WATER QUALITY ASSESSMENT OF ASHAKA COMMUNITY USING

PRINCIPAL COMPONENT ANALYSIS (PCA).

By

EzenyiliIshicheli ANYAFULU

PG/PSC0502903

Environmental Geoscience Option

DEPARTMENT OF GEOLOGY

FACULTY OF PHYSICAL SCIENCES

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BEING A PROJECT WORK WRITTEN IN THE DEPARTMENT OF GEOLOGY AND SUBMITTED TO THE SCHOOL OF POST GRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE (Msc) DEGREE IN ENVIRONMENTAL GEOSCIENCES.

DEPARTMENT OF GEOLOGY

FACULTY OF PHYSICAL SCIENCES

UNIVERSITY OF BENIN

BENIN – CITY, 2021.

JUNE,2021

CERTIFICATION

This is to certify that this project was carried out by Ezenyili Ishicheli Anyafulu, of the Department of Geology, University of Benin, Nigeria.

__________________________ ______________________

Professor O.I Imasuen Date
(Project Supervisor)

__________________________ ______________________

Professor O.I Imasuen Date
(Head of Department)

DEDICATION

This research work is dedicated to God Almighty for His grace, goodness and faithfulness upon my life and for seeing me through my studies. May His name be praised forever and ever Amen.

ACKNOWLEDGEMENT

First and Foremost, I return all the glory, honour and adoration to the Monarch of the Universe who in His enduring Mercy and Unfailing love made it possible for me to successfully complete this project.

My gratitude goes to my most and caring Supervisor and H.O.D Professor O.I. Imaseun whose assistance are too numerous to enumerate, may God bless you immensely sir. I also wish to appreciate Professor C.N Akujieze, Dr S.A Salami and other lecturers for the roles they played to ensure a successful completion of this Project.

My gratitude goes to Chief (Mrs) F.A Anyafulu my able mum for her love, support, care, assistance and encouragement during the program. Also special thanks to my siblings Bar chuks, MrsOmenogor, MrsEkufia, EngrChukwuka, MrsOlise, EngrNnamdi and MrsEkeh for their unrelenting support

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Finally, I want to say a big thank you to these wonderful personalities, Dr Marvelous O, Chidinma N, Esther A, Pst Lawrence S, Pst Dan Bubah and the entire members of RCCG Covenant Parish Ashaka and Believers Youth Movement, Ashaka for their support and also to all those who have helped me in one way or the other whose names are too numerous to mention. May God Almighty bless you all in Jesus name Amen.

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ABSTRACT

Water quality assessment of Ashaka Community has been carried out using Principal Component Analysis (PCA) to determine the prevalent parameters during wet and dry seasons respectively. The total of ten (10) samples; nine (9) groundwater and one (1) surface water sample(s) were collected at random to cover the area of study during both seasons. The results showed that pH, EC, Cl, TSS and alkalinity were the most prevalent parameters in both seasons. Furthermore, other parameters measured besides pH, E-Coli and Coliform counts were below the values set by the Standard Organization of Nigeria (SON) and World Health Organization (WHO). The high values of E-Coli and Coliform counts revealed the presence of biological contaminants in the water. The moderately acidic values obtained in the water samples and the high concentration of E-Coli and Coliform counts rendered the water unfit for drinking except routine treatment is administered(a neutralizing filter is used if drinking water is acidic to raise the pH to neutral synthetic magnesium oxide treats water with pH less than 6). However, the quality of water in the area can be used for crops production.

CHAPTER ONE

INTRODUCTION

1.1 BACKGOUND

Water is a basic necessity required by man and plants for adequate functioning. It's generally refer to as a universal solvent because it can dissolve most solute (Akujieze, 2004; Omorogieva and Tonjoh, 2020). Characteristically; it is a colourless, odourless and tasteless liquid in its pure form and can be introduced into the environment naturally through rain, snow, ice, flowing rivers, lakes, springs, and sea on the earth surface. There are two main form of water in the universe; surface water (found on the Earth surface e.g.; lakes, sea, stream, ocean) and groundwater (water found beneath the earth's surface, trapped in soil pore spaces and rock fractures). Over the years, the quest for groundwater has drastically increased to about 60% in Nigeria for instance as a result of government inability to meet up with water demands for the teeming population (Omorogieva and Imaseun, 2018); also non – availability of surface water in most community and for those community where such water bodies are available, the rate of contamination is often high as a result of anthropogenic influence.The recent trend of diversification in industry and government policies and programs to encourage farming especially fish farming has led to more drilling of boreholes (wells) for groundwater exploitation. Many water bodies are being reported in recent times to be contaminated consequently reducing areas of application. This was the motivation behind the current study in Ashaka. Ashaka is a community in Ndokwa East Local Government Area of Delta State, with many oil exploitation activities and gas flaring in place. Recently, Sterling Global(a leading oil and gas producing company) has established base in the community. Some of the products of the company include production of chemicals, gas flaring and occasionally, oil spill in the community of operation. This study became necessary in view of the detrimental effects of contaminated water on plants growth and human health.

The study area is drained by Ase- creek which flows South-East, The topography of the study area is generally plain. The main occupations of the inhabitants are farming, fishing, petty business, government workers and some oil and gas staff. The predominant food crops within the area include cassava, yam, plantain, corn, fruits such as orange, mango, guava, pineapple, and pear.

In recent times, the community has been experiencing rapid growth and expansion as a result of the 2012 flood which influenced the relocation of victims from the surrounding villages to Ashaka couple with the peaceful nature of the community. Hence it became imperative to monitor the quality of groundwater being the major source of water to the people for domestic purpose.

The aim of the work is to ascertain the prevailing parameters in the water system (surfaceand groundwater) of Ashaka in order to evaluate its usabilityfor domestic purpose. Principal Component Analysis (PCA) is a comparative complete method of multivariate statistical analysis, which can force multidimensional indexes to be in one system and then study these data quantification (Zhang, 2010). Because of theadvantage, it has been applied to evaluate water quality by many researchers. PCA is used to find a few comprehensive indexes, which have great influence on the quality of water, by studying the internal structure of correction matrix of initial variables. PCA makes it easier to grasp principal contradictions when dealing with the complex system of groundwater quality. Unlike full method and comprehensive evaluation method, PCA does not need to be scored by expert, which makes data processing more objective and scientific (Lu and Liu, 2006).

1.2 AIM AND OBJECTIVESS

The aim of the study is to use Principal Component Analysis (PCA) to determine the dominants parameters in groundwater of Ashaka community and its environs in Ndokwa East Local Government Area of Delta State inorder to establish its suitability for domestic purpose.

The specific objectives are;

1. collect water samples from existing boreholes in both seasons (raining and dry season);
2. determine the physiochemical and biological parameters;
3. apply Principal Component Analysis (PCA) and other statistical tools to determine the dominants water parameters in relation to its usability as well as to aid interpretation.

1.3 SCOPE OF WORK.

The first phase of the study entails desk study/literature review of previous work. The second phase involves reconnaissance visit to site (Ashakacommunity and environs) sample collection, storage and transportation to laboratory for analyses, determine the dominant water indices byapplying PCA. The final phase includes results, discussion, summary, conclusion and recommendations.

1.4LOCATION.

Ashaka is one of the maincommunities in Ndokwa East Local Government Area of Delta State. The community is bounded by Kwale to the North, Igbuku to the South, Ushie and Emu to the East, and Okpai to the West.Ase-creek is the main River that drains the community, which usually its overflows bank round the month of September and December respectively.Figure 1 represents sample Location map indicating the sampling points.

