



Determination of Baseline Data of Physicochemical and Microbiological Quality of Surface Waters in Nsit Ibom Local Government Area of Akwa Ibom State, Nigeria

¹AKPAN, BP; ²UDO, AL; ³*AKPAN, ES

¹Department of Biology, ²Department of Curriculum and Teaching, ³*Department of Physics, College of Education, Afaha Nsit, Akwa Ibom State, Nigeria

*Corresponding Author Email: enobongxst@yahoo.com

*ORCID: <https://orcid.org/0009-0009-5553-2710>

*Tel: +2348027591705

Co-Authors Email: basseyakpan477@gmail.com; agneslambertedutek@gmail.com

ABSTRACT: Surface waters in Nsit Ibom Local Government Area of Akwa Ibom State are the predominant sources of potable water for the rapidly increasing population in the area with the presence of three tertiary institutions. Hence, the objective of this paper was to determine baseline data of the physicochemical and microbiological quality of surface waters in Nsit Ibom Local Government Area of Akwa Ibom State, Nigeria using standard microbiological and analytical procedures and values compared to the World Health Organization WHO and Nigerian Standard for Drinking Water Quality (NSDWQ) recommended levels. Results showed that water from streams 3, 4, 5 and 7 were good as source of drinking water. Water from Ikot Oku Nsit and Anyam streams had high levels of 28.46 mg/l and 23.05 mg/l, 46.14mg/l and 46.51 mg/l, 51.85 mg/l and 56.42 mg/l for Chemical Oxygen Demand, Total Suspended Solids and nitrates respectively, making it necessary for treatment. Water from stream 6 had high values of Nitrates and Fecal Coliform well above the WHO recommended levels rendering it not good for human consumption without treatment. Proper sensitization of the populace on water management, regular assessment of the surface waters and the revamping of the public water works at Afaha Nsit, have been recommended.

DOI: <https://dx.doi.org/10.4314/jasem.v28i5.13>

Open Access Policy: All articles published by **JASEM** are open-access articles and are free for anyone to download, copy, redistribute, repost, translate and read.

Copyright Policy: © 2024. Authors retain the copyright and grant **JASEM** the right of first publication with the work simultaneously licensed under the **Creative Commons Attribution 4.0 International (CC-BY-4.0) License**. Any part of the article may be reused without permission provided that the original article is cited.

Cite this Article as: AKPAN, B. P; UDO, A. L; AKPAN, E. S. (2024). Determination of Baseline Data of Physicochemical and Microbiological Quality of Surface Waters in Nsit Ibom Local Government Area of Akwa Ibom State, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (5) 1425-1433

Dates: Received: 21 February 2024; Revised: 22 March 2024; Accepted: 20 April 2024 Published: 09 May 2024

Keywords: Physicochemical; Microbiological; Biochemical Oxygen Demand; Chemical Oxygen Demand

The presence of water in liquid form on planet earth is the reason for life and will also be the essence for sustaining the life of organisms and man on this clime (Ghose 2015). While it is known that water covers $\frac{3}{4}$ of the earth's surface, the quantity fit for human consumption is less than 1%. With world population increasing at an alarming rate and the problem of urbanization, the quality of the available 1% is grossly affected such that man needs to keep itself abreast of the water quality around him regularly to avert an outbreak of epidemic like cholera or diarrhea (Altieri 2016; Liyanage and Yamada 2017). Water related diseases such as cholera, diarrhea and bilharzias have

been reported to be on the increase among the poor local people who lack potable water and have resorted to using raw stream and underground water for drinking and domestic purposes (Galadima, *et al*; 2011). As reported in Obeta, Ocheje, and Nwokocho (2015), a survey by WHO has revealed that Nigeria, the most populous country in Africa with over 170 million people, lacks adequate access to improved drinking water supply. According to Dinka (2018), access to water is one of the main goals of the Sustainable Development Goals (SDGs). The UN-SDG goal 6 states that "Water sustains life, but safe clean drinking water defines civilization". According

