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Full Length Research Paper

Assessing Water Quality and Portability of Rivers in Rivers State, Nigeria: A Physicochemical Analysis

***Ukpaka C. P. and Chuku J.**

Department of Chemical/Petrochemical Engineering, Rivers State University of Science and Technology, Nkpolu, P.M.B. 5080, Port Harcourt, Nigeria

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The research work was focus on examining the physiochemical parameters of some rivers within Rivers state (Port Harcourt, Obi Akpor, and Oyigbo) as well as the portability of the river water for human utilization and for agricultural purposes. Based on these physiochemical parameters results obtained from the various rivers indicate high level of contamination. All the four rivers sampled, results obtained revealed that the industrial activities is one of the major agent of pollution. These findings cast some doubt because many communities living within the river area fish daily and use the fish for domestic cooking as well for human consumption as no relative effect on the body system for now. Some of the communities use the river water for drinking and washing. The oral examination on the quality and effect of the river water to them indicate positive answer "no effect on us'' the water is good for human utilization. In conclusion, the results obtained from the research work indicate high level of pollution. Although the effect on people is insignificant for now, but in the next ten years the effect on the people will be significant, if they continued to use these rivers water as a source of their drinking water. The toxicity of the river water will also be high in such a way that it will be corrosive in nature and bad for inhabitant.

Keywords: Investigating, Physiochemical Parameters, Portability, Rivers Water, Nigeria.

INTRODUCTION

The effect of physiochemical parameters on the quality of river water has become one of the major environmental challenges in our society today. However, numerous models and analyses have been carried out to determine the effect of physicochemical parameters in soil as well as in water environment, which is affected by various physical and chemical parameters. But the cost of embarking on some of them has become a major concern to the scientist in this field. With the understanding of the water environment it can be seen that most river water depends on the physical and chemical factors found in their environment (Sinninghe, Rijpstra, Hopmans, Prahl, Wakeham, Schouten, 2002).

MeMeekin, Chandler, Doe, Garland, Olley, Putro and Ratkowsy, 1987. Ralkowsky, Lowry, McMeekin, stokes and Chandler, 1983; UsGeological Survey Circular, 1973; Rosso, Lobry, Bajard and Flandrois, 1995; Ukpaka, 2005, 2006, 2008, 2009, 2010, and 2011).

Water is the chemical substance with chemical formula H_2O: one molecule of water has two hydrogen atoms covalently bonded to a single oxygen atom. Water appears in nature in all three common states of matter and may take many different forms on earth: water vapor and clouds in the sky; seawater One of the most serious forms of water pollution is oil spill and it has often been used in connection with losses of crude oil or petroleum products to the marine environment (Wijtzes, De-Wit, In-Hun, Van't and Zwietering, 1995). About 10% of the oil spilling into the sea comes from the tanker accidents. A typical example is the wreck of Exxon Valdez in 1989 that spilled 240,000 barrels (30,000 tons) of crude oil into Prince William Sound in Alaska (Wheeler and Ho-cking, 1988). The frequency of large – scale spillage of

*Corresponding Author E-mail:chukwuemeka24@yahoo.com

petroleum and its products in the last two decades has been alarming and the pollution it has caused has resulted in adverse ecological effects (Ukpaka, 2006). The existence of liquid water and to a lesser extent its gaseous and solid forms, on earth are vital to the existence of life on Earth as we know it (Aciego and Brookes, 2008 and 2008a; Anderson and Domseb, 1973; Arao, 1999; Rosso, Lobry and Flandrois, 1993; Ukpaka, 2005a, 2006a).

The physiochemical parameters of water that determines the survival and growth of microorganisms in them varies according to the requirement of these organisms. Hence, physiochemical parameters are the physical and chemical factors, *physical factors*-temperature, pressure (air pressure), osmotic pressure, pH, Dissolved oxygen, turbidity/underwater light, electrical conductivity, relative humidity, sunlight or rainfall, light and shade, current velocity, soil moisture, soil texture, turbidity and suspended solids. *Chemical factors* - carbon, sulfur, phosphorus, water, salinity, nitrogen, trace elements and growth factors (organic) vitamin, BOD (Biochemical oxygen demand), total hardness, ion content. The existence of microorganisms in the soil or water depends on the requirements of the organisms which happen to be the physiochemical parameter (Ukpaka, 2004, 2007, 2008a, 2009a; Ratkowsky, Lowry, McMeekin, Stokes, and Chandler, 1983; Anderson, Nilsson and Saetre, 2000; Gibson, Baranyi, Pitt, Eyles and Roberts, 1994 and Appuhn, Joergensen, Raubuch, Scheller and Wilke, 2004).

The importance of this study is to enable us determine the quality and the portability of these river water for domestic and industrial uses. To examine the physicochemical conditions for now and predict the characteristics of the river water in terms of domestic and industrial uses as well as the effect on human being. Hence the measurement of physical and chemical parameters, therefore, becomes an integral part of any study design where the intention is to observe change in species, populations, activities or function on an outcome of microbial population on various river water, each river water to ascertain its effect of physicochemical parameters on their growth as well. The microbial population was examined in compare microbial growth in various physiochemical conditions of water environment in the sampled areas. A way forward to reduce the level of environmental degradation of these rivers as well ascertain their effect currently on the environment in terms of human being for those that uses river water for domestic purposes.

The physiochemical parameters that influence their growth are numerous. However, in this research the following physiochemical parameters were considered which includes: Temperature, P^H, Salinity, Dissolve Oxygen, COD, BOD, and Conductivity, Turbidity, Total hardness, Chlorine, Total alkalinity, Nitrates, Phosph-ate, Sulphate, Cyanide, Ammonium, Aluminum, Calcium, Magnesium, Potassium, Sodium, Arsenic, Total Mercury, Selenium, Lead, Zinc, Total Iron, Copper, Manganese, Cadmium, Total chromium, Total Coliform, Faecal Coliform, E-coli, Faecal Streptococci, Total plate Count.

MATERIALS AND METHODS

Sample Collection

The water samples used for this investigation were collected within the Port -Harcourt city, Obi/Akpo and Oyigbo in Rivers State of Niger Delta area of Nigeria. All the water samples were collected using plastic container. The plastic containers were well wash to avoid contamination of the water samples collected from the various rivers sampled. The samples collected were installed in container containing an ice substance in order to avoid change in concentration and then the samples were transported to FUGRO Laboratory for onward analysis of the samples. The analysis covers the physicochemical parameters as shown in the results presented in this paper. Samples were collected from four (4) rivers within Port-Harcourt city, Obi-Akpo and Oyigbo namely, Choba river be represented as component A, Trans-Amadi Woji river be represented as component B, Elelenwo-Woji river be represented as component C, Oyigbo river be represented as component D.

Equipment Used

The following equipment was used in analysis the collected sample in the laboratory which include: Atomic Absorption Spectrophotometer (AAS), water distillation unit, beakers, graduated pipettes, volumetric flasks, refrigerator, heating mantle or hot plate, pH meter, UV spectrometer, stopwatch or electric timer, magnetic stirrer, conductivity meter, glass beakers

Reagent Used

The following reagent was used in analysis the collected sample in the laboratory which includes: phenolphthalein, conc. H_2SO_4, concentrated HCl, concentrated HNO_3, potassium chloride.

