Journal of Geography and Earth Sciences
June 2014, Vol. 2, No. 1, pp. 97-112
ISSN: 2334-2447 (Print), 2334-2455 (Online)

Published by American Research Institute for Policy Development

Hydrogeochemical Analysis and Potential Pollutant of Water Resources Around Ajaokuta Steel Complex, North Central, Nigeria

Mamodu Adegbe[1], Onoduku Usmanshehu[1], Ako Thomas Agbor[1], Abraham Stephen Unubi[1], Amadi Akobundu Nwanosike[1] and Omanayin Yunusa Adinoyi[1]

Abstract

The citing of Ajaokuta steel complex near its major raw materials (Iron) has brought about economic development in Kogi State, Nigeria.As a result of poor management of industrial waste, the only River where most people in the community get their drinking water became polluted. The aim of this research is to determine the quality of water and its pollutant within the study area. In order to meet the objective of the research, both physical and hydrogeochemical analysis were carried out. The physical parameters determined indicated (on average), a Ph of 7.44, temperature of 27°C, electrical conductivity of 106.8us/cm and turbidity of 157.4 NTU. 20 water samples were analyzed using Flame analysis photometry and Atomic absorption spectrophotometer.The result reveals on the average: 1.227mg/l Na^{+} , 2.3 mg/l K^{+}, and 2.545mg/l Ca^{2+}2.6mg/l NH_4^{+} , 0.17mg/l Cu^{2+}, 0.45mg/l Fe^{2+} , 0.4mg/l Cr^{3+} , 0.06mg/lMn^{2+}<10, ug/l As^{3} . There were gradual decreases in concentration in some elements as one move further away from the steel complex (inferred source of pollution). The reason for these decreases maybe due to distance from the source of pollution and seepageinto the groundwater. Iron and manganese were found to be very higher when compared to World health standards. Dangote group of Company's E.I.A report also shows higher concentration of Fe^{2+}, $Mn^{2+}$and Cu^{2+}in plant tissue. Therefore, the research concludes that Fe^{2+} and Mn^{2+} were the main pollutants while a Cu^{2+}andCr^{3+}arethe minor pollutantsof water resources in the study area. The research also, preliminaryconcludes that poor handling of industrial waste may have contributed majorly to the pollution of water.

Keywords: Ajaokuta, water, hydrogeochemical analysis, pollutant, Environmental Impact Assessment (E.I.A), industrial waste, Atomic absorption spectrophotometer

[1] Mamodu Adegbe, Department of Geology, Federal University of Technology, Minna, Nigeria, Email:adegbemamodu@futminna.edu.ng, Phone/no: +2347030496207

1. Introduction

Industry located in any community (either formal or informal) may have some negative impact on that environment.It may alsopose serious health risk where toxic gases are directly inhaled (Ako et al, 2014. Contaminated food and animal (or its products) resulting from such polluted environment, pose serious health challenges to humans who consumed them. (Ako, 2014).Golekar et al, 2013 reported that the industrial establishments in Kolhapur and the industrial township of Jawaharnagar and Kondawal as well as sugar factories/leather industries (all in India) are responsible for disposing treated and untreated effluents in the natural drainage system. This has led to widespread groundwater contamination in these respective parts of India. The negative impact suffered by any community by the location of industry maydependon thetype or category of such industry or its production scale and the types of raw material it utilizes. Governments' world over, cautions of such inferred or perceived negative impact of industry in any location made it a policy, mandating environmental impact assessment to be carried out through its relevant agencies or department, prior to commencement of such industry or project. The ultimate goal of the Environmental impact assessments is, toprevent or reduce the negative impact on the environment.Most times, water pollution is given greater priority and attention.This is becausewater plays a fundamental role in human life and development. The Safe portable water is absolutely essential for healthy living(Golekar et al, 2013). About 80% diseases of the world population and more than one-third of the deaths in the developing countries are due to contamination of water (WHO 1993). Talabi, 2014, reported that with increasing human population, industrialization, urbanization and the consequent increase in demand for water for domestic and industrial uses, the increase in the implication of polluted water on man and the environment have been on the increase.

According to HAMMER, (1977), polluted water is that which found to beunacceptable inits usage. However, the degree of this unacceptability depends largely on its physical, chemical and biological characteristics.

According to SAXENA, 1977, there exist a relationship between water systems (surface or groundwater) pollution of an area and refuse dumps. HOLLER, 1986, also mentioned that a street refuse deposition is a source of storm water run-off pollution which invariably ends in the ground.