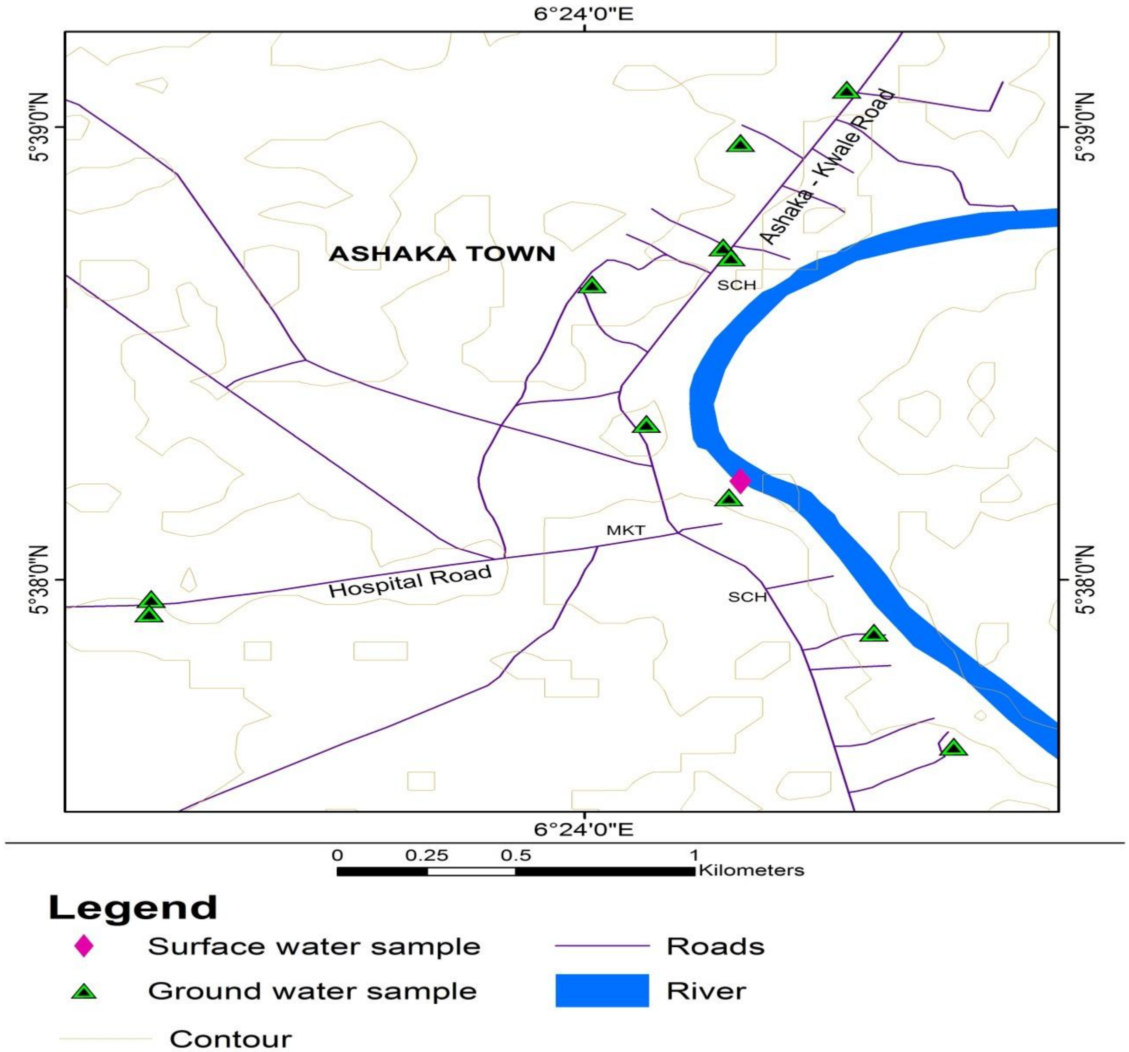

Fig.1 Location map indicating sampling points

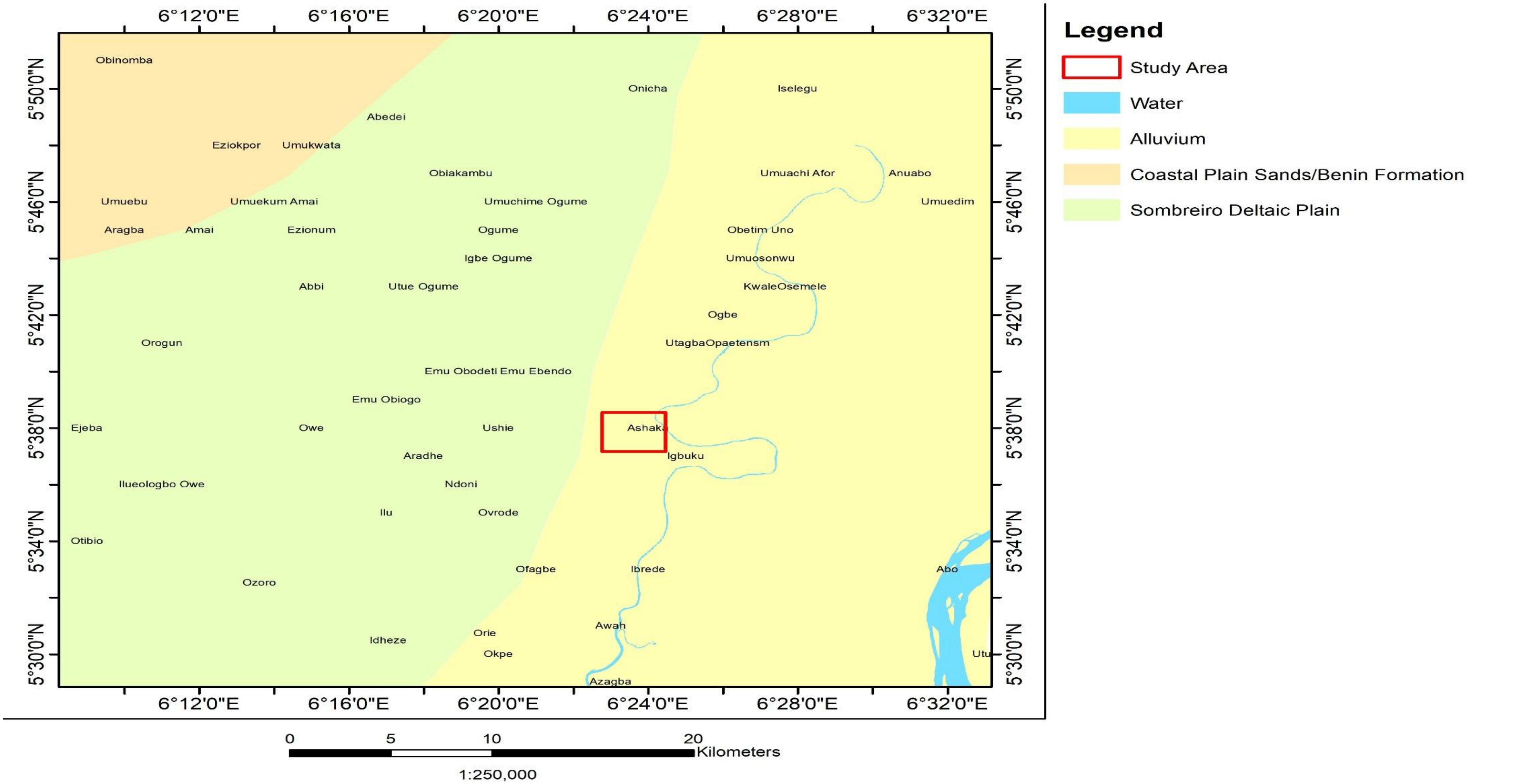

FIG 2 : GEOLOGICAL MAP OF ASHAKA

1.5 CLIMATE, GEOMORPHOLOGY AND VEGETATION.

Delta state has a plain terrain, except some part towards Ogwashi, and Agbor axis that is marked byrelativelyhigh land. The state experiences a tropical climate, characterized by two season namely dry season which usually starts from Oct-April, and the wet season which starts from April-October; December-February is characterized with the North-East trade wind which blows across the Sahara Desert causing harmattan. Annual rainfall is usually in excess of 3000mm, as there is barely any month of the year devoid of rainfall. Temperature is relatively high due to gas flaring thus making the community terrible hot during dry season. The vegetation is Freshwater Swamp Forest. This natural vegetation setting has been altered by human activities such as farming and lumbering and in many cases, has been replaced by grassland.

1.6 DRAINAGE PATTERN.

The terrain is plain with Ase-creek as the main river through which the community is drained, ASE-creek flows from North-West to South-East, and flows into river Niger at Asaba.

1.7 SIGNIFICANCE OF THE STUDY

This research titled "Water quality determination of Ashaka community in Delta state using Principal Component Analysis (PCA)" became necessary because groundwater serve as the main source of drinking water, agricultural purpose (fish farming) and industrial activity (sachet water production). The study will be of immense benefit to the inhabitants of Ashaka community since their main source of water-supply is groundwater. The results obtained from this study will help to conclude, recommend and enlighten the people on the quality of water in study area and area of application. Finally, the report emanating from this study will serve as a reference document for further study in the area. It will further help to keep in check the activities of the oil company in the area, and establishing environment standard.

CHAPTER TWO

LITERATURE REVIEW

1. PREVIOUS WORKS

Water is essential for life, yet millions of people around the world face water shortage. Water is a major solvent in the body and account for about 65-75% of the total weight of an average human being(Annan, 2005; Idiata,2006; Fox, 1996); about 40 percent of the human race does not have adequate access to safe water (Iyasele and Idiata, 2012). Waterborne diseases are estimated to kill more than 25,000 people daily (Train, 1976; Davis and Cornwell, 1991). In fact, 99.7% of the Earth's water supply is not usable by humans. This unusable water includes saltwater, ice, and water vapor in the atmosphere. Only freshwater, which is contained in rivers, lakes, and underground sources, can be used for human consumption. Furthermore, many freshwater sources are not suitable for humans to drink. Many serious diseases, such as cholera, are caused by drinking water that contains parasitic microorganisms. Water containing large amounts of industrial waste or agricultural chemicals (e.g., pesticides) can also be toxic and unfit for drinking. Around 1.1 billion people globally do not have access to improved water supply sources whereas 2.4 billion people do not have access to any type of improved sanitation facility. About 2 million people die every year due to diarrhea disease; most of them are children less than 5 years of age. The most affected are the populations in developing countries, living in extreme conditions of poverty, normally peri-urban dwellers or rural inhabitants.

Groundwater provides portable water to an estimated 1.5 billion people worldwide daily (DFID, 2001) and has proved the most reliable resources for meeting rural water demand in sub-Saharan Africa (MacDonald and Davies, 2002; Harvey.2004). The provision of adequate water supply and sanitation to the rapidly growing urban population is increasingly becoming a problem for government throughout the world. The water resources are threatened not only by this rapidly increasing demand of the population but also through diminishing quality caused by pollution and saline intrusion (Wegelin-Schuringa, 1999). From other similar research carried out in Edo South area of the state it shows that the groundwater in the area needs minimal treatment to be fit for drinking (Iyasele and Idiata, 2011). The Nigerian Government has long considered the provision of water supply and sanitation services to be the domain of the federal, state and Local governments (Henley, 2000). The total replenish able water resource in Nigeria is estimated at 319 billion cubic meters, while the groundwater component is estimated at 52 billion cubic meters. Nigeria has adequate surface and groundwater resources to meet its current water demands. However, in spite of the tremendous efforts put by various levels of governments to improve access to portable water supply to all Nigerians, estimates shows that only 58% of the inhabitants of the urban and semi-urban areas and 39% of rural areas have access to portable water supply.

The quality of surface waters is a very sensitive issue due to its dynamic nature. An anthropogenic influence, urban, industrial and agricultural activities increases the consumption of water resources. On the other hand, groundwater quality is normally characterized by different physiochemical characteristics.

The parameters are dynamic in nature due to seasonal variation fluctuation, groundwater extraction etc; hence the continuous monitoring of groundwater becomes mandatory in order to minimize groundwater pollution and have control on the pollution causing agents (SrinivasandNageswararao, 2013). The major source of groundwater is precipitation that infiltrates the ground and moves through the soil and pore spaces of rocks. Other sources include water infiltrating from lakes and streams, recharge ponds and waste water treatment system. Adekunle et al; (2011) assessed the groundwater quality in Ogbomosho township of Oyo state by measuring the physiochemical and bacteriological parameters, and they discovered that the water was alkaline, soft but however poor in terms of the bacteriological content. They concluded that it was unsafe for human consumption. Olobaniyi et al (2007) carried out hydrogeochemical and bacteriological investigation of groundwater in Agbor area, southern Nigeria and discovered that the water encounter in the area is useful for agricultural activities, upon appropriate bacteriological treatment; the water will be useful for industrial and human consumption. The sources of surface (running water) and groundwater is also a major factor in groundwater pollution. The runoff, storm water flow from areas of high anthropogenic activities can contaminate or pollute groundwater.

2.1 GEOLOGY OF THE NIGER DELTA BASIN.

The study area Ashaka is Located within Ndokwa East Local government area of Delta- state, which is situated within the Niger Delta sedimentary basin. Hence it is necessary to review the geology of the Niger delta sedimentary basin under the following headings:

- Stratigraphy
- Tectonic setting
- Sedimentation.

2.2 TECTONIC SETTING OF THE NIGER DELTA BASIN

The Niger Delta is a Continental sag type. Its development began as an interior graben fracture with the inception of the Benue Abakaliki through in the early Cretaceous. It is represented as a failed arm of the triple junction (aulacogen) associated with the opening of the south Atlantic. The Niger Delta is Located at the southern portion of Nigerian bordering the Atlantic Ocean and extends from about longitude 03^0 09'E and latitude 04 03' and 05 20'N.

The tectonics of the Niger Delta basin began with rapid sedimentation along the edge of the Delta resulting in faulting contemporaneous with sedimentation, thus producing an abrupt thickness of sediments across the fault line on the down thrown block. The origin and mode of formation of this growth fault may be due to gravitational slumping in under compacted marine clays.