Experimental Procedures

Determination of pH in Water Testing Procedure

Calibration *procedure* includes: Set up the pH meter and electrodes according to the manufacturer's instructions, always calibrate the meter against two buffer solutions,

either buffers pH 7.0 and 4.0 or pH 7.0 and 10.0, the range that will bracket the expected pH of the samples to be analyzed, perform calibration as in the pH meter manufacturer's specification.

Sample Analysis of Water and Wastewater procedure includes

Set up the pH meter and electrodes according to the manufacturer's instructions, on completion of the calibration run, rinse the electrodes thoroughly with distilled water, blot dry with soft tissue paper, Insert the electrodes to the sample, record the pH and temperature values after 120 seconds

Data Processing

Illustrates the report of the pH to the nearest 0.01 pH unit.

Determination of Alkalinity in Water and Testing Procedure

Blank Analysis Procedure includes: measure 100ml of distilled water into a conical flask, add 2 -3 drops of phenolphthalein indicator and swirl the flask. There will be no colour change. (Note: If there is any change in colour, discard the blank and repeat steps a and b), to the same solution add a 2 - 3 drops of methyl orange. A yellow coloration will be observed, record the reading on the burette (Initial burette reading), titrate against 0.01M HCl to an orange colour end point, record the reading on the burette (final burette reading), subtract this reading from the sample reading before data processing.

Sample Analysis

Measure 100ml of sample into a conical flask, add 2 -3 drops of phenolphthalein indicator, the colour changes to pink, flask (Note: On addition of phenolphthalein indicator if no colour change is observed, add 2-3 drops of methyl orange or Bromocresol green –methyl red indicator and continue with step c), record the reading on the burette (Initial burette reading), titrate against 0.01M HCl to a colourless end point, to the same solution add 2 – 3 drops of methyl orange the colour changes to yellow, or add 2 – 3 drops of Bromocresol green – methyl red, the colour changes to blue, continue the titration to an orange colour endpoint , record the total volume added.

Data processing;

Total alkalinity (mg/l) as $CaCO_3$ = A x N 50 000
Sample (ml)

Phenolphthalein alkalinity (mg/l) as $CaCO_3$ = A x N 50 000
Sample (ml)
where: A = ml standard acid used and
N = normality of the new standardized acid used.

Determination of Conductivity using Conductivity Meter Test Method (APHA 2510B)

Equipment / Apparatus used are: conductivity meter, glass beakers (50ml, 250ml), volumetric flask (100ml), polythene containers

Testing Procedure

Reagent

The following reagent was used, such as: 0.01N standard solution of potassium chloride (0.746g of dried A.R. grade Potassium Chloride (KCl) dissolved in distilled water and diluted to 1l). This solution gives a conductivity of 1413µS/cm, 0.1N standard solution of potassium chloride (7.46g of dried A.R. grade Potassium Chloride (KCl) dissolved in distilled water and diluted to 1l. This solution gives a conductivity of 12.9mS/cm, 0.39N standard solution of potassium chloride (29.0g of dried A.R. grade Potassium Chloride (KCl) dissolved in distilled water and diluted to 1l. This solution gives conductivity of 50mS/cm. Note: These solutions must be stored in a plastic container and air space kept to a minimum. The shelf life of this solution is one week. Storing at 4oC can increase it).

Calibration procedures are stated below

plug the conductivity and temperature probes into the unit, calibrate the meter with standards 0.001N and 0.1N KCl solution for analysis of samples with low conductivity according to the manufacturer's specification for the equipment, calibrate the meter with standard 0.39N KCl solution for seawater samples or samples with high conductivity in accordance with the manufacturer's specification for the equipment. should the equipment not give this value, the analyst should look for the source of error and rectify the problem.

Sample Analysis of Water and Wastewater Procedure includes

Plug the temperature and conductivity probes into the unit, set the display to read in oC and S/cm respectively by use of the MODE keypad, immerse the probes in the

liquid to be measured. The display will read directly in oC and S/cm or mS/cm

Determination of Total Dissolved Solids using Conductivity Meter

Reagent

The following reagents are used, such as: 0.01N standard solution of potassium chloride (0.746g of dried Potassium Chloride (KCl) dissolved in distilled water and diluted to 1l), 0.1N standard solution of potassium chloride (7.46g of dried Potassium Chloride (KCl) dissolved in distilled water and diluted. These solutions must be stored in a plastic container and air space kept to a minimum. The shelf life of this solution is one week as well storing at $4^{O}C$ can increase it.

Calibration

Calibrated as specified in procedure for conductivity

Sample Analysis Procedure

Plug the temperature and conductivity probes into the unit, set the display to read in ^{O}C and mg/l respectively by use of the MODE keypad, immerse the probes in the liquid to be measured. The display will read directly in ^{O}C and mg/l, result is reported as mg/l .

Determination of Total Hardness in Water

Sample Analysis Procedure includes

Measure 50ml of the sample into a 250ml conical flask, add 1to 2ml of the buffer solution and swirl the flask, add 1 to 2ml drops of the indicator solution and swirl the mixture, a wine red colour will develop, add standard EDTA titrant slowly, with continuous stirring, until the reddish tinge disappear and colour changes to sky blue, prepare a blank with distilled Water and carry out the test as stated above from steps a in the same condition.

Data processing,

Hardness (ETDA) as mg $CaCO_3$/L = $\frac{(A-B)X \quad M \quad X}{\frac{100\ X100}{S}}$

where; A = Standard EDTA solution required for titration of the sample (ml), B = Standard EDTA solution required for titration of the blank (ml), M = Molarity of the EDTA solution, S = Sample volume used for the analysis, ml, 100 = molar mass of $CaCO_3$, 1000 = conversion factor to liter.

Determination of Chloride, Ion Test Method: (ASTM D 512 B: Silver Nitrate Titration APHA 4500Cl-)

Equipment / Apparatus

The following equipment/apparatus was used, such as; 250-mL narrow mouth Erlenmeyer flask, 50ml Burette, volumetric flask, conical flask, weighing balance

Testing Procedure

Blank Analysis testing procedure includes: measure 50ml of distilled water into a conical flask, adjust the pH to the phenolphthalein end point (pH 8.3), using sulphuric acid (1 + 19) or NaOH solution (10g/L), add 1.0ml of Potassium Chromate Indicator Solution and mix, add standard AgNO3 solution drop wise from a 25ml burette until the brick-red (or pink) colour persists throughout the sample, repeat the procedure described in steps a –d using exactly one half of the original sample.

Sample Analysis

The following sample analysis was used: measure 50ml of sample into a conical flask, adjust the pH to the phenolphthalein end point (pH 8.3), using Sulphuric acid (1 + 19) or NaOH solution (10g/L)., add 1.0ml of Potassium Chromate Indicator Solution and mix, add standard AgNO3 solution drop wise from a 25ml burette until the brick red (or pink) colour persists throughout the sample, repeat the procedure described in steps a –d using exactly one half of the original sample, dilute to 50mL with water, if the volume of titrant used in step (e) is one half of that used in titrating the aliquot in step (a), proceed to the data processing section, if not, significant interference are present and compensation must be made; alternatively, use another method.

Data Processing,

Calculate the chloride ion concentration in the original sample, mg/L as follows:

$$\text{Chloride, mg/l} = \frac{\{(V_1 - V_2)\ X \quad N \quad X \quad 35450\}}{S}$$

where: V_1 = Standard solution $AgNO_3$ added in titrating the sample prepared (ml), V_2 = Standard solution, $AgNO_3$ added in titrating the sample prepared (ml), N = normality of standard $AgNO_3$ solution, S = original sample in the 50-ml test specimen prepared (ml)

Determination of Oil and Grease in Water/Wastewater by Infra - Red Spectrophotometry

Test Method using Infra-Red (IR) Spectrophotometry - ASTM D3921

Reagent

The following reagent was used: bonny Light and Bonny Medium crude oil or oil similar in composition to sample, carbon tetrachloride (solvent), anhydrous sodium sulphate, sulphuric acid.

