INDUSTRIALIZATION AND GROUNDWATER QUALITY IN ELEME, RIVERS STATE

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ABSTRACT

Groundwater samples were collected from different parts of Port-Harcourt metropolis and analyzed for relevant physical, chemical and bacteriological parameters using standard field and laboratory techniques. The high concentration of the trace elements (Pb, Mn, Cu, Fe, As and Zn), NO_3^- and low pH can be attributed the heavy industrial activity in the area. The bacteriological investigation also indicates the high concentration of total coliform, which can be attributed to groundwater contamination via animal faeces. Water in the area is predominantly soft to moderately hard and is dominated by Calcium-Chloride water type indicating a marine source.

Key words: Groundwater Quality, Industrialization, Eleme and Rivers State

INTRODUCTION

In the last few decades, there has been a tremendous increase in the demand of for water due to rapid growth of population and the accelerated pace of industrialization (Ramakrishnaiah, *et al.*, 2009). Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions (Okeke and Igboanua, 2003). In most towns in Nigeria with rivers passing through them, such rivers have been converted into dump sites or latrines, with the consequence adverse effects on the health of the downstream users. The recent documentary by World Health Organization (WHO) showing houses, public offices, schools not provided with latrines causing individuals to excrete anyhow in the bushes, rivers and open spaces is a pointer to the fact the Nigerian environment has been deterioted (Okeke and Igboanua, 2003); Egereonu, 2003). This is in addition to the poor sanitation culture exhibited by Nigerian populace.

Therefore, the determination of chemical parameters of the water samples can act as indicators of water pollution due to both natural and anthropogenic inputs. According to Nygard, *et al.*, (2004), the importance of the provision of potable water supply in any nation cannot be over emphasized. With increasing population, wealth and economic activities generally, there is a corresponding increase in the demand for water supply globally (United Nations Organization, 1978; Jayawarsena, 2004).

The waste resulting from human production at the Eleme Refinery and Petrochemical plant in Port-Harcourt, like other industrial waste, is potential source of major and trace element that constitute pollutants to soil, plants, surface and ground water. Over the last three decades, there has been much interest in the geochemical distribution and the concentration of major and trace element in the ecosystem. The present work was targeted at addressing these anomalies as it affects human existence.

MATERIALS AND METHODS

Study Area Location

The study area Eleme is the most important town in the Niger Delta and the center of the oil and gas industries. It is about 20 km east of Port Harcourt, and lies between, latitude $4^0$15'N and $4^0$48'N and longitudes $7^0$05'E and $7^0$15'E respectively. It covers an area of about 180km^2 which include prominent settlement such as Aleto, Ogale, Tai, Alesa, Alode, Akpajo, Ebubu, Eteo, Agbonchia and Port-Harcourt metropolis.

The area belongs to humid tropical climate, which is characterized by alternating wet and dry season. The wet season usually last from April to October and is dominated by heavy rainfall, while the dry season covers from November to March. The annual rainfall is about 1550mm (Knox, 1989), while the average annual temperature is 26.6^{0}C. The dry season is warmer and shorter, than the rainy season, it stretches from November to March, while rainy season starts from April to November. The period of December to March experience heavy wind-blown by the dust laden easterly Harmattan winds. The mean altitude at Eleme is about 3m above sea level (Esu, 1976).

The area under study is within Eleme, River state (Fig. 1). The Niger Delta basin has been studied and described in detail by various authors. The sedimentary basin of the Niger Delta encompasses a much larger region than the geographical extent of the modern Niger Delta. This is constructed by the Niger-Benue study. A lot of environmental pollution assessment work around the Niger Delta has been contracted out by oil producing company. Much of the result of this work still remains classified and unavailable to the public (*Ososami, 2000)* carried out determination of physical and chemical parameters of sample of surface and ground water in Port Harcourt and its environs to determine if they have been negative anthropogenic impact on them and to determine the possible health and economic impact.

Geology and Hydrogeology of the Area

The general geology of the Niger delta has been described by many workers, among which are Assez and Avborbo (1972). Statistically, the region ranks amongst the world's most petrolific petroleum producing delta. The Niger-Benue present day area which is about 1,200,000sqkm has produced a delta area of about 75,000sqkm with clastic fill sediments of about 12,000m (Encarta Encyclopedia, 2008)

The province is large, arcuate, wave and tidal-dominated, with deltaic sediments ranging in age from Eocene in the North to quaternary in the south. There are overall series of lap cycles that were intermediately interrupted by the period of see level changes. These periods resulted in minor marine transgressions and wide episodes of erosion. The geology of Niger Delta is divided into three lithologic formations; which includes Akata Formation, Agbada Formation and Benin Formation (Esu, 1976).