In another similar research, RAESNER and WALSCH, (1988) claim that urban run-off contributes tons of nutrients and pollutants to receiving water systems.

SLIVIDHER, (1986) observed that, heavy metal concentration in solid waste leach out chemical compound from dumped waste which eventually percolates into groundwater.

In Nigeria for instance, it has been reported that mining at commercial or artisanal scale,have resulted in the pollution, environmental degradation and health risk for communities where such activities took place (Ako, et al, 2014).Medecins Sans Frontieres (MSF)reportedin March 2010 that, an epidemic of lead poisoning in Zamfara state in North–Western Nigeria.The lead poisoning occursin Anka and Bukkuyum Local Government Areas of the state. Subsequent investigations by the Centers for Disease Control (CDC), the World Health Organization (WHO) and the Zamfara State Ministry of Health (ZMoH) confirmed that hundreds of children under ages of five were at risk of death or serious acute and chronic health effects due to extremely high levels of lead and mercury (WHO, 2011). At least 10,000 people were estimated to be affected overall (MSF, 2010). The source of the outbreak was associated with artisanal gold ore processing that occurs in the villages (Azubike, 2011). The medium through which the people were affected include drinking water, food, and inhalation of contaminated dust, oral ingestion of particles especially by children and through breast feeding. Reports from the local and international media have shown thatthe Niger delta region as result of the massive oil and gas production has led to severe pollution of environment thus destabilizing the ecosystem.

The drive to industrialized local communities as part of Federal Government of Nigeria policy initiative led to the establishment of the Ajaokuta Steel complex in 1975. This initiative amongst other thing will provide employment for hundreds ofpeople within and outside the community even to foreign expatriate.This will intun boost local and national economy, reduce poverty and hunger as the worker will be able to meet essential financial obligation of their respective family’s needs.

However, as the activities of the Ajaokuta steelindustry progresses over the years, through increased use of the Iron raw materialfrom Itakpe, generation of dust particle, heat from the furnace, release of gases into the surroundings, leakages and the discharge of untreated waste into the only river in the community,the destruction ofecosystem continues.

This hasresulted in the deterioration of the water quality and pollution in the study area. In the Southwestern Nigeria, appreciable hydrogeological works has been done by JONES, and HOCKEY, 1964, AZEEZ, 1971, AJAYI, and ABEGUNRIN, 1990, and OFFODILE, 1992.

But these researchers did little on the hydrogeochemistry of water resources probably with no extension to North Central Nigeria and Ajaokuta in particular. This research intends to fill that gap.

Water as a resource, is widely used and is very important to health and global economy. However, the determinations of its geochemical characteristics are in very key to understanding its quality. Such aforementioned researches for the study area are poorly known. Also, they have not been existing research or report about the water quality in the study area. Hence, this research will contribute to literature, raise awareness and provide platform for the local government water management agency to monitor and manage the water resources in most efficient ways. They have been a decline in operation and production at the Ajaokuta steel complex for over a decade now. However, the environmental challenges resulting from the period of active operations of the industry may have some long time effect. With increasing and fast growing population around the area, there lies a great challenge of good quality water in the area. The quality of water is of vital importance for its usability. For examples, industrial, irrigation and domestic purposes just to mention a few.

As result of the challenges mentioned above, the main focus of this study is to carry out:1. geochemical analysis of water from the river and wells (groundwater). 2.Determine the physically properties of the water and point out the major and minor pollutant in the study area 3.Determine its suitability for human consumption and 4.Propose to the local water management agency, ways of improving sustainable water quality devoid of pollution.

2. Geology and Geography of the Study Area

2.1 Geology of the Study Area

The study area is situated within the North central block (fig.1) of the Nigerian basement complex as reported by AJIBADE, (1987).

The following rock units or assemblages are characteristics of the study areaviz: Migmatite, Gneiss- Gneiss , Charnokitic rocks, Ajaokuta –hypesthene Quartzo-diorite, older granite, Granite Gneiss, the Ero-Granite Gneiss body, the Gbalasha hill Granite Gneiss body and the Migmatite Gneiss (this group is the most widely spread in the basement complex).

It is compose of gneiss rock, quartzite and hematite bearing rocks as well as metasomatic rocks.Ajaokuta –hypersthene Quart-diorite occur as shallow valley lying within the Ajaokuta older granite.