Equipment / Apparatus which includes

Fourier Transform Infra Red (FTIR) spectrometer, separatory funnel (500ml & 1000ml), clean, dry bottles for storing extracts (20ml), glass funnel, 100ml,50ml volumteric flask, clamp and stand, cotton wool, 10mm quartz cells.

Testing Procedure

Sample Extraction

500ml or 1000ml of sample collected in a calibrated glass bottle is sufficient for this test. Acidify sample with H_2SO_4 to a pH of 2 or less at the time of collection, 20ml - 100ml of Carbon tetrachloride (solvent) is used for extraction. Add 20.0ml of solvent to the sample and shake the bottle vigorously for 2 minutes, Empty the contents of the bottle into a separatory funnel. Rinse the bottle with solvent and empty into the separatory funnel, add the remaining solvent into the separatory funnel, shake vigorously, and intermittently release the stopper to release pressure build-up. Allow the contents of the separatory funnel to settle, transfer the bottom layer into a clean bottle through glass funnel in which cotton wool and about 1.0g of anhydrous sodium sulphate has been placed at the aperture to absorb water. A calibration curve of absorbance against concentration values for standard solutions, prepared and analyzed, would be plotted automatically. This graph is stored for use in determination of the oil and grease content of the extracts.

Analysis of Extracts Using FTIR

In determining oil and grease in the extracts, collect an aliquot of the extract into an IR cuvete after equipment initialization, select quant window open stored calibration, click the MP analyzed button to

display the window for qualification, add the saved sample files and the concentrations are displayed.

Data Processing and Reporting

Oil and grease concentration in mg/l

$$= \frac{\text{Instrumentreading(mg/l)x volumeof extractextract(ml)}}{\text{volumeof sample(ml)}}$$

Determination of Sulphate in Fresh Water by Spectrophotometry

Reagents which includes

Standard sulphate solution (dissolve 0,14-79g of anhydrous $Na2SO_4$ in distilled water and dilute to 1l in a volumetric flask, Note: 1ml = $0.100mgSO_4^{2-}$, buffer solutionA: Dissolve 30g magnesium chloride,($MgCl_2.6H_2O$), 5g Sodium acetate,($CH_3COONa.3H_2O$),1.0g potassium nitrate,(KNO_3) and 20ml acetic acid (CH_3COOH) (99%) in 500ml distilled water and make up to 1l, buffer solution B (required when the sample
sulphate concentration less10mg/l) Dissolve 30g magnesium chloride,($MgCl_2.6H_2O$), 5g Sodium acetate,($CH_3COONa.3H_2O$), 0.111g sodium sulphate (Na_2SO_4) and 20ml acetic acid (CH_3COOH) (99%) in 500ml distilled water and make up to 1l, Barium chloride ($BaCl_2$) crystals 20 to 30 mesh.

Testing Procedure

Preparation of Standard Solution for Calibration Curve which includes

Measure 0.00ml, 10.00ml, 20.00ml, 30.00ml and 40.00ml of the standard sulphate solution into separate 100ml volumetric flask, dilute to about half of the container with distilled water, add 20ml of the buffer solution A and mix in stirring apparatus, while stirring add a spoonful of $BaCl_2$ crystals and dilute with distilled water to the 100ml mark, stir for 1 minute at constant speed. The stirring should be at constant rate in all determinations, immediately after stirring pour the solution into 10mm cell and measure the turbidity at 5 minutes at 420nm, these solutions will have sulphate ion concentration of 0.00, 10.00, 20.00, 30.00 and 40.00mg/l respectively, on completion of the calibration run, the software automatically plots the measured absorbance of the standards against the known values for the standards entered, the correlation coefficient for standard curve should be at least 0.990, new calibration curve must be prepared after every 3 months, or if sample cell, lamp, or alteration is made to the procedure (Example: Purchase of new set of reagents).

Analysis sequence procedure includes the following: calibration blank, standards in increasing order, procedural blank, samples, quality control standard, blank (distilled water), repeat steps v and vi after every 10 samples.

Sample analysis procedure for turbidity includes the following: measure 100ml sample or a suitable volume into a 250ml Erlenmeyer flask or Beaker. Dilute to 100ml with distilled water if required, add 20ml of the buffer solution A and mix in stirring apparatus, while stirring add a spoonful of $BaCl_2$ crystals and begin timing immediately, Stir for 1 minute at constant speed. The stirring should be at constant rate in all determinations, immediately after stirring, pour the solution into 10mm cell and measure the turbidity within 5 minutes at 420nm.

Data Processing

SO_4^{2-}mg/l = $MgSO_4^{2-}$ 1000ml, sample volume (ml)

Determination of Phosphate in Water Test Method: (APHA 4500-P D)

Equipment / Apparatus which includes: UV spectrometer, stopwatch or electric timer, magnetic stirrer, beakers, volumetric flask, pipette.

Reagents: the following reagents were used: standard phosphate solution (0.2195g anhydrous KH_2PO_4 dissolved in distilled water and diluted to 1l), aqueous solution of phenolphthalein indicator (5g phenolphthate disodium salt dissolved in distilled water and diluted to 1l), strong acid solutions (slowly add 300ml conc. H_2SO_4 to about 600ml distilled water when cool, add 4.0ml conc. HNO_3 and dilute to 1l), ammonium molybdate reagent (dissolve 25g $(NH_4)6Mo7O_2.4H_2O$ in 175ml distilled water cautiously add 280ml conc. H_2SO_4 to 400ml distilled water. cool add the molybdate solution and dilute to 1l, stannous chloride reagent (dissolve 2.5g fresh $SnCl_2$. $2H_2O$ in 100ml glycerol, heat in water bath and stir with a glass rod to hasten dissolution).

Testing Procedure

Preparation of Standard Solution for Calibration Curve which includes

Transfer 0.00ml, 1.00ml, 2.00ml, 3.00ml and 4.00ml of the standard phosphate solution into separate 100ml volumetric flask, add 4.00ml of molybdate reagent to each flask and mix thoroughly, add 10 drops (0.5ml) of stannous chloride reagent and mix again, dilute with distilled water to the 100ml mark, after 10minutes but before 12 minutes measure the absorbance at 690nm with 10mm cell, these solutions will have PO_4^{3-} ion concentration of 0.00, 0.50, 1.00, 1.50 and 2.00mg/l respectively. On completion of the calibration run, the program plots the measured absorbance of the standards against the known values for the standards as entered, the correlation coefficient for standard curve should be at least 0.990, new calibration curve must be prepared after every three month, or if necessary to change the cell, lamp, or any other alteration of the instrument or new set of reagents are purchased.

Sample Analysis Procedures are stated: add 1 drop of phenolphthalein indicator to 100ml of the sample containing not more than 2.00mg/l phosphate and free from colour turbidity. If the sample turns pink, add strong acid solution drop-wise to discharge the colour. If more than 5 drops are required take a smaller volume of sample and dilute to 100ml with distilled water after discharging the pink colour with acid, add 4ml of molybdate reagent and mix thoroughly, add 10 drops (0.5ml) of stannous chloride solution and mix again, after 10 minutes but not before 12 minutes, measure the absorbance at 690nm with the 10mm cell.