*Corresponding Author Email: enobongxst@yahoo.com

*ORCID: <https://orcid.org/0009-0009-5553-2710>

*Tel: +2348027591705

to UNICEF (2018), only 26.5 per cent of the Nigerian population use improved drinking water sources and sanitation facilities. Akwa Ibom State, as many other states in Nigeria, lack adequate supply of potable water. In a study on water quality assessment of Odiok Itam and Ibiaku Uruan Rivers in Itu and Uruan local government areas of Akwa Ibom, Denise and John (2014) reported that Biological Oxygen Demand (BOD) fluctuates between 1.4mg/l and 1.8mg/l across stations. Station 1 in the month of January recorded a value of 1.8mg/l as the maximum; while a minimum value of 1.4mg/l was recorded in December also at station I. The BOD values recorded in the study were lower than the recommended WHO standard. The researchers, consequently, noted that low BOD value is an indication of low amount of degradable organic waste. However, the amount present at any point in time could be affected by several factors including the degree of water current, season and amount of rainfall. Meme, Arimoro and Nwudukwe (2014) noted that important physical and chemical parameters influencing the aquatic environment are pH, nutrient, temperature, salinity, dissolved oxygen and biochemical oxygen demand, chemical oxygen demand, colour and flow velocity. Others are total suspended and dissolved solids, total alkalinity and acidity and heavy metals. These parameters need to be ascertained regularly in sources of drinking water to prevent possible outbreak of water borne diseases. According to the US Environmental Protection Agency (2016), Physical contaminants primarily impact the physical appearance or other physical properties of water. Examples of contaminants are sediment or organic material suspended in the water of lakes, rivers and streams from soil erosion. The presence of some of these contaminants may be dangerous to health while some may be indicative of other contaminants. One physical property of water is Turbidity. The Turbidity in water is the reduction of transparency due to the presence of particulate matter such as clay or silt, finely divided organic matter, plankton or other microscopic organisms. These cause light to be scattered and absorbed rather than transmitted in a straight line through the water. The colloidal materials affect turbidity and provide adsorption sites for chemicals that may be harmful or cause undesirable tastes and odors. Disinfection of turbid water is difficult because of the adsorptive characteristics of some colloids and because the solids may partly shield organisms from disinfectant.

Water may be described as hard or soft. Hardness of water is caused by the presence of multivalent metallic cations and is largely due to calcium, Ca^{++} , and magnesium, Mg^{++} ions. Hardness is reported in terms of $CaCO_3$. It is the measure of capacity of water to

react with soap, to produce lather. The low and high value of Hardness has advantages and disadvantages. Ahmed (2010) reported that many of the water that we drink contain toxic chemicals. These chemical substances that are found in water come from natural processes or human activities. Such chemicals that affect quality of drinking water include: Sulphate, Nitrate, Inorganic Phosphorus, Iron, Chlorides, Calcium, Magnesium, Copper, Manganese and Zinc. Some of these substances have harmful effect on humans when ingested in quantities above the threshold while some have little or no effects at all.

Surface water is usually contaminated with micro-organisms which sometime endanger life when the water is consumed by humans. Pathogenic bacteria, viruses and protozoa may cause diseases that vary in severity from mild gastroenteritis to severe and sometimes fatal diarrhea, dysentery, hepatitis, and typhoid fever. According to Ahmed (2010), faecal contamination of drinking water is only one of several faeco-oral mechanisms by which they can be transmitted from one person to another or, in some cases, from animals to people. The most common organisms that are prevalent in contaminated water, according to Bartram and Pedley (1996) include Total coliforms, *Escherichia coli* (*E. Coli*) and Faecal Streptococci, three of which are indicators of faecal contamination of bodies of water. *E.coli* is found in large numbers in the faeces of humans and of nearly all warm blooded animals; as such it serves as a reliable index of recent faecal contamination of water. It is abundant in human and animal faeces, in fresh faeces it may attain concentrations of 109 per gram. It is found in sewage, treated effluents, and all natural waters and soils subject to recent faecal contamination from humans; warm blooded animals, or agricultural activity (Sofos 2014). Some birds are known to carry pathogens that affect humans. Faecal contamination of surface water by birds according to Wither, Rehfish and Austin (2005), can be a source of worry for health managers. Regular assessment of water quality should be considered for those that use surface waters for drinking. Any presence of *E. Coli* in drinking water indicates contamination and such water is not safe for drinking. The quality of drinking water available to any community has an impact on the health of that community. Nsit Ibom Local Government Area is traversed by many streams and rivulets where residents draw their drinking water. There are three tertiary institutions in the local government area; College of Education, Afaha Nsit; Maurid Polytechnic, Mbiaso and Kutiense Institute of Agriculture, Afaha Nsit. The institutions draw students from across the country. Students of these institutions all live off-campus and during the dry