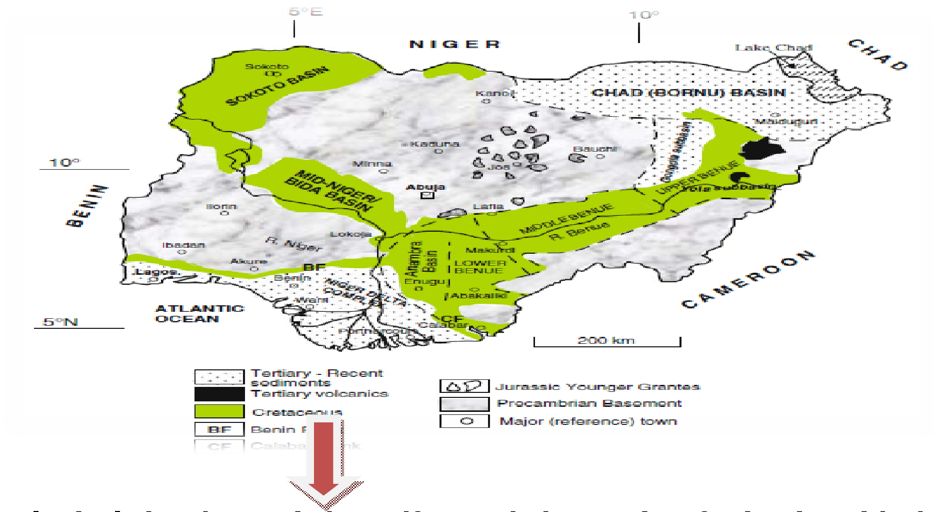

Fig. 2: Geological sketchmap (adoptedfrom Obaje, 2009). Of Nigeria, with the brownarrow pointing the major geological components of Ajaokuta; the following rock units or assemblages are characteristics of the study area viz: Migmatite, Gneiss- Gneiss, Charnokitic rocks, Ajaokuta –hypesthene Quartzo-diorite, older granite, Granite Gneiss, the Ero-Granite Gneiss body, the Gbalasha hill Granite Gneiss body and the Migmatite Gneiss. It is compose of gneiss rock, quartzite and heamatite bearing rocks as well as metasomatic rocks

2.2 Location Extent and Accessibility

The study area covers Ajaokuta steel territory of Kogi State, North Central Nigeria.

The area mapped lieswithin latitude 7° 23´ E and 7° 34´ E and Longitude 6° 33´´ N and 6° 43´ N covering a total area of 9000 km. The area is accessible by series of major roads which are dialyzed in some area with the Ajaokuta –ItobeBridge and within the township. They are also, fairlynetwork of minor roads that link the scattered villages to the major roads and towns.

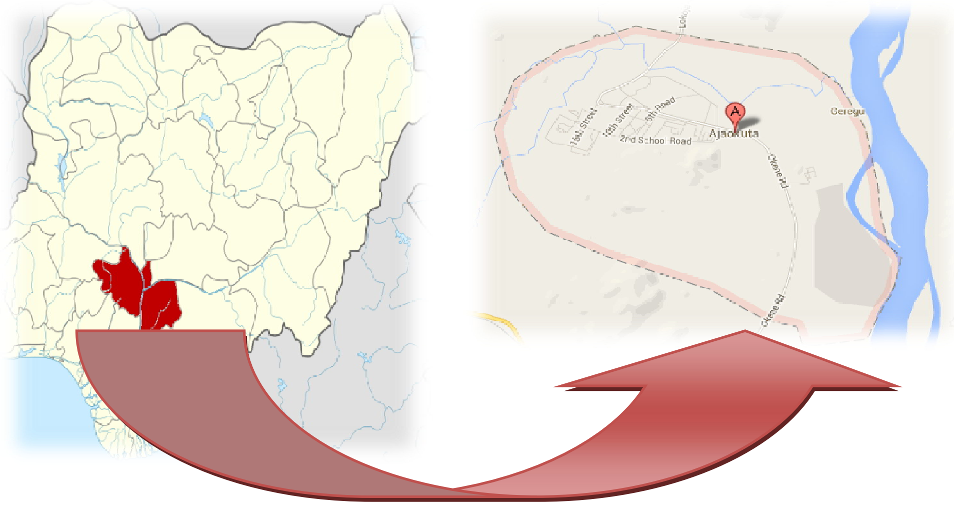

Figure: 3. Map of Nigeria showing Kogi state (coloured) which in turn project the study area (Ajaokuta). The steel complex is located very close to the River (in blue).