Analysis Sequence Procedures includes

Calibration blank, standards, procedural blank, quality control standards, samples, quality control standards, blank (distilled water), repeat steps 5 and 6 after every 10 sample.

Determination of Heavy Metals in Solids by Atomic Absorption Spectrophotometry

Reagent/Materials includes: reagent water- prepared by distillation, concentrated HCl, concentrated HNO_3, standard solution of each metal for calibration curve, calcium Solution: dissolve 630mg calcium carbonate, CaCO3, in 50ml of 1+5 HCl. If necessary, boil gently to obtain complete solution. Cool and dilute to100ml with distilled water, dissolve 54.66g calcium chloride hexahydrate ($CaCl_2.6H_2O$) in 500ml of water. Dilute the solution to 1litre with water. 1ml of this solution contains 10mg of calcium, aluminum nitrate solution: dissolve 139g of Al $(NO_3)3$ $9H_2O$ IN 150ml of water. Warm to dissolve completely. Cool and dilute to 200ml,

potassium solution: dissolve 19.07g of KCl in 700ml of water. Dilute the solution to 1litre with water. 1ml of this solution contains 10mg of potassium, sodium solution: dissolve 25.14g of NaCl in 500ml of water, dilute the solution to 1L with water. 2ml of this solution contains 10mg of sodium as well ensure that metals are not introduced into sample during preliminary treatment. Soak glassware such as volumetric flask, beaker and funnel with 10% HCl overnight and rinse with distilled water.

Preparation of Standard Solution for Calibration Curve include

Intermediate standard solutions are prepared every three months from the stock solution.

Testing Procedure and Sample Preparation Using ASTM D3976

The procedure includes samples collected in plastic bags; store sample at 40^{o}C if analysis is to be performed within one week. Otherwise, store the sample at –200C until analyzed, mix the sample thoroughly. Discard large particles with size >1mm and take about 25g of representative sample, oven dry the sample at 105^{o}C $\pm$ 2^{o}C for two hours. Disaggregate the dried sample by gently crushing the lumps in a mortar with a pestle to less than 1mm particle size, sample Digestion = AOAC 969.23

Equipment Operations includes: switch on the AAS, switch AAS and Auto-sampler on simultaneously if auto-sampler is required for analysis, switch on the computer/printer, activate solar software in computer, install hallow cathode lamp of element selected and align to ensure that ray path is not blocked, open methods/Spectrometer widow and select element of interest from periodic table, ensure that spectrometer parameters (Lamp current %, Wavelength, band-pass, background correction) are correctly entered, burner height should be set to 18 on the burner scale for all metals, switch on hallow cathode and deuterium lamp (for background correction). Ensure that both rays are superimposed to one another, click actions menu and select set-up optics for equipment to automatically set lamp wavelength, open methods/spectrometer window and enter analysis sequence/sample details.

Note, The order of entry must follow the sequence below: calibration blank (distilled water), standard solutions (in increasing order), procedural blank, Q.C Standard, samples, spiked sample, Q.C. standard, mid-point standard, blank (distilled water), repeat steps vii to ix after every 10 samples, enter auto-zero before each blank, QC standard solution and samples, open calibration window and enter calibration standards in ascending order. Select linear least squared fit for method of calibration and set the coefficient factor to 0.99, ensure gas lines and pressure gauges are properly secured, turn on air pump, ensure that pump outlet pressure is 2.5bars (35PSI) and gauge outlet pressure for acetylene and Nitrous oxide are 10PSI and 35PSI (2.5bars) respectively, ignite flame by pressing ignition button on AAS until flame comes on, click actions menu and set up flame, allow 10min elapse time for flame to stabilize or optimize, aspirate blank (1+499 HNO3:Distilled water) for 5 minutes to enable flushing of burner system, carryout instrument performance checks by aspirating the highest calibration standard. Adjust burner components (Impact bead knob, vertical/horizontal flame positioning knob) to attain maximum absorbance, click actions menu and select auto-zero while still aspirating blank, for equipment to set parameters for maximum performance.

Calculation of Results

Metal content, by mass of sample dried at 105oC, mg/kg: Results can be calculated manually with the formula below, or automatically by the instrument if the sample mass is entered into the sample amount column and extract volume is entered into the sample volume column;

Metal concentration in mg/kg $= \frac{(A - B)C}{D}$

where: A = concentration of metal in sample, mg/l as determined by AAS, B = concentration of the metal found in blank, mg/l, C = volume of extract, ml, D = weight of dry sample.

Determination of Exchangeable Cations (Ca, Mg, K, Na) Test Method

Sample Preparation Procedure: ASTM D5198
AAS Measurement: Mg, Ca, Na and K : APHA 20th edition 3111B / ASTM D3561
Al and Ca APHA 20th edition 3111D

Equipment/Apparatus include

Atomic absorption spectrophotometer (AAS), water distillation unit, beakers: 100ml, 200ml, 1l & 2l, graduated pipettes, 1ml, 2ml, 5ml, 10ml, 20ml and 25ml, volumetric flasks, 50ml, 100ml, 500ml and 1l, polypropylene sample container and polyethylene cap, refrigerator, heating mantle or Hot Plate, fume cupboard, glass funnel, medium speed filter paper.

Reagents / Materials include

Reagent water – prepared by distillation, concentrated HCl, concentrated HNO_3, standard solution of each exchangeable caution for calibration curve, prepare intermediate standard solution (100mg/l) by diluting 10ml of stock solution to 1l, working standard solutions of exchangeable cautions (Mg, Ca, Al, K, and Na) are prepared according to Table 1.0, stock Q.C. solution of each caution: 1000mg/l standard purchased from Accustandard Europe or any other accredited company, 50mg/ml of lanthanum solution: (134g LaCl3 .7H2O dissolved in 1000ml distilled water, stock potassium solution: 190.7g of potassium chloride in 1000ml distilled water, stock sodium solution: 254.2g of sodium chloride in 1000ml distilled water. Ensure that metals are not introduced into sample during preliminary treatment. Soak glassware such as volumetric flask, beaker and funnel with 10% HCl overnight and rinse with distilled water.

Determination of Nitrate in Water by Spectrophotometry

Testing Procedure

Preparation of Calibration Curve includes;
Measure 0.00ml, 1.00ml, 2.00ml, 3.00ml and 4.00ml of the intermediate standard nitrate solution into separate 100ml volumetric flask and dilute to the mark with distilled water. The solutions will have nitrate ion concentration of 0.00, .0.50, 1.00, 1.50 and 2.00mg/l respectively, transfer 1.00ml of each solution into separate sample vial, add 0.5ml of the brucine reagent, rapidly add 2.00ml of conc. sulphuric acid and mix for about 30 seconds, stand for 5 minutes, mix again and add 2.00ml of distilled water, and continue mixing for about 30 seconds, allow vial stand in cold water for about 5 minutes or in cold air for 15 minutes, measure the absorbance at 410nm using 10mm cell in the UV-4 Unicam spectrometer with the vision software. On completion of the calibration run, the program plots the measured absorbance of the standards against the known concentration values for the standards as entered, the correlation coefficient for the standard curve should be at least 0.990. New calibration curve must be prepared, every 3 months, or if it is necessary to change the cell, lamp, or if any other alteration in the procedure (Example: Purchase of new set of reagents).