The growth faults appear crescent shaped with the concave side towards the down thrown block. The origin and mode of formation of this growth fault may be due to gravitational slumping in under compacted marine clays. The growth faults appear crescent shaped with the concave size towards the down thrown block which tends to rotate along axis roughly parallel to the fault. The fault dips at 55^0 or more near the surface (Anderson, 1942) but flatten out with depth. This flattening is often attenuated by compaction. If sufficient movement occurs with the growth fault, an elongate anticline (roll over anticline) may from in front of the fault.

Marine geophysical profiles of the southern parts of the delta reported by mascle et, al. (1973) reveals the presence of diapric structures beneath the continental slope, thus indicating possible lateral extension of evaporate basin known as Angola.

2.3 SEDIMENTATION OF THE NIGER DELTA

During the Santonian, the sediments were folded and sequent uplifted to form the Anambra Basin to the West and the Afikpo syncline to the East separated by the Abakaliki Anticlinorium. These two Basins form the foci of Deltaic Sedimentation through the Maastrithtian to Paleocene and marked the beginning of the marginal sag phase of sedimentation.

In the early tertiary, during the Paleocene there was a major transgression terminating the advancing sediments of the upper cretaceous Anambra Basin. Sedimentation took place in a quite environment resulting in the deposition of a thick shale sequence (Imo shale) that formed part of the base of the tertiary Deltaic Sequence.

Continued growth of the Niger Delta complex resulted from epiorogenic movements on Benin and Calabar flank. This initiated a major regressive which has continued to this day in spite of minor transgressions. The Coastal plastic inputs and Progradation resulted in the deposition of parallicsequence which is composed of alternating sands and shale, some of which are maker horizons in the Delta

2.4**STRATIGRAPHY OF THE NIGER DELTA**

The tertiary sequence of the modern Niger Delta consists of Akata shale (formation), Agbada and Benin formation in ascending order. It is an overall coarsening upward sequence with maximum sediment thickness of about twelve thousand meters (12,000m). Short (1967) also recognize the above three subsurface stratigraphic units in the modern Niger Delta Basin Benin, Agbada and Akata formation.

2.4.1 BENIN FORMATION

Benin formation extends from west across the whole Niger Delta area and southward beyond the present coastline. It is coarse grained, gravely, locally fine grain, poorly socket, sub-angular to well-rounded and bear lignite streaks and wood fragments it is a continental of probable upper Deltaic dispositional environment various structural units (point bar, channel fill) are identifiable within the formation, indicating the variability of the shallow water depositional medium. In subsurface, it is of Oligocene in age in the north becoming progressively younger southward. In general it ranges from Miocene to recent. The thickness is variable but generally exceeds 6000ft. very little hydrocarbon accumulation has been associated with the formation.

2.4.2 AGBADA FORMATION

The Agbada formation occurs in subsurface of the entire delta area and may be continuous with the Ogwashi- Asaba and Ameki formations of Eocene- Oligocene in age. It is over 10,000ft thick and ranges from Eocene- Pliocene/Pleistocene in the south and recent in the delta surface.

Major hydrocarbon accumulation is found in the intervals between Eocene and Pliocene age.

2.4.3 AKATA FORMATION

It is the lower most unit of the tertiary Niger Delta and is a uniform shale development consisting of dark grey sandy, silty shale with plant remains at the top. This sandstone lenses occurs near the top particularly near the contact with the overlying Agbada formation. Planktonic foraminifera may account for over 50% the rich micro fauna and benthonic assemblage indicates shallow marine shelf depositional environment.

It is believed to have been deposited in front of the advancing delta and ranges from Eocene to Recent.

2.5REGIONAL GEOLOGY AND GEOMORPHOLOGY OF NIGER DELTA.

The regional geology and geomorphology of the studied area include:

2.5.1THE **DELTAIC PLAN BELT (SOMEBREIRO WARRI)**

An extensive low lying dominated by fluvial systems/some with braided characteristics although a few meandering belts are developed. The flood plain are vegetated with raffia palms while the inter-fluvial settings are characterized by oil palm tree.

2.5.2 THE FRESH WATER SWAMPS AND MENDER BELTS

These are represented by abandoned mender loops (ox –bow lakes) and extensive point bars. It is capped by natural levees with crevasse clay deposits typifying the flood plains. The vegetation is mainly mangrove.

2.5.3 COASTAL SAND AND BEACH RIDGES.

This belt includes both active and abandoned ridges facing zone of the sand and beach ridges is relatively narrow. It varies from a few hundred meters to about 16km

2.5.4THE SALTWATER MANAROOVE SWAMP BELT

These areas surround the estuaries, creeks and lagoons and are dominated by a system of interconnecting fairly rectangular meandering tidal flats in places. Thick undergrowths and rich mangrove vegetation characters this belt.

2.6 HYDROGEOLOGY

2.6.1 SURFACE HYDROGEOLOGY

The study area Ashaka community in Ndokwa East Local Government Area of Delta State is drained mainly by rivers, creeks and carnal, amongst them is the Utubolom creek, which empties into Ase-Creek. Ase-creek is the major river in Ashaka, it runs through Ndokwa East and part of Ndokwa West and eventually opens into the river Niger at Asaba-Ase (in the Northern end), and both communities are in Ndokwa East.

2.6.2 AQUIFER SYSTEMS (GROUND WATER)

Two stratigraphic units form the main aquifer systems in the Delta region (see table 1) these are:

2.6.2.1 THE ALLUVIM

This aquifer system is within the alluvial deposits, especially the near surface beds close to the shore, but is often saline bearing. However the lateral extent of these shallow aquifers is very erratic, occurring as lenses of sands with less permeable beds of silts and clay.

2.6.2.2THE BENIN FORMATION

In the Niger Delta Basin, this chronostratigraphic unit forms the main aquifer system having a total thickness of 1,892m (6000ft) around Warri; its lithological composition is mainly 90% sands and sandstones. The remaining 10% is made up of clay and lignite beds that are hardly continuous over any significant distance and largely occurring as lenses. Thus, the Benin formation is one large aquifer system with enormous storage. Recharge to this system is mainly through precipitation (rainfall), while discharge sources include ground water flow feed back to the river systems and abstraction through boreholes from the basin.

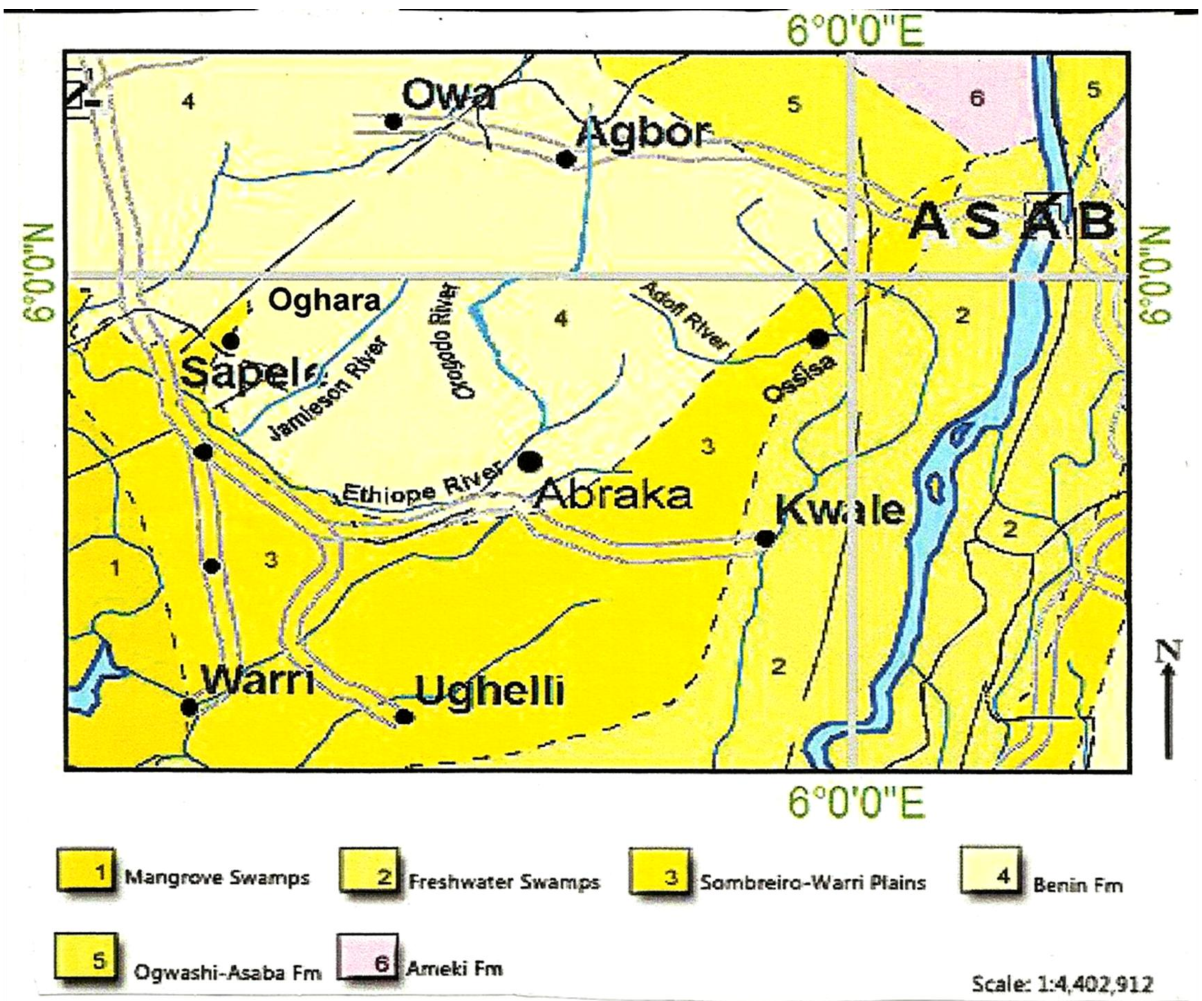

FIG3: GEOLOGICAL MAP OF DELTA STATE

Table 1 Stratigraphic sequence of Niger Delta Basin with aquifer characteristics.

Age	Stratigraphy	Lithologic Description	Aquifer Prospect
QUARTERNARY	Alluvium	Gravely –sands sand, silt and clay	Good
	Meander Belt Deposit	Gravely sand, sand within clay units	Good
	Wooded Back Swamps and Fresh Water Swap Deposit	Fine – sandstone, silt and silty clay and clays with organic matter.	Poor (saline water)
	Sombreiro Deltaic, Deltaic Sediments	Coarse to fine grained sands, silts and clay	Medium
MIOCENE TO RECENT	Benin Formation	Mainly coarse to medium grained sand lenticular with clay and shale lens	Good

CHAPTER THREE

MATERIALS AND METHODS

Having established the purpose of the project and its framework, the next step is to adopt a suitable method for data collection, aggregate,measurement,analysis and synthesis. In other words, what is the required information? Hence; the methodology determines what is to be done, how it is to be done, when it is to be done, and by whom it is to be done. Thus a reconnaissance survey was carried out on the area of Interest (Ashaka Community in Ndokwa East L.G.A Delta State) this helped me to get used to the study area.