The formation of Niger Delta has been related to the separation of African and South America and the consequent opening of the South Atlantic. The African and American continents moved apart along the ridge transform system of the Gulf of Guinea and South Atlantic arms of the junction (Whiteman, 1982). The river flowing along the Benin-Anambra failed arm disgorged into the regional down wrap of oceanic crust in the area of the triple junction. The direction and position of the progradational fill was controlled by the pre-tertiary structural framework (Knox, and Omatsola, 1989).

There are two major aquifers in the study area; the upper one which is the coastal alluvium is more prolific. Most of the boreholes for rural water supply in the state penetrate this coastal alluvium. It is the main source of water and about 80m thick though this thickness varies from one locality to another (Fig. 1). It consists mainly of fine white sand grading into gravely materials in some areas. Coastal aquifer comes in contact with the ocean at near seaward of the coastline and under natural conditions; fresh groundwater is discharged in to the ocean with the increased demand for ground water in the coastal areas of the Niger Delta and the resultant fast rate of pumping, the seaward flow of the groundwater has been decreased in some areas and even reversed in others (Short and Stauble, 1967).

Field Work

The sampling was carried out in November, 2009. Water sample were collected in two sets of plastic bottles: one set was used for the determination of anions while the other set of samples was acidified for cation using trioxonitrate (v) acid. A drop of concentrated HNO_3 was added to each of the samples in the plastic bottle at the point of collection. Every sample bottle was labeled after collection using the name of the location, the source of the water, the time samples was taken, date on which the samples was taken and description of the source area were noted in a field note book. The samples were adequately labeled and preserved in the refrigerator until they were taken to the laboratory for chemical analysis.

Physical parameters like temperature, pH, and conductivity was determined in-situ in the field using a WTV Conductivity meter, model LF/95. During the sampling exercise, the co-ordinate of the sampled boreholes was taken with the aid of global positioning system. The data obtained were used to generate the digital terrain model (DTM) and the contour map of the area as contained in FIGS. 2 and 3 respectively.

Laboratory Analysis

The concentration of Fe^{2-}, NO^{3-}, PO_4^{2-}, Mg^{2-}, K^- were determined by atomic absorption spectrometry (AAS), while HCO_3^-, Ca^{2-} and Cl^- were determined using gravimetric method, Na^- was determined by flame photometer. The extracted solution from the plant where filtered and diluted accordingly with distilled water.

The water and soil samples and the solution from the plant sample were then analyzed for Pb, Zn and Cu using ICP-Emission method. Iron and arsenic were determined by atomic absorption spectrometer (AAS). Some of the analysis where carried out at the Faculty of Science, Department of Plant Science and Biotechnology, University of Port-Harcourt, River State and some were carried out in Eleme petrochemicals company limited Port-Harcourt.

Theory of Atomic Absorption Spectrometer

Atomic Absorption Spectroscopy (AAS) uses the *absorption* of light to measure the concentration of gas-phase atoms. Since samples are usually liquids or solids, the analyte atoms or ions must be vaporized in a flame or graphite furnace. The atoms absorb ultraviolet or visible light and make transitions to higher electronic *energy levels.* The analyte concentration is determined from the amount of absorption. Applying the *Beer-Lambert law* directly in Atomic-absorption spectroscopy is difficult due to variations in the atomization efficiency from the sample matrix, and non-uniformity of concentration and path length of analyte atoms (in graphite furnace). Atomic absorption spectroscopy is now a well-established technique for the determination of trace elements covering a wide range of analyte types.

RESULTS AND DISCUSSION

Results and Discussion

The statistical summary of the physio-chemical and bacteriological analyses are contained in Table 1.

Physical Parameters

The concentration of most of the physical parameters analyzed were within the permissible limit of WHO (2006) and NSDWQ (2007) for a safe drinking water except pH. Water for drinking purposes has a better fresh taste at lower temperature of about 15^{0}C, but higher temperature do not imply impurities (Olasehinde, 1999). The pH of the water varied from a minimum of 4.02 to a maximum of 6.92. The pH is slightly low when compared with the recommended range of 6.5 to 8.5 by World Health Organization (WHO, 2006) and Nigerian Standard for Drinking Water Quality (NSDWQ, 2007). The water is said to be slightly acidic and this could be attributed to the industrial activities in this area.