Sample Analysis Procedure include

Analyse two standards and a calibration blank to check the reliability of the calibration curve before every analysis. If the standard is outside 90 to 110% of the expected concentration, repeat the analysis. If it is still outside the limit, re-zero the instrument and reanalyse. If it still falls outside, stop analysis and recalibrate instrument, transfer 1.00ml of sample into a vial and begin mixing as stated above which includes analysis sequence, blank, standards, QC.STD, sample NO_3 - mg/l = mg/l NO_3- from the graph - reagent blank

RESULTS AND DISCUSSION

Results obtained from the investigation were presented in tables and figures as well as mathematical tools were used to evaluate the mean, standard deviation and other statistical parameters (t-test), for the comparison of the water composition etc. *Arithmetic mean*: This is the same as the average. Also the mean of a set of scores is the aggregate divided by the number of scores. (By aggregate we mean the sum of the scores in the set). Considering the experimental results values for the four different samples as presented for the various rivers: Choba river be represented as A, Oyigbo river be represented as B, Trans-Amadi Woji river be represented as D, Elelenwo-woji river be represented as C; the parameters are represented alphabetically as presented in Tables below:

For sample A,

$$\bar{X} = \frac{\sum A}{N}$$

$$\bar{X} = \frac{1360.2025}{36} = 37.78$$

For sample B,

$$\bar{X} = \sum \frac{B}{N}$$

$$\bar{X} = \frac{1,239.0452}{36} = 34.42$$

For sample C,

$$\bar{X} = \sum \frac{C}{N}$$

$$\bar{X} = \frac{20,023.9352}{36} = 556.22$$

For sample D,

$$\bar{X} = \sum \frac{D}{N}$$

$$\bar{X} = \frac{12,676.5652}{36} = 352.1$$

Applying T-Test method on above data: T-test is used to assess whether two (2) groups are statistically different from each other. Thus, it is used whenever there is need to compare two groups.

$$T = \frac{\bar{X}_T - \bar{X}_C}{\sqrt{\frac{V_{AR_T}}{N_T} + \frac{V_{AR_C}}{N_C}}}$$

Let the fresh water values for A and B be V_T, V_C

Let the salt water values for c and C be V_T, V_C

For the fresh water, Applying T-test formula
Variance for fresh water A
Var_T = 34548.30
Variance for fresh water B
Var_c = 938.861
Solving with t-test method gives:

$$T = \frac{37.78 - 34.42}{\sqrt{\frac{34548.30}{36} + \frac{938.861}{36}}}$$

$$T = \frac{3.36}{\sqrt{959.675 + 26.079}}$$

$$T = \frac{3.36}{31.397}$$

Table 1. Analysis results of physiochemical parameters of the various rivers water (A)

Fresh Water Samples				Salt Water Samples				
For sample A		For Sample B		For sample C		For Sample D		WHO
A1	5.56	B1	5.88	C1	6.46	D1	6.50	6.5-8.5
A2	33.0	B2	58.0	C2	20.0	D2	28.0	5
A3	21.1	B3	20.8	C3	5540	D3	3450	500
A4	35.2	B4	34.7	C4	9240	D4	5730	1000
A5	3.84	B5	3.84	C5	1042	D5	768	150
A6	0.001	B6	0.001	C6	0.001	D6	0.001	-
A7	20.0	B7	15.6	C7	20.0	D7	40.0	-
A8	32.0	B8	22.0	C8	30.2	D8	64.4	-
A9	1.76	B9	1.36	C9	1465	D9	86.0	250
A10	1.00	B10	4.57	C10	5.08	D10	35.5	-
A11	0.12	B11	0.22	C11	0.80	D11	0.63	250
A12	0.50	B12	0.55	C12	0.30	D12	1.14	-
A13	0.07	B13	0.15	C13	3.51	D13	2.71	100
A14	8.81	B14	9.17	C14	5.89	D14	5.90	-
A15	0.01	B15	0.01	C15	0.01	D15	0.01	250
A16	0.02	B16	0.02	C16	0.02	D16	0.02	40.0
A17	0.10	B17	0.10	C17	0.10	D17	0.10	0.07
A18	0.70	B18	0.92	C18	34.2	D18	22.5	1.5
A19	0.20	B19	0.23	C19	230	D19	129	0.2
A20	1.33	B20	0.73	C20	64.7	D20	38.3	70
A21	1.17	B21	0.88	C21	945	D21	432	30
A22	0.001	B22	0.001	C22	0.001	D22	0.001	-
A23	0.0002	B23	0.0002	C23	0.0002	D23	0.0002	200
A24	0.001	B24	0.001	C24	0.001	D24	0.001	0.01
A25	0.01	B25	0.001	C25	0.01	D25	0.01	0.001
A26	0.05	B26	0.05	C26	0.05	D26	0.05	0.01
A27	0.49	B27	2.14	C27	0.44	D27	0.63	0.01
A28	0.05	B28	0.05	C28	0.05	D28	0.05	3.0
A29	0.10	B29	0.10	C29	0.10	D29	0.10	0.3
A30	0.002	B30	0.002	C30	0.002	D30	0.002	1.0
A31	0.01	B31	0.01	C31	0.01	D31	0.01	0.5
A32	50.0	B32	36.0	C32	1.02×10^3	D32	61.0	0.005
A33	13.0	B33	0.00	C33	0.00	D33	0.00	0
A34	0.00	B34	0.00	C34	0.00	D34	0.00	0
A35	10.0	B35	11.0	C35	68.0	D35	0.00	0
A36	1.12×10^3	B36	1.01×10^3	C36	1.20×10^3	D36	1.00×10^3	0
Total =	1360.2025		1239.0452		20,023.9352		12,676.5652	

Mathematical application using statistical approach, calculating for the Arithmetic mean in the four different samples will be:
Given the formula,

$\bar{X} = \frac{\sum X}{N}$, where x is the sum of the samples in a set, n is the number of sample, $\bar{x}$ is the arithmetic mean

Table 2a. Statistical approach in evaluating the data obtained from fresh water river.

A	Sample (x)	$\sqrt{\frac{\sum(x-\bar{x})}{n-1}}$	s^2
A1	5.56	5.430	29.485
A2	33.0	0.808	0.653

Table 2a. Continue

A3	21.1	2.819	7.946
A4	35.2	2.819	7.946
A5	3.84	0.436	0.190
A6	0.001	5.737	32.913
A7	20.0	6.386	40.781
A8	32.0	3.005	9.030
A9	1.76	0.977	0.955
A10	1.00	6.088	37.064
A11	0.12	6.216	38.639
A12	0.50	6.366	40.526
A13	0.07	6.301	39.703
A14	8.81	6.374	40.628
A15	0.01	4.897	23.981
A16	0.02	6.384	40.755
A17	0.10	6.383	40.743
A18	0.70	6.369	40.564
A19	0.20	6.268	39.289
A20	1.33	6.352	40.348
A21	1.17	6.161	37.958
A22	0.001	6.188	38.291
A23	0.0002	6.386	40.781
A24	0.001	6.386	40.781
A25	0.01	6.384	40.781
A26	0.05	6.378	40.781
A27	0.49	6.369	40.564
A28	0.05	6.303	39.727
A29	0.10	6.378	40.679
A30	0.002	6.86	47.057
A31	0.01	6.384	40.755
A32	50.0	2.066	4.268
A33	13.0	4.186	17.523
A34	0.00	6.386	40.781
A35	10.0	4.696	22.052
A36	1.12×10^3	182.930	33463.385
Total =	1360.2025	356.933	34548.30