2.3 Drainage and Relief

The area is characterized by lots of fascination relief features surrounding Ajaokuta and its neighboring villages like Geregu, Gboloko where large outcrop are exposed. The main River in Ajaokuta is the River Niger/Benue which separates the town from Itobe via a brigde.

2.4 Climate and Vegetation

The area is characterized by two distinct seasons which are defined a period of rainfall and a period of dryness. The rainy seasons starts in April and ends in October while the harmattan (dry) season begins in October and ends in March. Temperature prevailing in the area is generally high with values ranging from 24°C to 35°C with an annual mean of 30°C.

The average rainfall is about 250mm. the study area lies within the middle belt of Nigeria, which is characterized by Guinea savannah type of vegetation with thick forest. The vegetation comprises of thick forest, clusters of trees, shrubs, herbs and grasses.

2.5 Settlement and Landuse

The area mapped can be classified as rural area, though, they are lots of estates and other company quarters in Ajaokuta main town. They are lots of private houses too. Ajaokuta local Government is populated with lots of commercial and industrial activities.The available is being used by both peasant and commercial farmers. The various crop cultivated includes maizes, guinea corn, millet, pepper and vegetables.

3 . Methodology

The method of investigation of this study consisted of fieldwork and laboratory analysis.

3.1 Fieldwork

An intensive fieldwork was carried out in the study area for two weeks. During this period, field mapping was carried out to delineate the various rock units underlying the area. Also, during the fieldwork, the community waste disposal systems were observed to see if they are close to the river. Twenty (20) samples of water were carefully collected during the fieldwork. 10 of the water samples were collected from the riverclose to the Ajaoukuta steel complex and every other at interval of 250m apart along the river bank where the current is not high to avoid being drowned.

Accessibility to the river bank was also taken into account and in some case; assistance was sought from the local fishermen around the Ajaokuta-Itobe axis. The remaining 10 water samples were taking from hang dug well (groundwater) across the study area mostly in area where they are found. Some of the wells are shallow, about 2 meters while other may be as deep as 5 meters. The surface water samples were collected into a clean rubber container while the well water was collected into clean glass container and a plastic container.

In each of the plastic containers, two drop s of concentrated HNO_3 were added in order to prevent the metallic ions from adhering to the walls of the containers, as wells as to homogenize the water samples and prevent the growth of algae or microbial organism. The water samples were preserved in a refrigerator at a minimal temperature in order to prevent the loss of ions.

During the fieldwork, physical parameters of the water samples were determined. They are the temperature (measured using mercury thermometer), Ph (measured using Jennway ph meter model 3051), and electricalconductivity (measured using a conductivity meter).

3.2 The Laboratory Analyses

The laboratory analyses were carried out within 48 hours at the water quality control and monitor department of the upper Niger River Basin Authority, Minna, Niger State, Nigeria.

Flame analysis photometry and Atomic absorption spectrophotometer analyses were carried out to determine the concentration of the interested elements presents in the composition of the water samples. The elements determined are Fe^{2+}, Pb^{2+}, Mn^{2+}, As^{3+}, Mg^{2+}, Ca^{2+}, K^{+}, Na^{+}, Cr^{3+},NH_4^{+}.

3.2.1 Determination of Na+ and K+ using Flame Analyzer

The gallenkamp flame analyzer (model FCA-330) was used for the determination of Na+ and K+ .

In principle, when solution containing alkali earth metals are heated to a high temperature, they emit light each having a distinct spectrum. The analyzer was switch on for inflow of current for about 25 minutes. Then distilled water was injected into the instrument to set it at zero.

Standard stock solution of the salts were prepared and serially diluted at different range of concentration. Their intensities were then measured for each of the water samples.

3.2.2 Determination of Ca^{2+}, Mg^{2+}, Fe^{2+}, Mn^{2+} and Cr^{3+} using Atomic Absorption Spectrometer

The atomic absorption spectrometer (AAS pu 900 model) was used for the determination of the above listed metallic ions in the water samples.

In principle, light beam directed through flames into a monochromatic and then onto a detector that measure the intensity of light absorbed. AAS depends on the presence of free unexpected atoms. As each metallic element has its own specific characteristic absorption wavelength. The amount of light intensity absorbed in the flame is proportional to the concentration of the element in the water sample. Therefore, the water samples were analyzed with atomic absorption spectrophotometer by using single hallow cathode lamp at the wavelengths of 248.3, 279.5, 213.9 and 324.7 nm, respectively following the procedure as described by APHA (1995).