season, depend on the surface waters around for their drinking water. With the increased population in the area caused by the location of three tertiary institutions there, the water quality may be affected as a result of increase in the volume of waste deposited around it. Faecal contamination which can lead to epidemic may be possible. With a student and staff population of about 16,000 from the three tertiary institutions residing in the locality and the local population of about 22,000, with no functional public water supply, the population depends on the streams and rivulets which abound in the community for sources of drinking water and other uses. The course of the rivers, streams and rivulets that passes through Nsit Ibom which is part of the River Catchment goes through other semi-urban areas which would have attendant effect on the water quality before reaching the area. For example, the Kwa Iboe River passes through 5 Local Government Areas (LGAs) in Abia State and 13 LGAs, including Nsit Ibom in Akwa Ibom, making a total of 18 Local Government Areas in all before reaching the Atlantic Ocean (Ituen and Johnson 2015). Hence, the objective of this paper was to determine baseline data of the physicochemical and

microbiological quality of surface waters in Nsit Ibom Local Government Area of Akwa Ibom State, Nigeria.

MATERIALS AND METHODS

Description of Site: Water samples were collected from seven sites of surface waters flowing through villages in Nsit Ibom Local Government Area. Site one is located at the Ikot Oku Nsit stream serving border villages of Uyo Local Government and Ibesikpo Asutan. Site two is at Anyam Stream located at Anyam Nsit. Site three is at Ayie Asana stream of Edeobom which is within the heart of Nsit Ibom. The fourth site is at a stream that forms the boundary between Nsit Ibom and Etinan Local Government Areas at Ikot Iwud/Ikot Ekang villages. The fifth site is at the boundary stream between Nsit Ibom and Etinan at Afaha Nsi/Ikot Ebiyak villages. The sixth site is at the stream that is a boundary between Nsit Ibom and Nsit Ubium at AfahaNsit/Ndiya villages. Site seven is located at the stream at Mbiaso. The sites can be traced using the coordinates presented on table 1.

Table 1. Coordinates of sites of the surface waters.

S/N	Name Of Stream /Village	Date	Time Of The Day	Coordinates	
				Northing	Easting
1.	Ikot Oku Nsit	June 2020	9.00 am & 4.00 pm	4°58'33.0"	7°52'25.3"
2.	Anyam Nsit Stream	June 2020	9.30 am & 4.30 pm	4°56'42.5"	7°53'32.4"
3.	Ayie Asana Edeobom	June 2020	9.40 am & 4.35 pm	4°53'29.7"	7°53'44.9"
4.	Ikot Iwud /Ikot EkangStream	June 2020	9.50am & 4.45pm	4°49'31.5"	7°51'57.1"
5.	Afaha Nsit /Ikot Ebiyak	June 2020	10.15 am & 5.00 pm	4°49'41.9"	7°52'00.8"
6.	Afaha Nsit /Ndiya	June 2020	10.30 am & 5.20 pm	4°47'37.1"	7°53'33.9"
7.	Mbiaso	June 2020	10.45 am & 5.35 pm	4°49'10.2"	7°54'16.7"

Sample Collection: Water samples from each of the streams delineated for the study were collected at source two times daily using two pre-cleaned sample bottles filled to the brim and labeled accordingly; one of 1-L polyethylene type used for estimating major ionic composition and the other of another dark bottle of 1-L used for BOD and COD analyses. They were collected twice daily to obtain the daily mean values for each parameter. It was also to find whether there is impact of usage of the stream during day time on the values obtained in the evening. This provided two samples of water per stream per day for seven days. Samples obtained were analyzed daily or as required by scientific process in the standard Bio-Chemistry and Microbiological Laboratories of University of Uyo. One sample bottle was used for physicochemical analyses and the other for microbiological analyses according to recommended standard procedure for water quality analysis (American Public Health Association APHA, 1998).