3.1**FIELD SURVEY AND DATA COLLECTION**

This involved general reconnaissance and detail survey of the area of interest which in this case fall within Ashaka Community in Ndokwa East Local Government Area of Delta State. The coordinate of the study area falls within latitude 005^{o}38’0” and longitude 006^{o}24’0”. The samples were collected from existing borehole with aid of a pumping machine. The sample were kept in 35cl plastic bottle which was properly washed and dried before putting the water samples to avoid external influence. The samples were sent toSplendidstan Research Laboratory Ltd Benin – City. for analysis, In the case were required parameters were to be analyzed, the water was kept in a refrigerator to maintain room temperature.The Total of Nine(9) groundwater samples were collected, with one (1) surface water. The surface water was used as a control measure to check the influence of anthropogenic activities and land use on groundwater.Sample was collected twice to cover both the dry and raining seasons, the first sample was collected in September 2017 (Raining Season/Flood Period) while the second sample was collected by Feb 2018 during dry Season.

3.2 **LABORATORY ANALYSIS**

This involves a proper analysis of the physiochemical parameter of groundwater of the collection samples. This was done according to the standard procedure specified by APHA (1985) and Allen etal. (1974). The parameters are;

3.2.1 DETERMINATION OF pH

This is an insitu parameter; it was measured in the laboratory using a buffer 4 and 9 solution. The material needed was standard using buffer solution of pH4 and 9

3.2. 2 DETERMINATION OF ELECTRICAL CONDUCTIVITY (EC)

The conductivity meter bridge was used, this gives the reading in us/cm {the conductivity meter designed for insitu measurement was employed and properly utilized for it}

The sample was thoroughly mixed together before an aliquot was drawn into the meter sample holder/cell. The reading was taken directly immediately the reading knob is depressed.

3.2.3 DETERMINATION OF CHLORIDE

The AOAC Mohr's method was employed as 50ml of sample was measured into a conical flask and a pinch of powdered calcium carbonate added. This was followed by addition of 0.0lml of potassium dichromate as an indicator. The whole mixture was then titrated against standard silver nitrate solution to a permanent reddish brown precipitate.

3.2.4DETERMINATION OF ALKANITY

About 100ml of water was pipette into a filtration flask, 2 drops of phenolphthalein indicator was added and titrated against n/50 H_2SO4 until the pink color changes to yellow, 2 to 3 drops of methyl orange indicator was added and then titrated further until the color changed from yellow to red. The additional volume of acid used was recorded as (Bml).the whole process was repeated for a number of times to get concordant readings.

3.2.5 DETERMINATION OF TEMPERATURE

This parameter was determined with a thermometer having a calibration from 10^{o}C.its reading was taken to the nearest$^{+}_{-}1^{o}$c. Measurements were performed by dipping the thermometer into the water and as in the laboratory until the reading became stable before it was finally recorded.

3.2.6 DETERMINATION OF TURBIDITY

This was carried out using the laboratory colorimeter techniques. Each of the water samples was poured into the sample cell, heed by the cell holder and covered by the light shield. The instrument was switched and adjusted to the appropriate scale to read the turbidity.

3.2.7 DETERMINATION OF TOTAL DISSOLVED SOLID

The sample was filtered using a whatman filter paper, the sample was heated to dryness and the residue properly weighted.100ml of the sample was then evaporated to dryness on a water bath before drying to a constant weight in the oven at 105^{o}. The weight to the dish was subtracted from the final weight to obtain the weight of the total dissolved solid

3.2.8 DETERMINATION OF NITRATE

Calorimetric method was adopted using an appropriate spectrophotometer. 05ml of each sample was used under standard (0, 2,4,6,8 and 10) which was introduced into test tube with as micro pipette, and 1ml of salicylic acid (GH_60_3) solution was added to test tube prior to mixing which was allowed to stand for 30minutes, this was followed by addition of 10ml of sodium hydroxide to each test tube to allow the mixture for color development. The abundance of the sample and standard was read at 655nm.

3.2.9 DETERMINATION OF TOTAL HARDNESS

About 30ml of the water was pipette into a conical flask, and a 2ml buff solution of the Eriochromo black Vindicator was added. The sample was titrated against 0.0ml **EDTA** solution, until the red wine color changes to pure blue.

3.2.10 DETERMINATION OF METALS

Calcium (Ca^{2+0}), Magnesium (Mg_{2+}), Chromium (Cr^{6+}) and Zinc (Zn^{2+}) were determined with flames photometric and atomic absorption spectrometric (AAS) methods (APHA, 1985)

3.2.11 DETERMINATION OF SULPHATE IN WATER

Five series of standard solution with concentration range of 1mg/L to 5mg/L were prepared and analyzed with the samples. To each 10ml of standard, 1ml of barium chloride gelatin was added. the mixtures were allowed to stand for 45minutes. The respective absorbance of the solution at 420nm was determined. From this data a graph of absorbance of the solution at 420nm was determined. From this data graph of absorbance against concentration was plotted.

Barium chloride gelatin (1ml) was added to 10ml of sample and the mixture was diluted to 50ml with double distilled water. Prepared samples were allowed to stand for 45minutes. The concentrations were determined using UV- Visible spectrometer at 420nm. A blank without sample was prepared and read at the same wavelength.

3.2.12 DETERMINATION OF PHOSPHATE IN WATER

Ascorbic acid method (orthophosphate-Phosphorus) was used. Five series of phosphate standard solution with concentration range of 0.2mg/L to 1mg/Lorthophosphates (PO) was used to standardize the UV- Visible spectrophotometer. 50ml of standard was measure into test tube and 2ml of ascorbic acid molybdenum was added. The absorbance of the solution after 10minutes was taken at 655nm against blank solution with UV-Visible spectrophotometer. A curve of absorbance versus concentration was plotted. to 50ml of the sample was added 2ml of ascorbic acid molybdenum. The mixture was allowed to stand for 10minutes after which the absorbance of the samples was taken at 655nm with UV- Visible spectrometer. A blank analysis was performed with all the reagents without the samples for all the analysis.

3.2.13 DETERMINATION OF TOTAL SUSPENDED SOLID (T.S.S)

This is the dry-weight of suspended particles that are not dissolved in a sample of water that can be trapped by a filter. T.S.S is analyzed by using a filtration apparatus.

3.2.14 DETERMINATION OF E-COLI

The E-coli concentrated at the reaction zone of the paper strip will react with custom formulated chemical reagents to produce a pinkish-red colour. Such a colour change on the paper strip when dipped into water samples indicates the presence of E-coli contamination in portable water.

3.2.15 DETERMINATION OF COLIFORM

To determine the number of colonies in 100ml of a given sample, you divide the number of colonies counted with the milliliters of the sample used in the procedure and multiply the results with a 100. This gives the percentage of the coliform in the sample.

3.2.16 DETERMINATION OF CHEMICAL OXYGEN DEMAND

To test for COD in a particular sample the following procedures are followed:

1) Take 10ml of sample into a round bottom reflex flask.

2) Add some glass beads to prevent the solution from bumping into the flask while heating.

3) Add 1ml of mercury sulfate ($HgSO_4$) solution to the flask and mix by swirling the flask.

4) Add 5ml of Potassium dichromate ($k_2Cr_2O_7$) solution.

3.2.17DETERMINATION OF DISSOLVED OXYGEN

The levels of Dissolved Oxygen in the sample were determined by a basic chemical analysis method (titration method), an electrochemical analysis method (diaphragm electrode method) and photochemical analysis (fluorescence method). The diaphragm electrode method is the most widely used method.

3.2.18: PRINCIPALCOMPONENT ANALYSIS(PCA)

Principal Component Analysis(PCA), is a dimensionally – reduction method that is often used to reduce the dimensionality of large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set. This is done with Statistical Package for Social Sciences (Spss) for this study version 22 was used.

Method of carrying PCA is summarized as follows;

- Standardize the range of continuous Initial variables

- Compute the covariance matrix to Identify correlations
- Compute the eigenvectors and eigenvaluesnof the covariance matrix to Identify the Principal Component.
- Create a feature Vector to decide which Principal Components to keep
- Recast the data along the Principal Components axes.

CHAPTER FOUR

RESULT AND INTERPRETATION

The geochemical results obtained during laboratory analysis of the water samples based on the parameters of interest are presented in appendix 1 and 2. Furthermore, predominant parameters in each season were also considered to have a detailed evaluation of the ground and surface water condition in the study area. These parameters were afterward subjected to Principal Component Analysis (PCA) to select the parameters that are more dominant and or prevalent in the water of Ashaka at both seasons respectively. Principal Component Analysis (PCA) was applied because it provides a unique solution, in such a way that the original data of the results can be reconstructed and also takes the clades of data points and rotates it in such a way that maximum variability is visible; this was to identify the most essential analyte. The result obtained from statistical analysis using Statistical Package for Social Sciences Software (SPSS) Version 22 is shown as presented in Table 2.

Table 2 Result of prevalent parameter in Water at both seasons using PCA

Parameters	L1	L2	L3	L4	L5	L6A	L6B	L7	L8	L9	WHO
pH	5.83	5.70	6.02	5.90	5.66	5.70	5.85	5.69	5.69	5.89	6.5-8.5
	5.45	5.86	5.55	6.04	5.41	5.34	6.41	5.17	5.16	5.41	
EC (µs/cm)	95.00	20.00	19.00	28.00	159.00	24.00	47.00	33.00	44.00	38.00	500
	193.00	77.00	156.00	133.00	201.00	94.00	198.00	99.00	146.00	81.00	
Cl (mg/L)	31.35	6.60	6.27	9.24	52.47	7.92	15.51	10.89	14.52	12.54	250
	25.09	10.01	20.28	17.29	26.13	12.22	25.74	12.87	18.98	10.53	
Alkalinity (mg/L)	16.05	15.02	15.86	14.57	16.27	16.48	13.73	17.02	17.05	16.27	500
	16.82	17.19	16.29	16.61	17.32	17.19	16.76	17.22	16.43	16.64	
TDS (mg/L)	0.09	0.02	0.02	0.03	0.14	0.02	0.04	0.03	0.04	0.03	5.00
	0.17	0.07	0.14	0.12	0.18	0.08	0.18	0.09	0.13	0.07	