CHEMICAL PARAMETERS

Anions

The concentration of the major anions analyzed are very low and falls within the maximum permissible limits by WHO (2006) and NSDWQ (2007) except NO_3^-. Nitrate contamination of ground water depends upon climate, fertilizer or manure management, rock-type and animal wastes. A climate with rainfall exceeding evapo-transpiration often leads to the movement of rainwater to groundwater. In Eleme, water received though precipitation is more than that lost through evapo-transpiration from soils and plants. Nitrates are highly soluble salts and when water moves on the surface of a soil, it dissolves some nitrates that are present in the surface layers of soils and seeps into the soil and recharges the groundwater. Also animal wastes, which are rich in nitrates, can find their way into the groundwater via infiltration. High concentration of nitrate in water causes blue baby syndrome in infants.

Cations

All the cations have their concentrations within permissible limits of WHO (2006) and NSDWQ (2007) standards (Table 1).

Trace Elements

The concentrations of Pb, Mn, Cu, Fe, As and Zn were high in some (Table 1). High concentration of Mn and Cu in the body causes neurological and gastrointestinal disorders respectively while high concentration of As causes cancer in the body.

Bacteriological Analysis

The concentration of the total coliform and E.coli are generally high indicating that the water is very poor bacteriological. The mean concentration of both total coliform and E.coli exceed the recommended maximum permissible limit of 10.0 cfu/ml and 0.0 cfu/ml by WHO (2006) and NSDWQ (2007) respectively. Faecal indicator bacteria are universally present in high numbers in the faeces of humans and warm-blooded animals and causes urinary tract infection like meningitis, diarrhea, cholera, typhoid as well as morbidity and mortality among children (Amadi, 2009). It also causes acute renal failure, hemolytic anemia in adults and other water borne diseases (Okuofu, et al., 1990).

Piper Diagram

Plots of the major cations and anions in surface and groundwater on Piper (1944) trilinear diagram (Fig. 4), based on Furtak and Langguth (1967) classification, shows that 30% of the water is earth alkaline type with high alkaline proportion. About 44% of the water falls within the alkaline water field, while 4% belongs to the normal earth alkaline water. This characterization has revealed 3 important water facies. This water type constitutes about 20% in the study area. Here, the water has appreciable amount of $NaHCO_3$, which is an indication of cation exchange water (Lohnert, 1973). One of the characteristics of this water type is the higher carbonate hardness as compared to the total hardness. This in effect means that there is more HCO_3, than the available alkaline earth metal ions (Ca^{2+} and Mg^{2+}) in equivalent concentration (Lohnert, 1973). This excess bicarbonate ions then release the alkaline (notably Na) into the solution by exchange reaction with the cation exchangers such as clay minerals and other selected minerals that form part of the aquifer materials thus enriching the water with $NaHCO_3$.

CONCLUSION

Groundwater samples from Eleme area were analyzed for different physical, chemical and bacteriological parameters. Majority of the results falls within the permissible limits of WHO except pH with low values signifying slightly acidic condition which can be linked to gas flaring forming acid-rain and subsequent infiltration into the shallow aquifer in the area. The high Fe, Pb, Zn, Mn and Cu concentration in some locations within the vicinity of dumpsites can be attributed to the infiltration of effluent from nearby industries into the aquifer system while the high NO_3^- concentration may be attributed to fertilizer application during farming as well as human and animal waste. The upsurge in human population in the area coupled with poor sanitary system accounted for the high concentration of total coliform and E.coli in the groundwater, which signifies faecal contamination. The water in the area is Calcium-Chloride type, indicating possible marine origin.

Communities in Eleme and its environs that depend on surface water for domestic use should at every time need to boil and filter the water before consumption and if possible, chlorinate, or fluorinate it.