4 Result and Discussion

4.1 Fieldworks

It was observed from fieldwork that a lot of outcrop occur and are exposed along the road network were detailed mapping were carried out. The rock units mapped include banded gneiss, (figure 4) migmatite, and pegmatite. Most of the metamorphic rocks were foliated and have undergone mild to severe weathering. Structural feature mapped on the outcrop includes faults, fractures and joints. The aquifers found in Ajaokuta and environ are of the crystalline types.

These aquifers are formed as result of fracture and high degree of weathering of the basement complex rock. They are generally unconfined aquifers.

Figure 4: photograph of one of the mapped banded-Gneiss (metamorphic rock). The rock was formed from metamorphosed igneous rock, mainly of granitic composition. The mineral assemblages areplagioclase feldspar, quartzo-feldspathic veins bodieswhich are light colured to pink. They alternate with some dark colured minerals like the biotite mica, which are ferromagnesian minerals. The new mineral alignments are evidence of metamorphism probably as a result of high temperature or pressure or a combination of the two. (Source: fieldwork).

The result of the physical properties of the study area areshown below (table 1 and 2)

Table: 1: Physical Properties of the Surface Water

Sample/no	Sample source	Temperature/°C	Ph	Turbidity/NTU	Conductivity/us/cm
1	River	23	7.52	241	68
2	River	23	7.52	242	68
3	River	24	7.56	245	69
4	River	22	7.50	249	70
5	River	24	7.51	243	69
6	River	23	7.55	242	65
7	River	23	7.54	241	67
8	River	24	7.50	246	69
9	River	22	7.51	248	70
10	River	23	7.53	247	65

Table: 1: Physical Properties of the Well Water (Groundwater)

Sample/no	Sample source	Temperature/°C	Ph	Turbidity/NTU	Conductivity/uc/cm
11	well	26	7.2	80	100
12	well	27	7.2	82	100
13	well	26	7.3	85	90
14	well	28	7.2	86	96
15	well	27	7.1	87	94
16	well	26	7.3	82	96
17	well	29	7.2	85	97
18	well	27	7.2	86	98
19	well	27	7.3	84	100
20	well	26	7.2	82	101

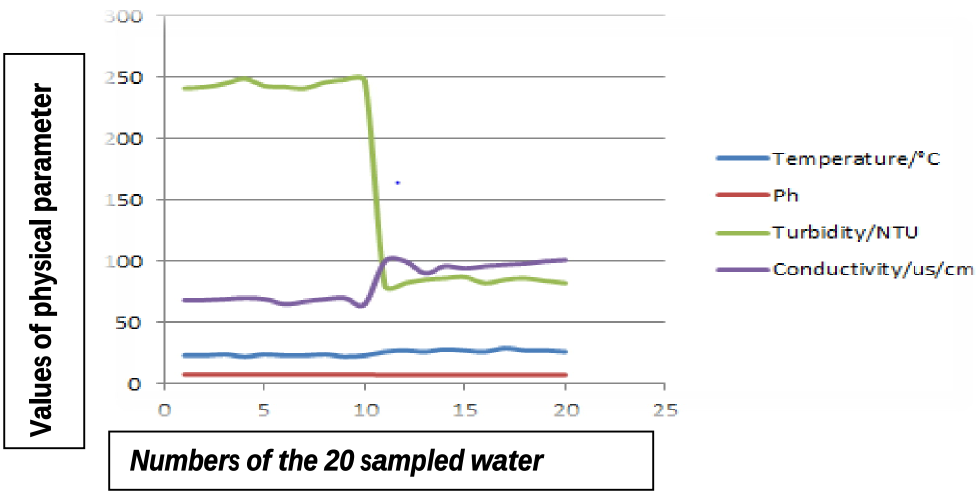

Figure 5: plots of all the physical properties measured. The horizontal represents the 20 samples of water across the study area while the vertical depicts the value for all the measured physical properties

Figure 5 shows clearly how the surface water differs from the groundwater in terms of physical properties. In terms of temperature, the figure shows a slightly increased in temperature from the surface water to the groundwater. This increase is expected because the surface water is opened to wind and other atmospheric indices that tend to the lower the temperature.