Wet season
Dry season

Table 3: Initial Eigen value and the Extraction sum Square Loading for Wet Season.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	18.716	69.318	69.318	18.716	69.318	69.318
2	3.141	11.633	80.951	3.141	11.633	80.951
3	1.733	6.419	87.370	1.733	6.419	87.370
4	1.601	5.931	93.301	1.601	5.931	93.301
5	1.097	4.065	97.366	1.097	4.065	97.366
6	.437	1.619	98.985			
7	.133	.492	99.476			
8	.086	.317	99.793			
9	.056	.207	100.000			
10	5.254E-15	1.946E-14	100.000			
11	3.607E-15	1.336E-14	100.000			
12	1.449E-15	5.365E-15	100.000			
13	1.032E-15	3.821E-15	100.000			
14	6.888E-16	2.551E-15	100.000			
15	3.006E-16	1.113E-15	100.000			
16	2.407E-16	8.915E-16	100.000			
17	1.982E-16	7.339E-16	100.000			
18	8.501E-17	3.148E-16	100.000			
19	-3.843E-17	-1.423E-16	100.000			
20	-1.305E-16	-4.834E-16	100.000			
21	-2.485E-16	-9.204E-16	100.000			
22	-4.095E-16	-1.517E-15	100.000			
23	-4.223E-16	-1.564E-15	100.000			
24	-6.491E-16	-2.404E-15	100.000			
25	-7.475E-16	-2.768E-15	100.000			
26	-8.407E-16	-3.114E-15	100.000			
27	-1.428E-15	-5.288E-15	100.000			

Table 4 The initial Eigen values and the Extraction Sum of Square Loadings for Dry Season

Component	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	18.183	67.344	67.344	18.183	67.344	67.344
2	3.225	11.946	79.290	3.225	11.946	79.290
3	2.362	8.747	88.037	2.362	8.747	88.037
4	1.489	5.516	93.553	1.489	5.516	93.553
5	1.035	3.834	97.387	1.035	3.834	97.387
6	.441	1.633	99.020			
7	.236	.874	99.894			
8	.023	.085	99.979			
9	.006	.021	100.000			
10	2.914E-15	1.079E-14	100.000			
11	7.927E-16	2.936E-15	100.000			
12	6.366E-16	2.358E-15	100.000			
13	6.247E-16	2.314E-15	100.000			
14	4.775E-16	1.769E-15	100.000			
15	4.300E-16	1.593E-15	100.000			
16	2.910E-16	1.078E-15	100.000			
17	2.237E-16	8.284E-16	100.000			
18	7.867E-17	2.914E-16	100.000			
19	-3.427E-17	-1.269E-16	100.000			
20	-1.343E-16	-4.972E-16	100.000			
21	-2.056E-16	-7.614E-16	100.000			
22	-2.407E-16	-8.914E-16	100.000			
23	-3.599E-16	-1.333E-15	100.000			
24	-4.606E-16	-1.706E-15	100.000			
25	-4.864E-16	-1.802E-15	100.000			
26	-6.598E-16	-2.444E-15	100.000			
27	-2.714E-15	-1.005E-14	100.000			

Table 3 and 4 represents the initial eigen values and the extraction sum of square loadings of all the variables in which the prevalent parameters for wet and dry seasons were determined respectively. The tables showed that pH, EC, Cl, Alkalinity and TSS were the prevalent contaminants in Ashaka water at both seasons haven clinch a minimum cumulative percentage of 95% of the Extraction Sums of Squared Loadings, hence they are used to assess the water quality of Ashaka. Figures 4 and 5 represent the Principal Component Plots for wet and dryseasons respectively.

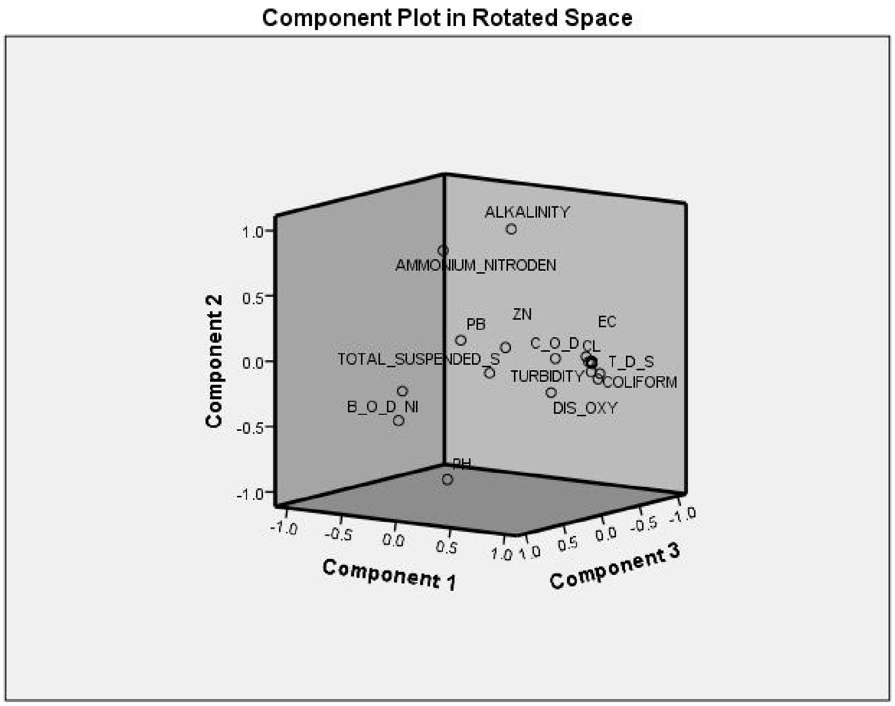

Fig. 4 Principal Component Variables for wet season

During the wet season, the principal component plot showed that pH dominates Component 1, while BOD, Ni, and Ammonium-Nitrogen were prevalent in Component 2. Conversely, Alkalinity, Zn, Pb, TSS, COD, Turbidity, DO, TDS and Coliform were prevalent in Component 3 with Cl, clustering at the center of the plot.

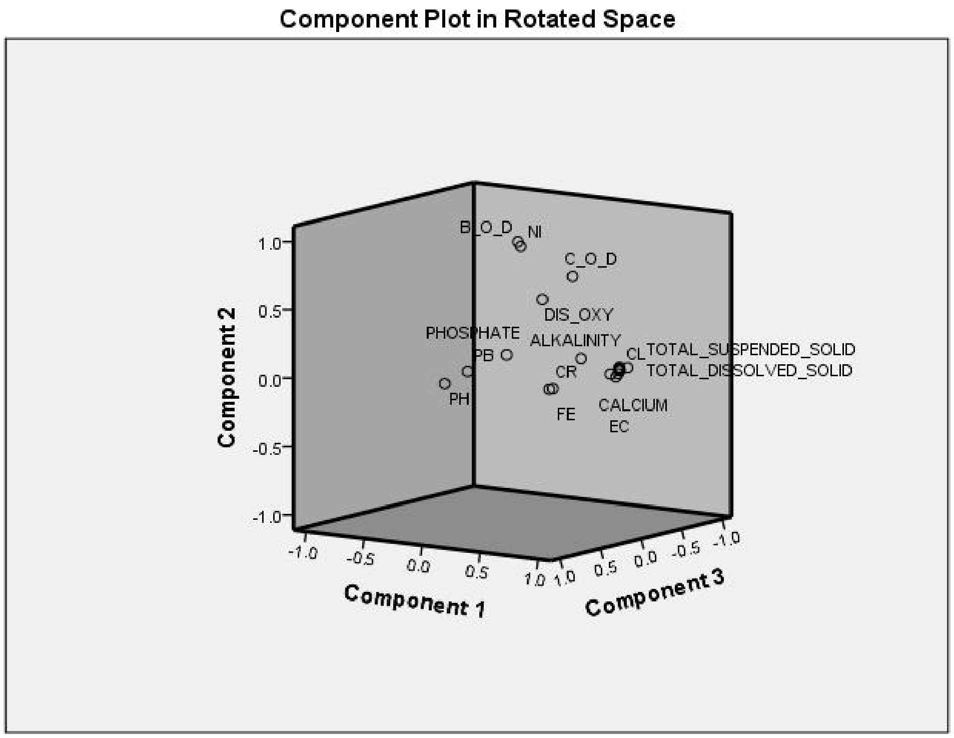

Fig. 5 Principal Component Variables for dry season

The dry season plot (Fig. 4) revealed that Principal Component 1 do not house any parameter whereas PC 2 showed that the commonly distributed parameter was pH while Pb cut cross PC 2 and 3. In Component -3 Biological Oxygen Demand (BOD), Ni, Chemical Oxygen Demand (COD), Phosphate, Alkalinity, Dissolved Oxygen (DO), Cr, Fe, Calcium, EC, Cl, TDS and TSS were present.

The values obtained for the prevalent parameters at both season were within regulatory values set by the Standard Organization of Nigeria (SON) and Word Health Organisation (WHO). For example, the pH values recorded for both season in this study ranged from 5.17 to 5.90. This value is above the range of 6.5 -8.5 set by SON (2012). On the basics of the pH value, Ashaka water is moderately to fairly acidic;

because of the acidic nature, acidic nature of water are caused due to natural occurrence or acid rain. the water is not fit for consumption but can be useful in that regard when the water is treated before consumption(when a neutralizer filter is introduced). Others include EC (19 -193 us/cm) against 500 us/cm value set by SON; Cl, TDS and Alkalinity recorded the 6.6 -52, 0.02 – 0.17 mg/L, 15.02 – 17.22 mg/L against SON values of 250 mg/L, 500 mg/L and 5.0 mg/L respectively.

Correlation coefficient which measures the degree of relationship between the variables was also determined. Positive loading indicates that the contribution of the variables increases with increasing loading in dimension whereasthe negative loading indicates a decrease in dimension. In this present study, the coefficients at $p < 0.5$ (95%) for each of water sample are presented Figures 6 - 10. Figures 6 represent the correlation of pH at both seasons. The red colour indicates water samples obtained during the dry season while the blue colour represents water samples of wet season. At $p < 0.5$ (95%)pH correlates strongly with Fe, Pb and e-coli and inversely with Cl, alkalinity, Phosphate. Other parameters measured show a poor relationship with pH indicating that pH has little or no influence on them (Fig. 6).