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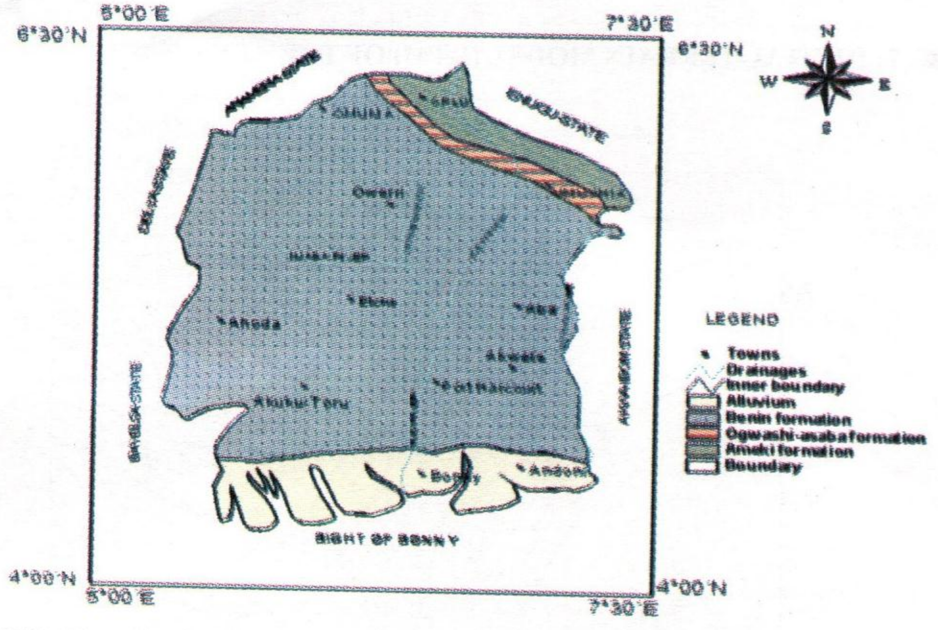