Table 2b. Statistical approach in evaluating the data obtained from fresh water river (B)

B	**Sample(x)**	$\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$	s^2
B1	5.88	4.824	23.271
B2	58.0	3.985	15.880
B3	20.8	2.302	5.299
B4	34.7	2.302	5.299
B5	3.84	0.047	0.002
B6	0.001	5.168	26.708
B7	15.6	5.817	33.837
B8	22.0	3.181	10.119
B9	1.36	2.099	4.405
B10	4.57	5.588	31.226

Table 2b. Continue

B11	0.22	5.046	25.462
B12	0.55	5.781	33.419
B13	0.15	5.733	32.867
B14	9.17	5.793	33.559
B15	0.01	4.268	18.216
B16	0.02	5.816	33.826
B17	0.10	5.814	33.802
B18	0.92	5.801	33.652
B19	0.23	5.662	32.058
B20	0.73	5.779	33.397
B21	0.88	5.695	32.433
B22	0.001	5.669	32.138
B23	0.0002	5.517	30.437
B24	0.001	5.818	33.849
B25	0.001	5.817	33.837
B26	0.05	5.816	33.826
B27	2.14	5.809	33.744
B28	0.05	5.456	29.768
B29	0.10	5.809	33.744
B30	0.002	5.801	33.652
B31	0.01	5.818	33.849
B32	36.0	5.816	33.826
B33	0.00	0.267	0.071
B34	0.00	5.818	33.849
B35	11.0	3.958	15.666
B36	1.01×10^3	5.279	27.868
Total =	1239.0452	221.920	938.861

Table 3a. Statistical approach in evaluating the data obtained from salt water river (C)

C	Sample(x)	$\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$	s^2
C1	6.46	92.966	8642.677
C2	20.0	90.638	8215.247
C3	5540	842.413	709659.633
C4	9240	842.413	709659.633
C5	1042	1467.826	2154513.166
C6	0.001	82.112	6742.381
C7	20.0	94.018	8839.384
C8	30.2	90.637	8215.065
C9	1465	88.914	7905.699
C10	5.08	153.612	23596.646
C11	0.80	93.159	8678.599
C12	0.30	93.883	8814.018
C13	3.51	93.968	8829.985
C14	5.89	93.425	8728.231
C15	0.01	93.023	8653.279
C16	0.02	94.017	8839.196
C17	0.10	94.015	8838.820
C18	34.2	94.001	8836.188
C19	230	88.237	7785.768
C20	64.7	55.141	3040.529
C21	945	83.082	6902.618
C22	0.001	65.715	4318.461
C23	0.0002	94.018	8839.384

Table 3a. Continue

C24	0.001	94.018	8839.384
C25	0.01	94.018	8839.384
C26	0.05	94.017	8839.196
C27	0.44	94.009	8837.692
C28	0.05	93.944	8836.475
C29	0.10	94.009	8837.692
C30	0.002	94.001	8836.188
C31	0.01	94.018	8836.384
C32	1.02×10^{3}	94.018	8839.384
C33	0.00	76.777	5894.907
C34	0.00	94.018	8839.384
C35	68.0	82.3528	6782.017
C36	1.20×10^{3}	108.818	11841.357
Total =	20,023.9352	3,391.070	3859994.74

Table 3b. Statistical approach in evaluating the data obtained from salt water river (D)

D	**Sample(x)**	$\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$	s^2
D1	6.50	58.422	3413.130
D2	28.0	54.788	3001.723
D3	3450	528.636	279456.021
D4	5730	528.636	279456.021
D5	768	909.026	826328.269
D6	0.001	70.295	4941.387
D7	40.0	59.521	3542.749
D8	64.4	52.759	2783.512
D9	86.0	48.635	2365.363
D10	35.5	85.846	7369.536
D11	0.63	53.520	2864.390
D12	1.14	89.459	8002.913
D13	2.71	59.328	3519.812
D14	5.90	59.603	3552.518
D15	0.01	58.3523	3404.956
D16	0.02	59.519	3542.511
D17	0.10	59.517	3542.273
D18	22.5	59.504	3540.726
D19	129	55.718	3104.496
D20	38.3	53.049	2814.196
D21	432	13.500	182.250
D22	0.001	59.521	3542.749
D23	0.0002	59.522	3542.868
D24	0.001	59.519	3542.511
D25	0.01	59.519	3542.511
D26	0.05	59.512	3541.678
D27	0.63	59.512	3541.678
D28	0.05	59.512	3541.678
D29	0.10	59.520	3542.630
D30	0.002	59.519	2421.511
D31	0.01	49.209	2421.526
D32	61.0	49.209	2421.526
D33	0.00	59.520	3542.630
D34	0.00	59.520	3542.630

Table 3b. Continue

D35	0.00	59.503	3540.607
D36	1.00×10^{3}	109.510	11992.440
Total =	12,676.5652	3,391.070	1508950.45

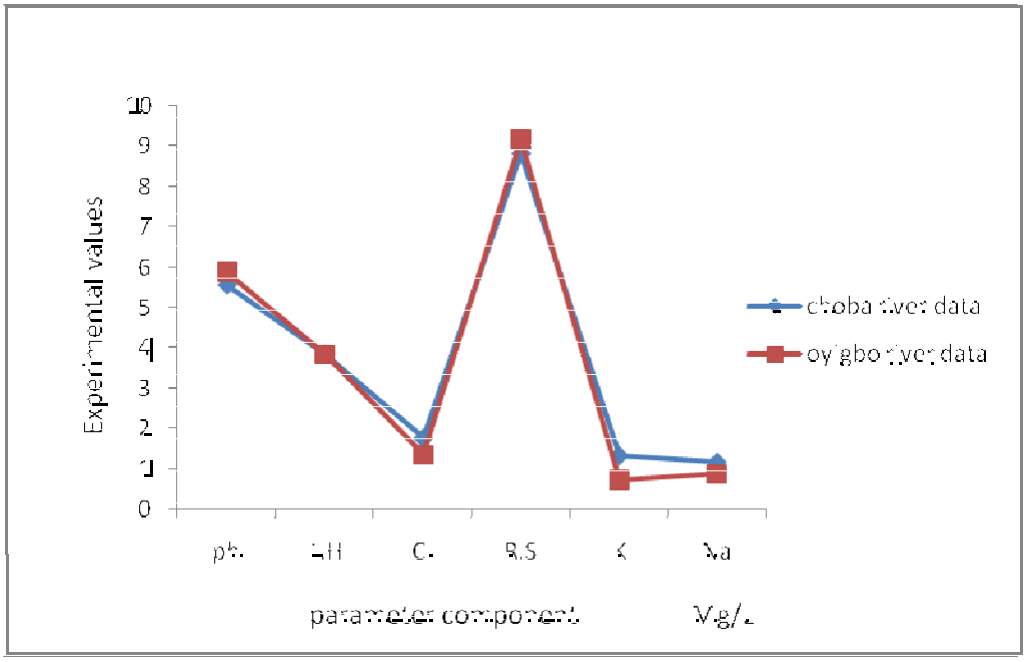

Figure 1. Graph of experimental values against parameter component of pH, T.H, Cl, RS, K, and Na for Choba and Oyigbo river

t = 0.107

Therefore, the t-test value for the river water is 0.00058 Similarly, this is also done for the salt water.

$$T = \frac{556.22 - 352.13}{\sqrt{\frac{3859994.74}{36} + \frac{1508950.45}{36}}}$$

$$T = \frac{204.09}{\sqrt{107222.08 + 41915.29}}$$

$$T = \frac{204.09}{386.18} T = 0.528$$

Hence, for salt water:
tcal (0.528)‹ tab (5368945.19)
for fresh water:
tcal (0.107)‹ tab (35487.161)

Figure 1 illustrates the relationship between the Choba river data and Oyigbo river data for the following physiochemical parameters, pH, Total Hardness, Chlorine, Reactive Silica, potassium, and Sodium. Comparing the values obtained in this two fresh water samples. The results indicate that pH value of Oyigbo river data is greater than Choba river data. The total hardness of both river data is equal. Reactive silica of Oyigbo river data is slightly greater than Choba water. But potassium and sodium value of Choba river data is greater than Oyigbo river data and when compared with the WHO Standard the result obtained indicate the status of Choba and Oyigbo river.