The figure 5 also clearly shows a very sharp difference in turbidity for the surface water than the groundwater. The reasons for this are that, surface water is prone to all sources of materials/sediments entrained as the river flows. Besides, erosion from the inland/urban area carried through tributaries finds their ways into the river. This is not normally the case for groundwater, which in most cases carry dissolve chemical substances as it flow with respect to difference in gradients.

PH of water sample measures its hydrogen ion concentration and indicates whether the sample is acidic, neutral or basic. The pH value of absolute pure water is 7. If the pH value is less than 7, the water is said to be acidic in nature and if it is more than 7 the water is called as alkaline.

The pH value in analyzed water samplesvariesfrom 7.1 to 7.52 with an average value 7.3. This shows that the groundwater of the study area is mostly alkaline in nature.

The electrical conductivity is directly related to the concentration of ionized substance in water and may also be related to problems of excessive hardness and other mineral contamination (Johnson C. C., 1979). The value of EC in analyzed water samples varies from 65 to 101 s/cm with an average value of 83s/cm. These values are typical of fresh water bodies.

4.2 laboratory Results

Table 3: Chemical Properties of Surface Water (All Units Are in Mg/L Except As^{3+} In μg/L)

Sample/no	NA^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Mn^{2+}	NH^{4+}	Fe^{2+}	Al^{3+}	Cu^{2+}	Cr^{3+}	As^{3+}
1	1.50	3.63	3.08	1.42	0.04	0.078	0.41	0.021	0.00	0.49	<10
2	1.51	3.60	3.08	1.40	0.05	0.08	0.41	0.021	0.00	0.47	<10
3	1.61	3.80	3.0	1.40	0.06	0.09	0.32	0.025	0.00	0.40	<10
4	1.60	3.82	3.8	1.32	0.03	0.08	0.31	0.00	0.00	0.45	<10
5	1.0	3.49	3.25	1.30	0.07	0.08	0.30	0.00	0.01	0.47	<10
6	1.2	3.65	3.6	1.30	0.04	0.07	0.25	0.00	0.02	0.44	<10
7	1.3	2.9	3.4	1.20	0.06	0.39	0.26	0.00	0.01	0.42	<10
8	1.9	2.8	3.25	1.20	0.05	0.41	0.22	0.01	0.00	0.41	<10
9	1.40	2.8	3.2	1.10	0.031	0.39	0.20	0.21	0.01	0.35	<10
10	1.61	3.0	3.41	0.80	0.055	0.40	0.20	0.02	0.02	0.35	<10

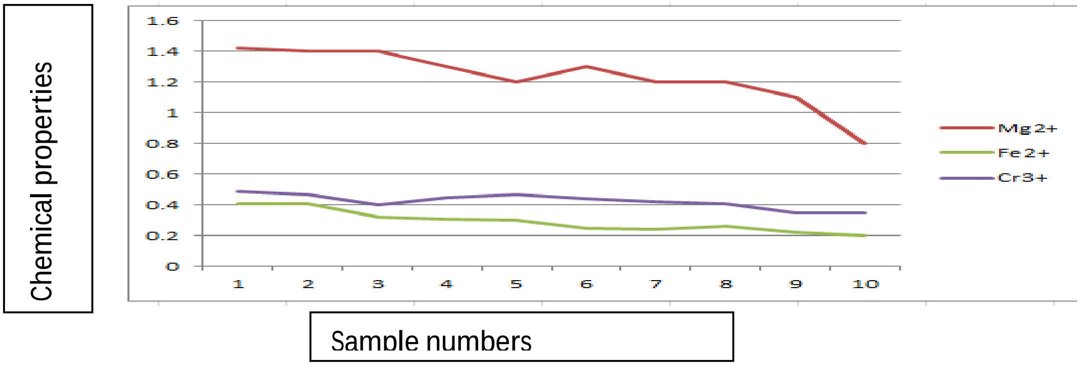

Figure 6: Plots of the Chemical Properties of Surface Water Against the Sample Locations

Looking critically on the result on table 3, it was found that Mg^{2+}, Fe^{2+} and Cr^{3+}show some trends. For this reason, the 3 cations where plotted against each of the sample location on figure 6. The results reveal a gradual decrease in concentration in each of the 3 cations as one move further away from the steel complex (inferred source of pollution). Mg^{2+} decrease from 1.42 mg/l in location 1 to 0.80mg/l location 10, Fe^{2+} decrease, from 0.41 mg/l in location 1 to 0.2mg/l in location. While Cr^{3+} decrease from 0.49mg/l in location 1 to 0.35mg/l in location 10. The reason for these decreases as one move from location 1 to 10 may be due to distance from the source of pollution. As the river flows downstream from the pollution source, more volume of water further dilutes these cations. Thus, reducing their concentrations. Also as the distance from the pollution source increase, some of the elements seepinto the groundwater thus reducing their concentration downstream.

