samples from rain, open-well and borehole for the seasons.

Turbidity values of rain and borehole waters were very low in both seasons when compared to that of open-well water. However, there was no significant difference ($P \leq 0.05$) found to exist in conductivity among the three water resources during dry and wet season, indicating that each of the three water resources are laden with pollutant load in almost equivalent degree irrespective of the season. The total suspended solids (TSS) relatively measure the physical or visual observable dirtiness of a water resource. The mean values of TSS in the study area for the three water resources are 510.2, 508 and 6.25 for dry season and 443.4, 499.4 and 5.804 for wet season. The low levels of TSS in borehole water are quite understandable, as ground was originally been filtered by nature and then extracted by filter aided mechanical pumps. The total dissolved solids (TDS) are an indication of the degree of dissolved substances such as metal ions in the water.

Table 2. Physico-chemical characteristics of water resources in the study area during the wet season. Results are given in range ± mean.

Parameters	Rainwater	Open-well water	Borehole water
pH	5.0 – 5.9 ± 5.48	5.00 – 5.38 ± 5.18	5.30 – 5.42 ± 5.34
Turbidity, TU	5.1 – 5.4 ± 5.20	14.3 – 16.8 ± 15.70	0.98 – 2.08 ± 1.63
Conductivity, Scm^{-1}	56.8 – 58.4 ± 57.32	60 – 66.1 ± 61.52	57.6 – 63.2 ± 60.02
TSS, mg/L	408 – 508 ± 443.4	480 – 509 ± 499.4	1.00 – 5.00 ± 4.80
TDS, mg/L	28.2 – 29.0 ± 28.52	203 – 214 ± 207.4	8.20 – 11.0 ± 8.68
DO, mg/L O_2	5.48 – 5.62 ± 5.53	3.42 – 3.43 ± 3.41	1.00 – 1.06 ± 1.02
BOD, mg/L O_2	0.02 – 0.04 ± 0.032	1.00 – 1.08 ± 1.03	0.80 – 1.08 ± 0.96
Chloride, mg/L Cl_2	24.7 – 30.0 ± 27.88	700 – 760 ± 720	212 – 511 ± 346.9
Nitrate, mg/L N	39 – 50 ± 46.6	50.0 – 51.1 ± 50.8	14.0 – 20.6 ± 20.3
Sulphate, mg/L SO_4	15.2 – 16.5 ± 16.51	5.6 – 6.8 ± 6.3	3.4 – 6.4 ± 5.12
Total hardness, mg/L $CaCO_3$	104 – 116 ± 107.7	468 – 470 ± 469.4	380 – 478 ± 455.8

The mean values of TDS in open-well water ($\bar{x}$ =276.8) are greater than rainwater ($\bar{x}$ = 29.62) and borehole water ($\bar{x}$ =9.096) for dry season and 207.4, 28.52 and 8.68 for wet season. The data revealed that the dissolved solids are more in dry season than wet season, though not significant at the 5% level ($P > 0.05$), but each was significantly higher for open-well waters than rain and borehole waters.

Dissolved oxygen levels in rainwater are greater than open-well and borehole waters, however, no significant difference exists ($P < 0.05$) between the two seasons. Biochemical oxygen demand was however observed to be greater in open-well water resource than that of rain and borehole waters, though not significant ($P < 0.05$) between dry and wet seasons, but open-well and borehole were significant .