Figure 2 illustrate the relationship between the Choba river data and Oyigbo river data for the following physiochemical parameters, Turbidity, Conductivity, Total coliform, BOD and COD. The results indicate that turbidity value of Choba river data is lesser than Oyigbo river data, the conductivity value of Choba river is greater than Oyigbo, the BOD and COD values of Choba river data is greater than Oyigbo river data and when compared with the WHO standard the results obtained indicate the status of Choba and Oyigbo river.

Figure 4 illustrate the relationship between Choba river data and Oyigbo river data for the following physiochemical parameters, phosphate, calcium, total iron, manganese, comparing the values obtained in this two fresh water samples. The results indicate that phosphate and calcium values in both fresh water are equal, total iron value of Oyigbo river data is greater than Choba river data. Manganese value of Choba river data is greater than Oyigbo river data and when compared with the WHO standard the results obtained indicate the

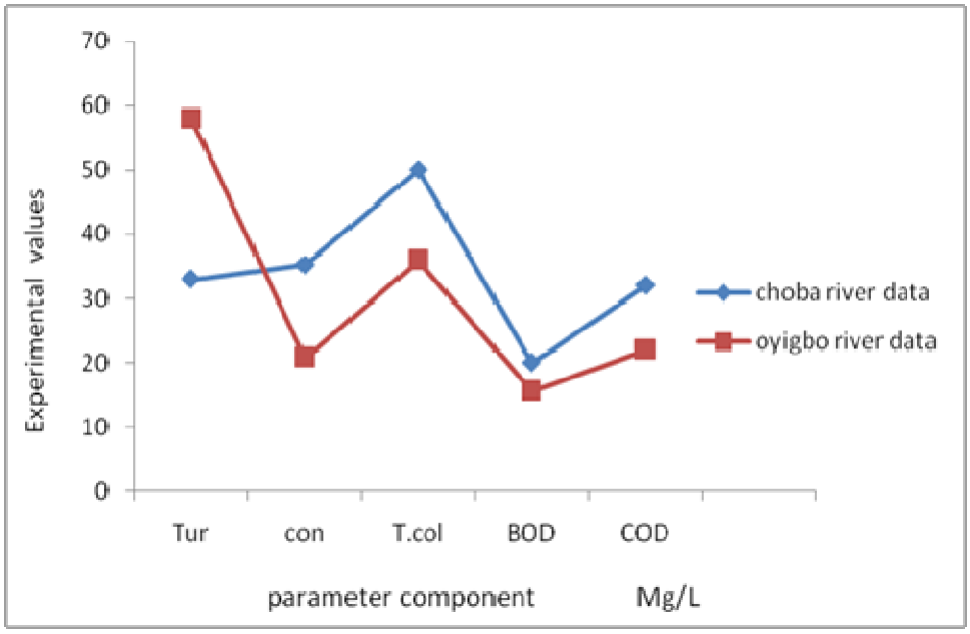

Figure 2. Graph of experimental values against parameter component of Tur, Con. T.col. BOD and COD for Choba and Oyigbo river

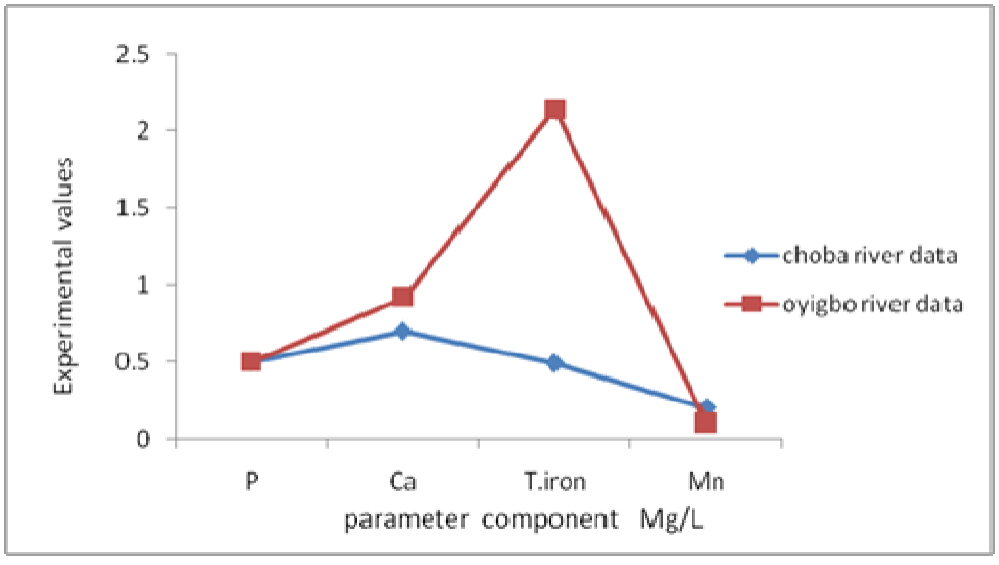

Figure 3. Graph of experimental values against parameter component of P, Ca, T,.iron, and for Choba and Oyigbo river

status of Choba and Oyigbo river.

Figure 4 illustrate the relationship between the Trans-Woji river data and Elelenwo river data for the following physiochemical parameters, turbidity, BOD, total alkalinity, potassium. Comparing values obtained in this two salt water samples. The results shows that the turbidity, BOD, Total alkalinity values of trans- Woji river data is greater than Elelenwo river data. While the potassium value of Elelenwo river data is greater than Trans- Woji river data and when compared with the WHO standard the results obtained indicate the status of Trans-Woji and Elelenwo river.