Table 4: Chemical Properties of Groundwater (All Units Are in Mg/L Except As^{3+} In μg/L)

Sample/no	Na^{+}	K^{+}	Ca^{2+}	$=Mg^{2+}$	Mn^{2+}	NH^{4+}	Fe^{2+}	Al^{3+}	Cu^{2+}	Cr^{3+}	As^{3+}
11	0.8	2.4	2.5	1.6	0.05	0.39	0.50	0.00	0.03	0.38	<10
12	0.8	2.0	2.8	1.7	0.06	0.07	0.57	0.00	0.03	0.45	<10
13	0.9	2.0	2.3	1.5	0.07	0.08	0.55	0.03	0.03	0.42	<10
14	1.7	2.1	2.0	1.8	0.04	0.02	0.60	0.02	0.03	0.35	<10
15	0.9	0.7	2.56	1.5	0.03	0.07	0.70	0.03	0.02	0.48	<10
16	1.5	0.8	1.9	1.6	0.04	0.21	0.60	0.02	0.21	0.46	<10
17	0.9	0.9	1.2	1.7	0.06	0.35	0.50	0.02	0.01	0.45	<10
18	0.0	1.0	2.2	1.6	0.30	0.36	0.65	0.00	0.12	0.47	<10
19	0.6	1.2	1.95	1.6	0.03	0.20	0.60	0.00	0.03	0.35	<10
20	0.6	2.0	2.3	1.7	0.05	0.33	0.70	0.00	0.04	0.4	<10

Sodium concentration in analyzed water samples value varis from 1.7 to 0.6 mg/l. It higher in the surface water compare to the groundwater. The reason may be due to anthropogenic effect.

Potassium concentration in analyzed water samplesvaries from 3.82 mg/l to 0.7mg/land as per European Economic Community (EEC, 1980) criteria all samples of the study area fall within the guideline level of 10 ppm

Looking critically at table 4, there is no contrast in terms of the concentration of Fe^{2+} and Mg^{2+}.The Cr^{3+} is fairly the same with that of the surface water.

In the groundwater chemical analysis, there is no specific trend in concentration from one well to another. However, it Fe^{2+} and Mg^{2+} concentrations are higher in groundwater when compared to the surface water. The reason for this may be in due to addition from polluted surface water seepage into the groundwater and natural Fe^{2+} and Mg^{2+} from weathered ferruginous basement rock.

The geochemical analysis of this research, agrees with the Environmental impact Assessment result conducted byDangote group in parts of the study area. In that report, analysis of plant tissues shows a higher concentration of Fe^{2+}, $Mn^{2+}$and Cu^{2+}. This was a clearindication and validation that the surface, groundwaterand even the plants have been affected by the pollution.

5 Conclusions

The study demonstrated that geochemical studiesare important in determining contaminants/pollutant in water.The research found that physical properties of water system are not enough to determine the level of its quality and contamination but should be subjected to through geochemical analysis. However, anions and coliform bacteria analysis were also recommended to be carried out for comprehensive analysis.

The research concludes that $Fe^{2+}$and Mn^{2+} are the main pollutants while the minor pollutants are $Cu^{2+}$and Cr^{3+} of water resources in Ajaokuta steel complex, North Central Nigeria.

The water quality determined wasnot suitable for human consumption.Reason being, they exceeded the normal limit (0.3mg/l for Fe^{2+} and 0.05mg/l for Mn^{2+})in the WorldHealth Organization permissiblestandard. The high concentration of these metallic ions in the plant tissue as observed from the Environmental impact Assessment report conducted by Dangote group of company was also, reflection on the nature of the pollution in the study area.

The research concludes that poor management of industrial waste resulted in the pollution of the River where most people in the community get their drinkingwater. It therefore recommended that appropriate sanctions be meted to erring company who failed to comply with existing environmental policies and regulations regarding industrial waste disposals.