FIG. 1: GEOLOGY MAP OF THE STUDY AREA

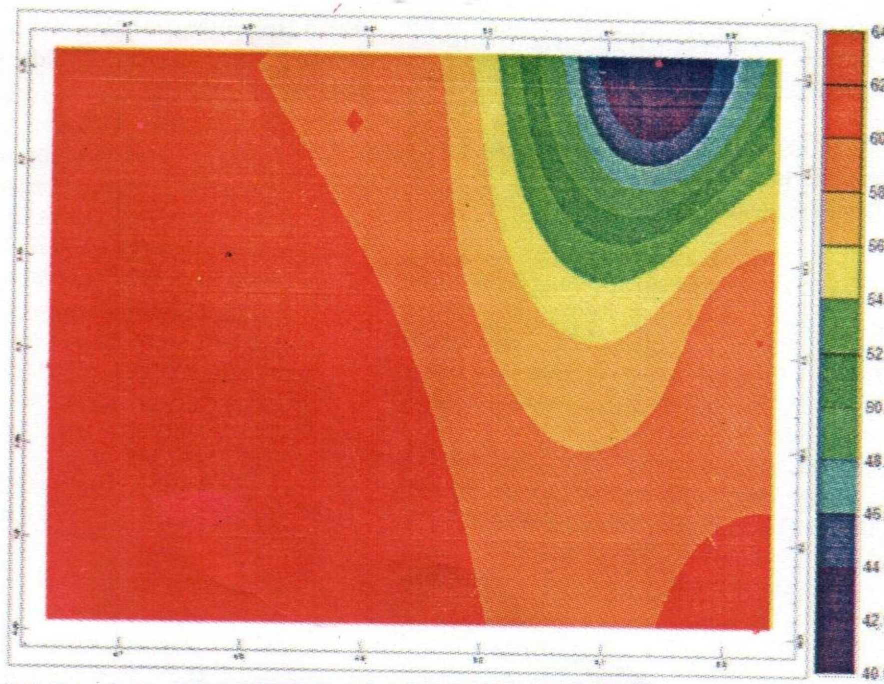

FIG. 2: DIGITAL TERRAIN MODEL (DTM) OF THE AREA

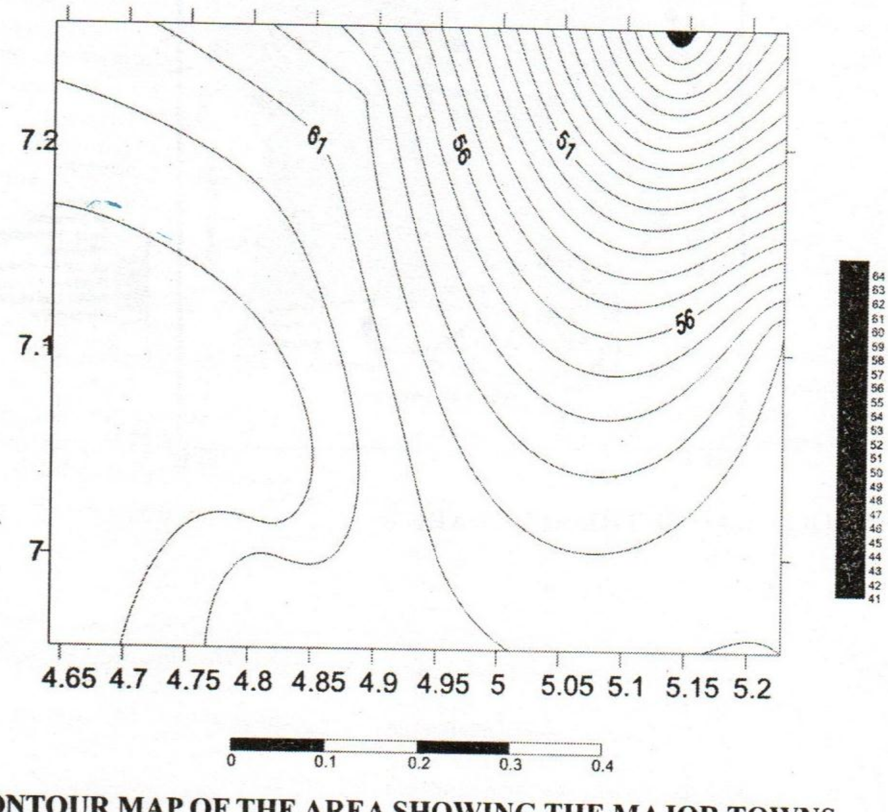

FIG. 3: CONTOUR MAP OF THE AREA SHOWING THE MAJOR TOWNS

TABLE 1: SUMMARY OF THE PHYSIO-CHEMICAL PARAMETERS ANALYZED

Parameters	Minimum	Maximum	Mean
pH	5.0 1	7.22	6.30
Temp. (°C)	27.0	31.0	29.5
Cond. (µs/cm)	106.0	142.0	128.0
Na^+ (mg/l)	8.40	48.71	21.43
K^+ (mg/l)	21.17	62.22	44.31
Cu^{2+} (mg/l)	1.60	6.75	3.52
Pb (mg/l)	0.0	0.02	0.01
Ca^{2+} (mg/l)	66.13	98.11	79.86
Mg^{2+} (mg/l)	2.25	30.72	15.80
Fe^{2+} (mg/l)	0.01	0.75	0.35
Mn (mg/l)	0.03	2.7	0.73
Zn (mg/l)	0.01	0.84	0.42
As (mg/l)	0.00	0.03	0.01
Cl^- (mg/l)	21.09	43.60	31.93
HCO_3^- (mg/l)	0.00	10.15	4.05
SO_4^{2-} (mg/l)	2.96	11.78	5.30
NO_3^- (mg/l)	20.00	85.60	48.20
COD (mg/l)	11.55	12.98	12.11
BOD (mg/l)	4.00	10.23	8.14
Total Coliform (cfu/100ml)	12.00	155.00	88.00
E. Coli. (cfu/ml)	0.00	10.00	4.00

BOD- Biochemical Oxygen Demand; COD- Carbon Oxygen Demand

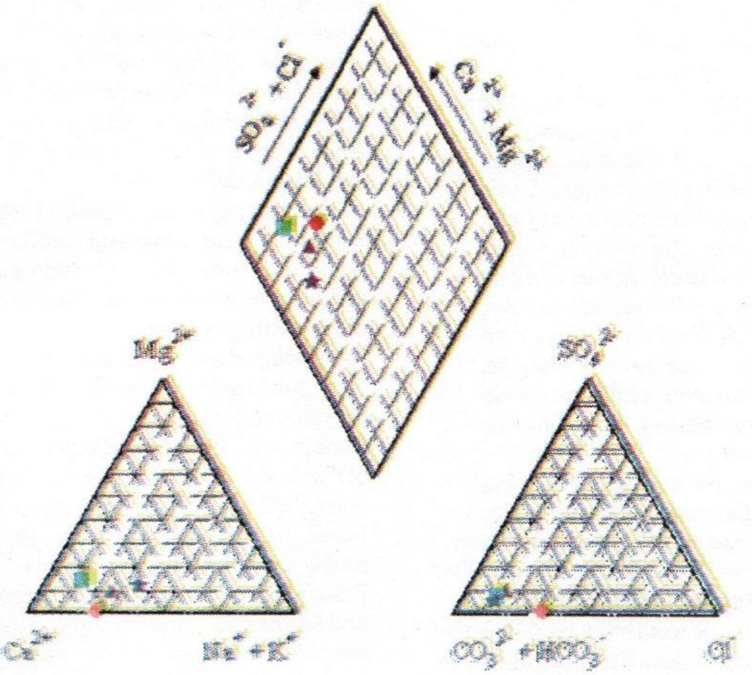

FIG.4: PIPER DIAGRAM OF GROUNDWATER SAMPLES IN THE AREA