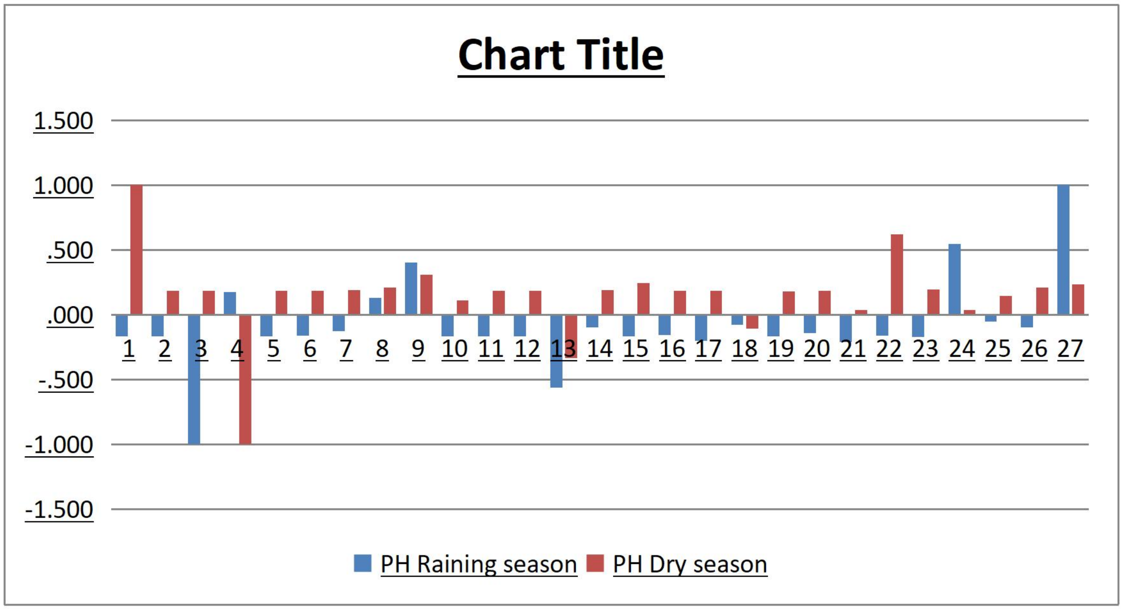

Fig. 6 Graphical correlation of pH with other parameters

Electrical Conductivity correlate strongly with other parameters measured except alkalinity and phosphate, for both season while DO,Cr, Fe and *E-coli* count for wet seasons respectively. This indicates that these parameters have similar source which could be attributed to human influence on natural environment in the study area (Fig. 7).

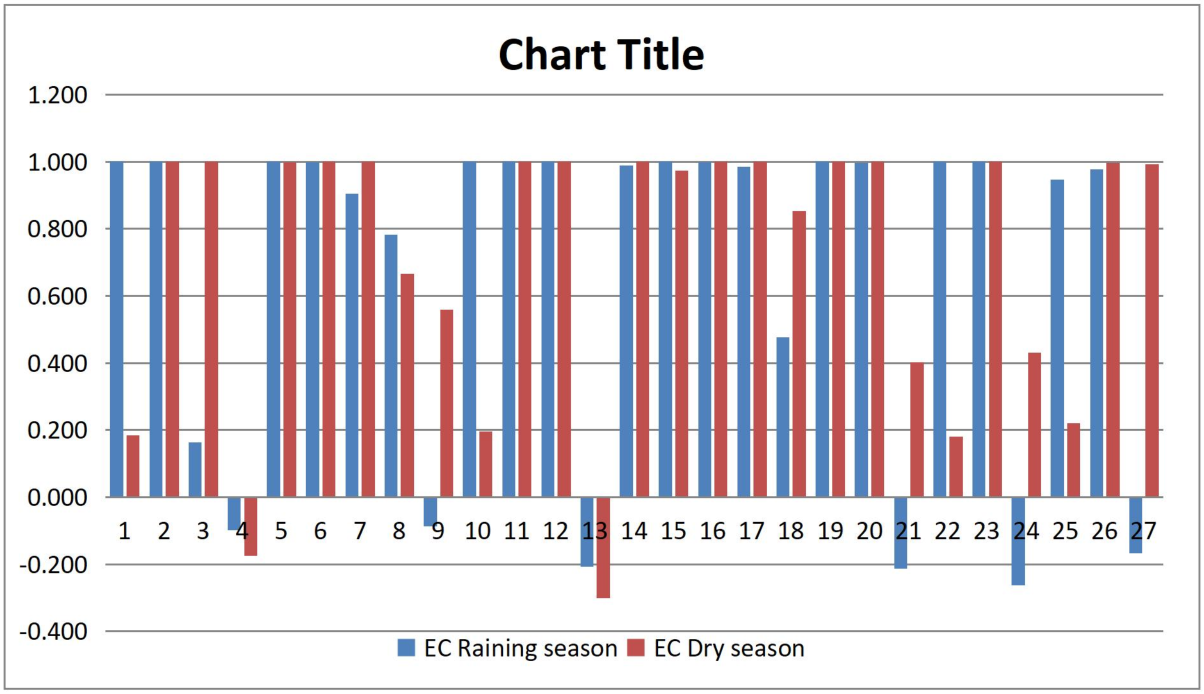

Fig. 7 Graphical correlation of EC with other parameters in the wet and dry season

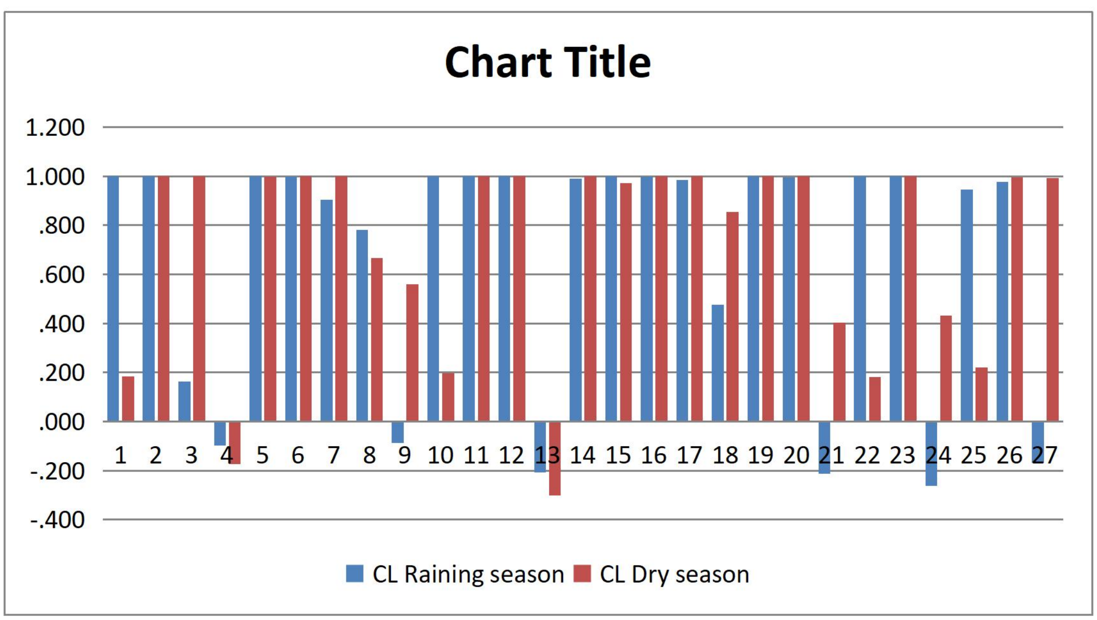

Fig. 8 Graphical correlation of Cl with other parameters in the wet and dry season

Chlorine show a similar trend with the EC in terms of relationship during the wet and dry seasons; besides alkalinity and phosphate in both season, while DO, Cr, Fe and E-coli count during wet season. other parameters measured show a positive strong relationship with chlorine (Fig. 8).

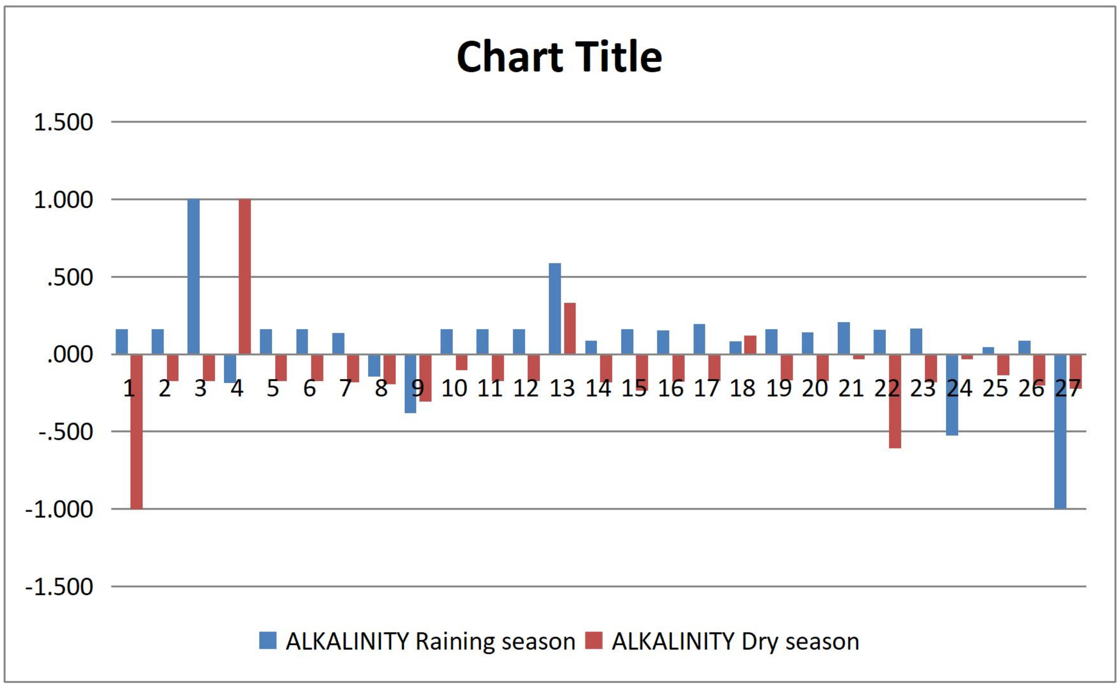

Fig. 9 Graphical correlation of alkalinity with other parameters in the wet and dry season

It was also observed that alkalinity correlated very strongly with EC and alkalinity itself and strongly with phosphate at both seasons. This observation indicates that alkalinity influence EC and phosphate in the environment, hence they are likely from a similar source. Conversely, the graphical correlation shows that e-coli count, Fe, Pb, DO and pH were not influenced by the presence of alkalinity, hence the negative correlation as represented in Figure 9.