Figure 5 illustrates the relationship between Trans-Woji data and Elelenwo river data for the following physiochemical parameters, ph, reactive silica, sulphate, and phosphate. the result shows that the pH and reactive

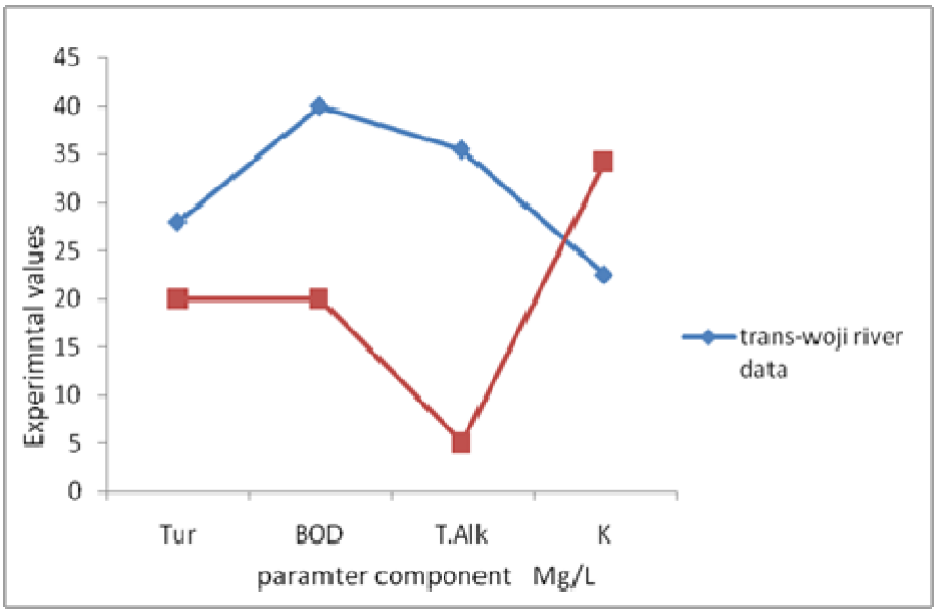

Figure 4. Graph of experimental values against parameter component of Tur, BOD, T,,Alk, K for Trans-Woji and Elelenwo river

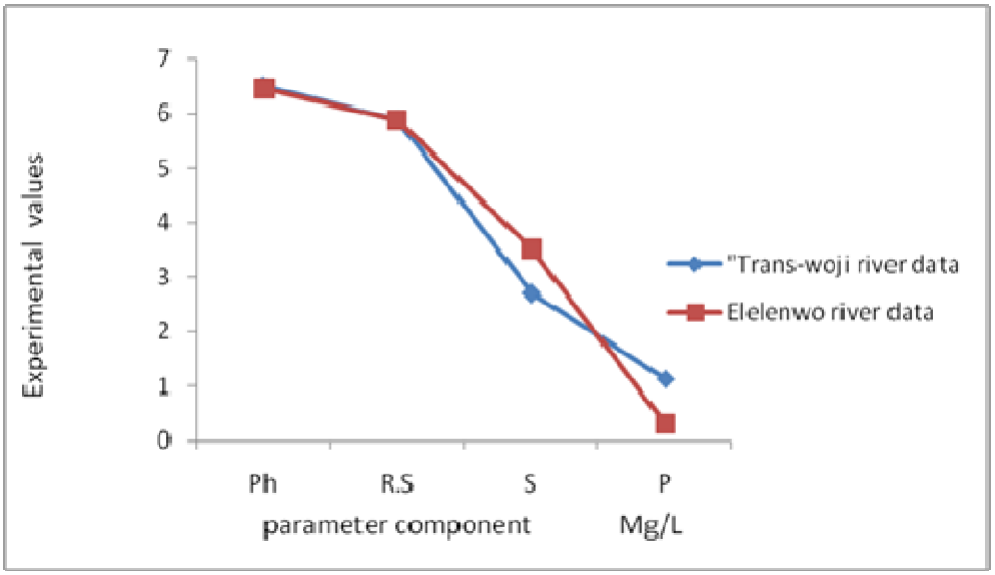

Figure 5. Graph of experimental values against parameter component of pH, R.S, S, and P, for Trans- Woji and Elelenwo river

silica values of both river data are equal, while the sulphate value of Elelenwo river data is greater than Trans-Woji. The phosphate of Trans-Woji is greater than Elelenwo river data.

CONCLUSIONS

In conclusion, the results obtained from the research work indicate high level of pollution, as shown in Table 1, the physiochemical parameters for the four river water sampled determines the rate of pollution in the different river water. From the calculated results, it was observed that both river waters were not portable for human consumption. The fresh river water is less polluted than the salt water. Hence aquatic animals will survive and grow in the fresh environment than the salt water. Also since the fresh water is less polluted, it can be treated, easily when subjected to further water treatment compared to the salt water. The companies discharging

their industrial waste into these rivers without adequate treatment should be caution. The communities living along the river side should also be caution not to use the river water for drinking since the level of contamination is high and above the World Health Organisation (WHO) recommendation for portable water.

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Nomenclature

A_1, B_1, C_1 and D_1	=	pH of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_2, B_2, C_2 and D_2	=	Turbidity (NTU) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_3, B_3, C_3 and D_3	=	TDS (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_4, B_4, C_4 and D_4	=	Conductivity ($\propto$S/cm) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_5, B_5, C_5 and D_5	=	Total hardness (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_6, B_6, C_6 and D_6	=	Mineral Oil (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-woji river respectively
A_7, B_7, C_7 and D_7	=	BOD (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_8, B_8, C_8 and D_8	=	COD (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_9, B_9, C_9 and D_9	=	Chloride (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{10}, B_{10}, C_{10} and D_{10}	=	Total Alkalinity (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-woji river respectively
A_{11}, B_{11}, C_{11} and D_{11}	=	Nitrate (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-woji river respectively
A_{12}, B_{12}, C_{12} and D_{12}	=	Phosphate (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-woji river respectively
A_{13}, B_{13}, C_{13} and D_{13}	=	Sulphate (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{14}, B_{14}, C_{14} and D_{14}	=	Reactive Silica (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{15}, B_{15}, C_{15} and D_{15}	=	Cyanide (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{16}, B_{16}, C_{16} and D_{16}	=	Ammonium (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{17}, B_{17}, C_{17} and D_{17}	=	Aluminum (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{18}, B_{18}, C_{18} and D_{18}	=	Calcium (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{19}, B_{19}, C_{19} and D_{19}	=	Magnesium (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{20}, B_{20}, C_{20} and D_{20}	=	Potassium (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{21}, B_{21}, C_{21} and D_{21}	=	Sodium (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{22}, B_{22}, C_{22} and D_{22}	=	Arsenic (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{23}, B_{23}, C_{23} and D_{23}	=	Total Mercury (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{24}, B_{24}, C_{24} and D_{24}	=	Selenium (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{25}, B_{25}, C_{25} and D_{25}	=	Lead (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{26}, B_{26}, C_{26} and D_{26}	=	Zinc (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{27}, B_{27}, C_{27} and D_{27}	=	Total Iron (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively
A_{28}, B_{28}, C_{28} and D_{28}	=	Copper (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

A_{29}, B_{29}, C_{29} and D_{29} = Manganese (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

A_{30}, B_{30}, C_{30} and D_{30} = Cadmium (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

A_{31}, B_{31}, C_{31} and D_{31} = Total chromium (mg/L) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

A_{32}, B_{32}, C_{32} and D_{32} = Total Coliform (cfu/100mL) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

A_{33}, B_{33}, C_{33} and D_{33} = Faecal Coliform (cfu/100mL) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

A_{34}, B_{34}, C_{34} and D_{34} = E-coli (cfu/100mL) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

A_{35}, B_{35}, C_{35} and D_{35} = Faecal streptococci (cfu/100mL) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

A_{36}, B_{36}, C_{36} and D_{36} Total Plate Count (cfu/mL) of Choba river, Oyigbo river, Trans-Amadi Woji river and Elelenwo-Woji river respectively

COD = Chemical oxygen demand (mg/L)

BOD = Biochemical oxygen demand (mg/L)

RS = Reactive silica (mg/L)

TH = Total Hardness

Con = Conductivity ($\propto$S/cm)

MO = Mineral oil (mg/L)

TM = Total mercury (mg/L)

TI = Total iron (mg/L)

TC = Total Chromium (mg/L)