It strongly recommended with immediate effect that local government and state government should partner in the establishment of water board in the area in order to ensure purification and sustainability of good drinking water in the area. They should be awareness programme on the danger of drinking polluted water and also free routine medical check –up for the community. This will help the government to monitor medical cases related to water pollution.

References

APHA (American Public Health Association) (1995), “Standard Methods for the Examinationof Water and Wastewater”, 19th edn. Washington DC, USA.

AJIBADE, A.C, 1987.The Geology of part of Niger state of Nigeria. Bulletin of Geol. Surv. Nigeria.

AJAYI, O and ABEGUNRIN, 1990. Causes of boreholes failure in crystalline rocks of Southwestern Nigeria. 1st Bien. Nat hydrol .Symposium.

Ako T. A, Onoduku U. S., Oke S. A., Adamu I. A., Ali S. E., Mamodu A., Ibrahim A. T, 2014.Environmental Impact of Artisanal Gold Mining in Luku, Minna, Niger State, North Central Nigeria. Journal of Geosciences and Geomatics, 2014, Vol. 2, No. 1, 28-37.

AKO, B.D, ADENIYI, F.T, J.F ADEPOJU, 1990. Statistical tests and chemical quality of shallow groundwater metamorphic terrain, Ile-ife/Modakeke, SW, Nigeria, Journal of African Earth Sciences, vol. 10, No.3, P602-613.

AZEEZ, I.O .1971. Hydrogeology of Southwestern Nigerian Engineer V and vol 1, pp 20-29.

Azubike, A. L. The Technology of peaty soils in Mozambique and Angola. Transactions of the 5thInternational Congress of Soil Science, Leopoldville 3: 398-401, 2011

DANGOTE GROUP, 2004, a report of the Environmental Impact Assessment (E.I.A) of the Ajaokuta-Obajana Gas pipeline project.

EEC (European Economic Communities) (1980), Richtlinic des Rates Vem., 15.7 1980 liber diequalitat Von Wasser fur den menschlichenGebrauch. Amtslelatt der Europaischengemeinschaftvom 30-8-1980, no L 229, pp. 11-29.

Johnson, C. C. (1979), Land application of water-an accident waiting to happen Ground Water, 17(1), pp 69-72.

Golekar R B , SalokheAbhay , KambleNirmal , Baride M V, Patil S NPathare S V,2013,Hydrogeochemistry of subsurface and surface water from bank of Jayanti stream, Kolhapur area, Maharashtra (India).International Journal of Geomatics and GeosciencesVolume 4, No 1, 2013

HAMMER, 1977. Principles of water control 2nd Edition University of Birmingham, pp, 6-27.

HOLLER, 1986. Protection of the quality and supply of fresh waters resources: application of integrated approaches to the development, management and use of water resources of Agenda 2001. United Nations publication, New York.

JONES, H.A and HOCKEY, R.D, 1964.The Geology of part of Southwest Nigeria. Geol. Surv. Bull.3.1. pp100-101.

MédecinsSansFrontières (MSF). Nigeria Country Security and Safety Plan - Draft 1, May, 2010.

Obaje, N.G., Nzegbuna, A.I., Moumouni A., Ukaonu, C.E. Geology and Mineral Resources of Nasarawa State, Nigeria.A preliminary Investigation. Paper presented at the 4th Nasarawa State Agricultural and Solid Minerals Exposition held at Agyaragu, Nasarawa State, Nigeria, 21-23 March, pp. 1-27, 2005

OFFODILE, M.E, 1992. An approach to groundwater and development in Nigeria. Mecon Services. Ltd. Pp.247.

RAESNER AND WALESH, 1988.Water quality management under condition of scarcity.Pp 21-23Groundwater hydrogeology.Second Edition, John and wiley& sons Inc.

Talabi, A. O, Afolagboye, O. L., Tijani, M. N., Aladejana, J. A. and Ogundana, A. K, 2014, Hydrogeochemistry of Some Selected Springs' Waters in Ekiti Basement Complex Area, Southwestern Nigeria.The International Journal Of Engineering And Science (IJES), Volume3, Issue 2, Pages, 19-30.

WHO (1993), World health organization, Guidelines for drinking water, 1, pp 52-82.

SAXENA, 1977. Groundwater hydrogeology. Second Edition, John and wiley & sons Inc. pp 316-317, 322-325.

SLIVIDHER, 1986. Examination of water for pollution control. Vol 12, pergamon press, New York, pp 107, 116, 121.