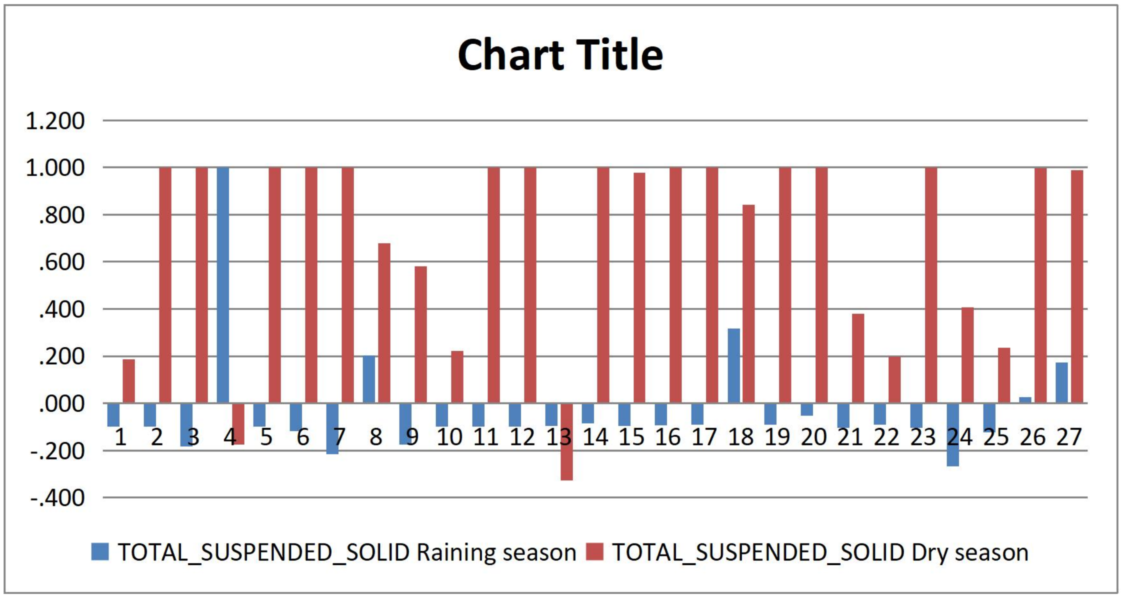

Fig. 10 Graphical correlation of TSS with other parameters in the wet and dry season

Total Suspended Solid was observed to correlates with all other parameters strongly during the dry season; this could be explained from the hazy weather couple with the strong wind carrying various particles sizes into the water body. Toxicants and or environmental pollutant can attached itself to suspended materials within the water body.

In addition to the principal component analysis carried out, cluster analysis was also carried out in order to have an ideal of the relationship between the sampling points and the analytes (Fig.11 and 12). Figure 11 represents the cluster relationship between the analytes and the sampling points during the wet season. The dendrogram revealed four cluster relationships with Ca, Cl, Alkalinity, COD and E-coli in cluster 1, TDS in addition to cluster 1 together form cluster 2. On the other hand, EC and *Coliform Count* formed cluster 3 while cluster 4 shows the interaction of the analytes with the general environment. In the same vein, Figure 12 represents cluster analysis during the dry season; the dendrogram also shows four cluster arrangement. Iron and Potassium exhibit a strong relationship in cluster 1 while Na, Cl, *e-coli count* and alkalinity exhibit a strong relationship in cluster 2. In cluster 3, COD, Coliform Counts and TDS display a unique relationship whereas cluster 4 shows that these analytes are sourced within the environment (Ashaka Community); this could be attributed to anthropogenic activities.

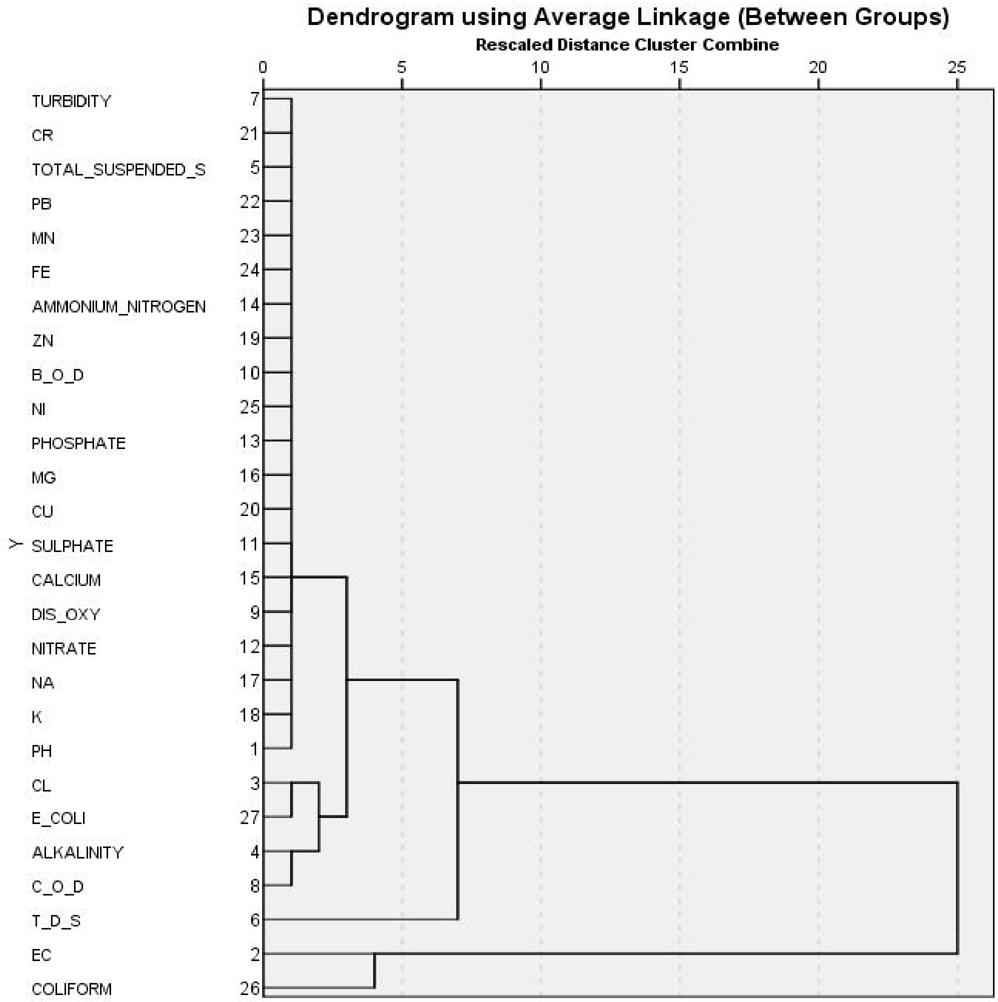

Fig. 11 Cluster analysis for wet season

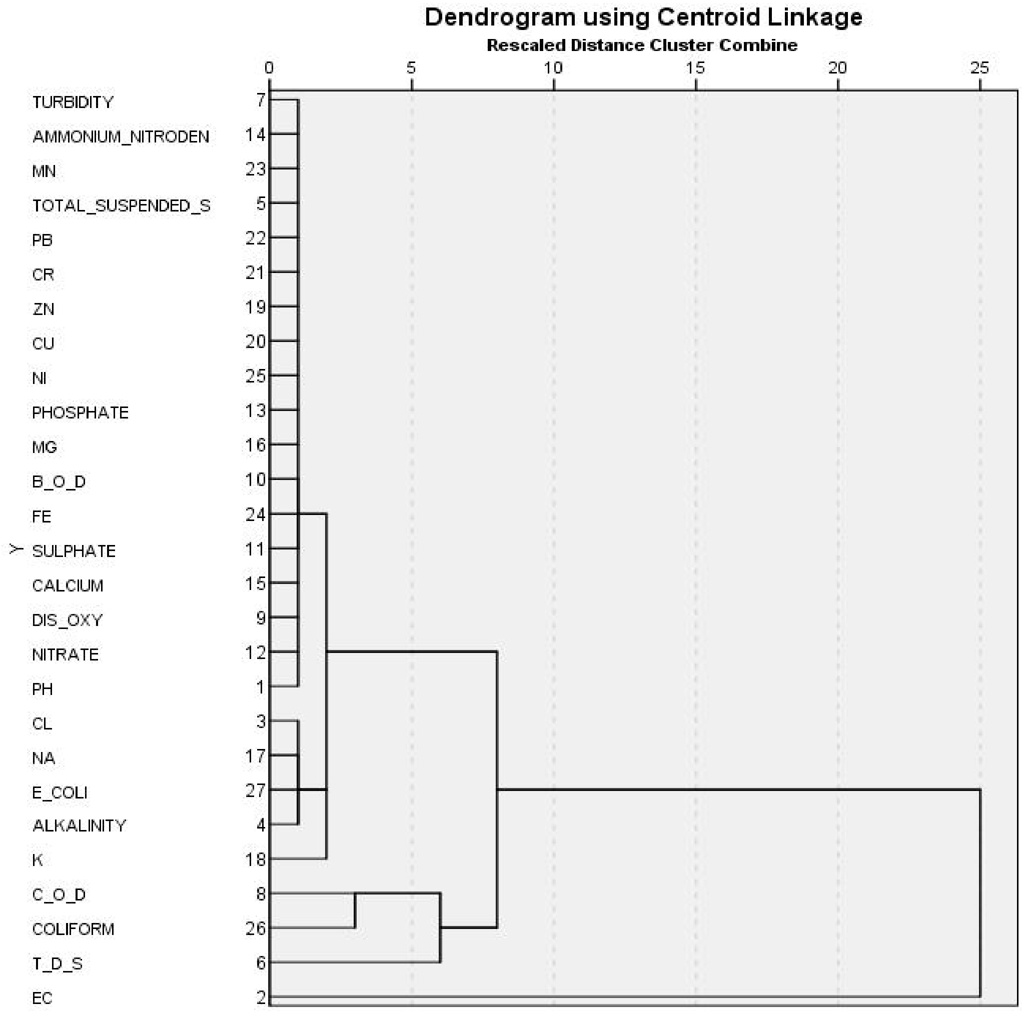

Fig. 12 Cluster analysis for dry season

The values obtained from biological parameters of *coliform* and *e-coli* counts are alarming. For example, WHO recommends 0 presence of these biological species in potable water, however the values recorded in this study shows a range of 7 – 19 cfu/mL of *e-coli* species and 22 – 58 cfu/mL of coliform species (Appendix 1 and 2). The presence of these species in the water of Ashaka shows that the quality of water is poor in terms of drinking purpose.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Drinking contaminated water is detrimental to human health because the contaminants in the water can result in the malfunctioning of the human system consequently leading to death. It is therefore imperative to monitor sources of drinking water to ensure it's free from contaminants of any sort. This study employed integrated approach in assessing the quality of water in Ashaka community in Delta State, Nigeria. The results obtained shows that most of the parameters monitored in the water were within the recommendation of regulatory body like the World Health Organization (WHO), the Standard Organization of Nigeria (SON) and Nigeria Standard For Drinking Water Quality (NSDWQ) except pH, e-coli and coliform counts.

The study clearly demonstrates the usefulness of PCA in studying water quality and it's usability, the prevalent parameters were determined and the environment of the analyte was also shown from the dendrogram The study reveals pH, EC, Cl, Alkalinity and TSS are the predominant Parameter in Ashaka water. The study also reveals that pH is the most significant parameter in the water of Ashaka; this is because all other parameter relate with pH in the dendrogram. It is therefore not out of point to conclude that PCA study of Ashaka water is essential in monitoring water quality to determine what it can best be used for. Although the water from Ashaka community is moderately contaminated, it can be used for irrigation purposes and can be consumed with routine treatment.

5.2 RECOMMENDATION

It is recommended that;

1. Soils of Ashaka community should be assessed to determine the level of contamination and its application in food production.
2. This study focused more on groundwater; it is suggested that detailed assessment of river water should be carried out.
3. The Impact of the contaminant should be examined in the Life of the inhabitant.