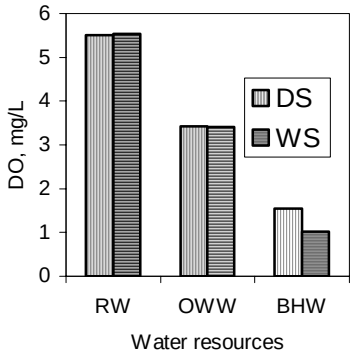

Fig 3. Seasonal variation of DO

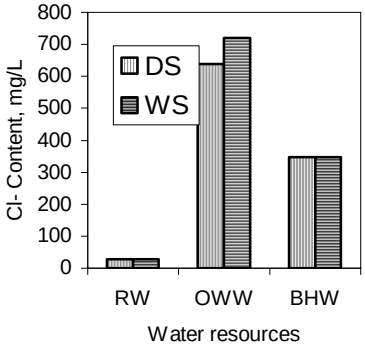

Fig 4. Seasonal variation of chloride

The mean sulphate concentrations in the three water resources (rain, open-well and borehole) are 16.51, 6.08 and 5.18 for dry season and 1651, 6.30 and 5.12 for wet season. No significant difference in sulphate levels was observed for the two seasons, however, rainwater seems to contain greater concentration of sulphate than open-well and borehole waters. This may be as a result of high-level combustion of sulphur containing hydrocarbon fuels in the study area. Oxidation of sulphur containing compounds higher than rainwater. The chloride content of water is an indication of the intrusion of seawater. The levels of chloride in open-well and borehole waters indicates that sea water within the area has a great influence on the salt content of the underground water resources. Chloride content in rainwater << open-well and borehole for both seasons. Nitrate in drinking water is highly deleterious especially to babies due to the formation of methmoglobinamea and the TWQR has recommended less than 10mg/l of nitrate for domestic use. The data for nitrate concentrations in the three water resources for dry and wet seasons are well above 10.0mg/l, thereby exposing babies in the study zone to serious health hazards. Levels of nitrate in rain and open-well waters are significantly ($P < 0.05$) higher than borehole water resources after rainwater water has been charged to ground water resources may increase the acidity and toxicity of open-well and borehole water resources. This observation is supported by the acidic nature of the open-well and borehole waters found in the study area. The mean concentrations of water hardness measured, as $mgCaCO_3/l$ in rain, open-well and borehole water resources are 160.12, 452.6 and 456.4 for dry season and 107.6, 469.4 and 455.8 for wet season respectively. These values relates to

moderately hard and hard water resources. According to DWAF (1996a), classification of water in terms of softness and hardness can be made in considering the following schemes: 0-50 soft; 50-100 moderately soft 100-150 moderately hard; 250-above hard. This classification shows that all the three water resources available for domestic purposes in the western Niger Delta region are hard water. Seasonal variation shows that hardness is lower during wet season, probably due to strong dilution.

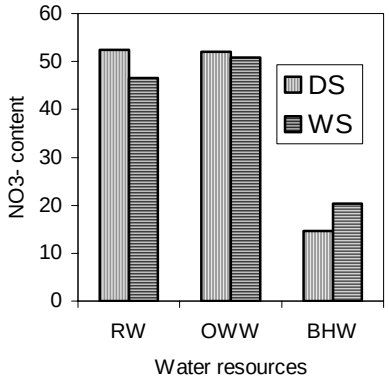

Fig 5. Seasonal variation of nitrate

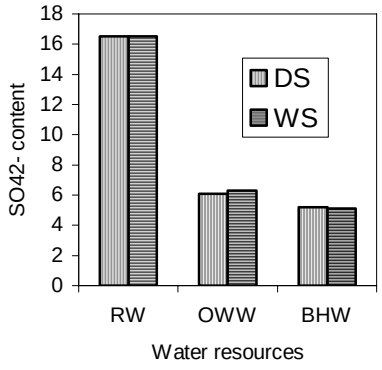

Fig 6. Seasonal variation of sulphate

Conclusion: Physico-chemical characteristics of selected priority parameters in rainwater open-well water and bore hole in Warri metropolis-western Niger Delta of Nigeria during dry and wet seasons has been determined in this study. Deleterious levels of almost all the physico-chemical parameters were observed, which stands as a potential health hazards to the inhabitants of the area, that uses these water resources directly for domestic purpose without treatment. The overall observation of the data indicated a fast deterioration of water quality in the available water resources, the pollution source being non-point sources. It is therefore needful that urgent steps be taken to ensure effective water resources management.

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