REFERENCES

Adekunle, I.M. et, al. (2011). Bioremediation of Soils Contaminated with Nigeria

Petroleum Products Using Composited Municipal Wastes Bioremediation Journal 15(4) 1-13

Akujieze, C.N.(2004). Effect of Anthropogenic Activities on Urban groundwater system and aquifer Vulnerability assessment in Benin City, Edo State Nigeria. PhD Thesis University of Benin, Benin City Nigeria

Allen et al(1974).Chemical Analysis of Ecological Material, Oxford,England: Blackwell Scientific, 1974.

Anderson, R. L. (1942). Distribution of the Serial Correlation Coefficient Ann. Maths. Statist. 13 (1) 1 -13 (March), 1942.

Annan, K. (2005).Water for life former United Nations Secretary.

APHA 1985 Standard method for the Examination of water and Wastewater. 19th Edition, American Public Health Association, Washington DC.

Davis, M. L. and Cornwell, D. A. (1991). Introduction to Environmental Engineering. Second edition

Department for International Department DFID (2001): Addressing the Water Crisis.Healthier and more Productive Lives for poor People.*Strategies for achieving International Department Targets*

Harvey, P.A. (2004). Borehole Sustainability in Rural Africa: An analysis of routine field DATA.WEDC International Conference, Vientiane, Lao PDR. People-Center Approaches to Water and Environmental Sanitation

Henley, D. (2006). Federal Republic of Nigeria water supply& sanitation interim strategy,November.Q:\PERSONAL\WORD\Nigeria Water sector\Nigeria WSS Strategy 2000.doc

Idiata, D. J. (2006). Assessment of Water use and demand in Edo State: the case study of Benin City.Project work submitted to the Department of Civic Engineering, Ambrose Alli University, Ekpoma and Edo State, Nigeria

Iyasele, J.U. and Idiata, D.J. (2012). Determining the Borehole Water Quality in Edo South and Edo North Area of Edo State Research journal in *Engineering and Applied sciences (ISSN: 2276-8467)4(14); 209-213*

Iyasele, J.U. and Idiataa, D.J.E.(2011). Benin City Borehole Water Ananlysis Submitted and Aceeepted for publication by pan-African Journal Series Ninka-Premo Co.3 Emmause, 2nd Close, Labone, P.O.Box 1495,Accra, Ghana

MacDonald, A.M. and Davies, J. (2002). A Brief Review of Groundwater for Rural Water Supply in Sub-saharan Africa. British Geological Society,*Nottingham, UK*

Mascle et, al. 1973, Submarine Niger Delta: Structural Framework.

Omorogieva, O.M,andTonjoh, J. A. (2020). Bioavailability of heavy metal Load in Soil, groundwater, and food crops manihortesculenta and carica papaya in dumpsite environment. International Journal of Environment Science and Technology, 1-12, 2020.

Omorogieva, O.M. andImasuen, O.I. (2018).Litho-stratigraphic and hydrogeological evaluation of groundwater system in part of Benin Metropolis, Benin City Nigeria: The Key to groundwater Sustainability. Journal of Applied Science and Environmental Management 22(2), 275-280.

Olobaniyi, S.B.,Ogala, J. E. and Nfor, N. B. (2007). Hydrogeochemical and Bacteriological Investigation of Groundwater in Agbor Area, Southern Nigeria.*Journal of mining and Geology 43(1):79-89.*

Short, K.C. and Stauble, A.J. (1967). Outline Geology of the Niger Delta. AAPG Bull 51; 761 – 779.

SrinivasRoa, G. and Nageswararao, G. (2013). Assessment of Government Quality Using Water Quality Index.*Arch. Environ. Sci Vol. 7pp1-5*

Train, R. E. (1976). Excerpt from lecture delivered at Los Angeles World Affair Forum, December 16. Former EPA administrator. Unpublished M.sc thesis presented to the department of Geology, university of Benin, Benin City. Pp 81

Wegelin-Schuringa, M. (1999). Water Demand Management and the urban poor international Research Center (IRC), Hague.

WHO,(2006). Guideline Value for chemical World Health Significant in Drinking Water Quality *World Health Organization, Geneva pp41-49*

Zhang, M. et, al. (2010). creation of hyperpermeable yeast strain to genotoxic agents through combined Inactivation of PDR and CWP genes.ToxicolSci 113 (2): 401 – 11.

Appendix 1 Laboratory Results of measured parameters in Wet season

Variables	Units	Loc1	Loc2	Loc3	Loc4	Loc5	Loc6	Loc6b	Loc7	Loc8	Loc9
pH	mg/l	5.45	5.86	5.55	6.04	5.41	5.34	6.41	5.17	5.16	5.41
EC	uS/cm	95.00	20.00	19.00	28.00	159.00	24.00	47.00	33.00	44.00	38.00
Cl	mg/l	31.35	6.60	6.27	9.24	52.47	7.92	15.51	10.89	14.52	12.48
Alkalinity	mg/l	16.15	15.02	15.86	14.57	16.27	16.48	13.73	17.02	17.05	16.27
TSS	mg/l	0.09	0.02	0.03	0.14	0.02	0.04	0.03	0.04	0.05	0.05
TDS	mg/l	48.45	10.20	9.69	14.28	81.09	12.24	23.97	16.83	22.44	19.38
Turbidity	mg/l	0.11	0.02	0.02	0.03	0.19	0.03	0.06	0.04	0.05	0.05
COD	mg/l	19.95	4.20	7.79	5.88	33.39	9.84	19.27	6.93	18.04	15.58
DO	mg/l	3.42	0.64	0.68	1.07	2.54	0.23	1.69	0.53	0.42	1.37
BOD	mg/l	0.21	0.01	0.28	0.02	0.05	0.09	0.69	0.01	0.17	0.56
Sulphate	mg/l	4.85	1.02	0.97	1.43	8.11	1.22	2.40	1.68	2.24	1.94
Nitrate	mg/l	2.85	0.60	0.57	0.84	4.77	0.72	1.41	0.99	1.32	1.14
Phosphate	mg/l	0.95	0.20	0.19	0.28	1.59	0.24	0.47	0.33	0.44	0.38
HN_4N	mg/l	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.33	0.33	0.33
Calcium	mg/l	4.28	0.90	0.86	1.26	7.16	0.60	2.12	1.49	1.10	1.71
Magnesium	mg/l	1.05	0.22	0.21	0.31	1.75	0.26	0.52	0.36	0.48	0.42
Sodium	mg/l	11.40	2.40	2.28	3.36	19.08	2.28	5.64	3.96	5.28	4.56
Pottasium	mg/l	8.46	1.42	0.97	1.12	11.29	1.70	3.34	2.34	3.12	2.70
Zinc	mg/l	0.54	0.11	0.11	0.16	0.21	0.14	0.27	0.19	0.25	0.22
Copper	mg/l	0.67	0.14	0.13	0.20	1.11	0.17	0.33	0.23	0.31	0.27
Chromium	mg/l	0.06	0.01	0.01	0.02	0.10	0.01	0.03	0.02	0.03	0.02
Lead	mg/l	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Manganese	mg/l	0.20	0.04	0.04	0.06	0.33	0.05	0.10	0.07	0.09	0.08

Iron	mg/l	0.29	0.06	0.06	0.08	0.48	0.07	0.14	0.10	0.13	0.11
Nickel	mg/l	0.32	0.21	0.34	0.04	0	1.41	2.97	1.49	0.04	0
Coliform	10^3cfu/ml	56	22	45	39	59	27	58	29	46	24
E-coli	10^3cfu/ml	18	7	15	12	19	9	18	9	15	8

Appendix 2: Laboratory Result of Measured Parameters in Dry Season.

Variables	Units	Loc1	Loc2	Loc3	Loc4	Loc5	Loc6	Loc6b	Loc7	Loc8	Loc9
pH		5.83	5.7	6.02	5.9	5.66	5.7	5.85	5.89	5.96	5.89
EC	uS/cm	193	77	156	133	201	94	198	99	146	81
Cl	mg/L	25.09	10	20.28	17.29	26.13	12.2	25.7	12.9	18.98	10.5
Alkalinity	mg/L	16.82	17.2	16.29	16.61	17.32	17.2	16.8	17.2	16.43	16.6
TSS	mg/L	0.17	0.07	0.14	0.12	0.18	0.08	0.18	0.09	0.13	0.07
TDS	mg/L	98.43	39.3	79.56	67.83	102.5	47.9	101	50.5	74.46	41.3
Turbidity	mg/L	0.62	0.25	0.5	0.43	0.64	0.3	0.63	0.32	0.47	0.26
COD	mg/L	40.43	16.2	63.96	27.93	42.21	38.5	81.2	40.6	30.66	17
DO	mg/L	6.54	2.46	5.98	4.79	3.22	0.9	7.13	7.21	5.25	1.3
BOD	mg/L	0.39	0.05	2.45	0.1	0.06	0.37	2.92	2.96	0.11	0.03
Sulphate	mg/L	9.84	3.93	7.69	6.78	10.25	4.79	10.1	5.05	7.45	4.13
Nitrate	mg/L	5.79	2.31	4.68	3.99	6.03	2.82	5.94	2.97	4.38	2.43
Phosphate	mg/L	1.93	0.77	1.56	1.33	2.01	0.94	1.98	0.99	1.46	0.81
HN_4N	mg/L	0.58	0.23	0.47	0.4	0.6	0.28	0.59	0.3	0.44	0.34
Calcium	mg/L	8.69	3.47	7.02	5.99	9.05	2.35	8.91	4.46	6.57	3.55
Magnesium	mg/L	2.12	0.85	1.72	1.46	2.21	1.03	2.18	1.09	1.61	0.89
Sodium	mg/L	23.16	9.24	18.72	15.96	24.12	11.3	23.8	11.9	17.52	9.72
Potassium	mg/L	17.2	5.47	7.96	5.32	14.27	6.67	14.1	5.05	5.84	5.75
Zinc	mg/L	1.1	0.44	0.89	0.76	1.15	0.54	1.13	0.56	0.83	0.46
Copper	mg/L	1.35	0.54	1.09	0.93	1.41	0.66	1.39	0.69	1.02	0.57
Chromium	mg/L	1.44	0.03	0.03	0.03	0.03	0	0.03	0.03	0.03	0.03
Lead	mg/L	0.04	0.05	0.17	0.13	0.05	0.01	0.04	0.04	0.05	0.02
Manganese	mg/L	0.41	0.16	0.33	0.28	0.42	0.2	0.42	0.21	0.31	0.17

Iron	mg/L	11.81	0.23	0.47	0.4	0.6	0.28	0.59	0.3	0.44	0.24
Nickel	mg/L	0.32	0.21	0.34	0.04	0	1.41	2.97	1.49	0.04	0
Coliform	10^3cfu/ml	56	22	45	39	59	27	58	29	46	24
E-coli	10^3cfu/ml	18	7	15	12	19	9	18	9	15	8