Analysis of Water Samples: Physicochemical Analysis: pH and electrical conductivity were measured on site using WTW conductivity meter (LF 320) and WTW 525 or digital water multi parameter measuring instrument. Samples used for BOD and COD were analyzed the same day of sampling whereas the samples collected for major ionic composition were stored at 4°C for only few days until time of analysis. The following major cations and anions in the water samples were analyzed using ion chromatography (Dionex-100). AG4A-SC guard column, AS4SC separating column and SSR1 anion self-regenerating suppressor and conductivity meter were used for the anions (Cl⁻, NO₃²⁻ and SO₄²⁻) respectively. For the major cations (Ca²⁺, Mg²⁺, Na⁺ and K⁺) the CS12 column (250 × 4 mm ID), CG guard column (50 × 4 mm ID) and CDM-2 detector were used. Samples were injected through 25.1 sample loop and eluted at 2.0 ml/min. using Na₂CO₃ in milli-Q water. Data were collected by 4400 integrator from Dionex (Jaradat, Monami and Jiries 1997).

For carbonate and bicarbonate determination, titration with 0.01 mg/l hydrochloric acid was used.

Microbiological Analysis: A total of ninety eight (98) water samples were analyzed, precisely, 10ml of each water sample was accurately measured and mixed with 90mls of sterile water in a conical flask. Flasks were labeled accordingly (Prescott 2004).

Serial dilution of samples: Serial dilutions of the samples were carried out according to the method of Cheesbrough (2004). Precisely, the 10 in 90ml (aliquot) dilution were further diluted by transferring 1ml from the aliquot into a sterile 9ml of dilution blank in a test tube, dilution were further carried out till 10^{-5} dilution factors were obtained.

Estimation of microbial loads in the water samples: Standard microbiological techniques described by Harrigan and MacCance (1990) were employed for the microbiological analysis of these water samples. Total Heterotrophic Bacteria Count (THBC) and coliform counts were estimated by the pour plates methods, while for fungal count, the spread plates method was adopted using Nutrient agar (NA), MacConkey agar (MCA) and Sabouraud Dextrose agar (SDA) as analytical media respectively.

Total fecal coliform count, vibrio count, staphylococcus count, clostridium count, salmonella and shigella counts were estimated by pour plates method using Eosine Methylene Blue Agar (EMBA), Thiosulphate Citrate Bile-Salt Sucrose agar (TCBS), Mannitol Salt Agar (MSA), Re-enforced clostridial agar (RCA), Salmonella Shigella Agar (SSA), respectively, as analytical media.

Incubation of culture media and counting of microbial colonies: The bacterial plates were incubated for 24 hours at 28°C using a Gallenkamp incubator and fungi plates at room temperature for 5-7days.

Microbial colonies that emerged on the incubated plates after were counted with the aid of a Quebee Colony counter and recorded as colony forming unit (CFU/ml) of water sample.

Purification and maintenance of microbial isolates: Representatives or discrete colonies of bacteria from culture plates were picked and repeatedly sub-cultured onto freshly prepared Nutrient agar plates by streak methods and incubated for growth at 28°C for 24 hours. Pure isolates of bacteria were maintained on agar slants as stock and preserved in the refrigerator for further use (Cheesbrough, 2004).

Characterization and identification of Microbial isolates: Bacterial isolates were characterized and identified presumptively based on their morphological and cultural characteristics, confirmatory identification was based on Biochemical reactions. The following Biochemical tests were carried out. Gram staining, motility test, coagulase test, catalase test, spore staining test, oxidase test, urease test, citrate test, starch hydrolysis test, methyl red-Voges Proskauers (MR-VP) test and sugar fermentation test (lactose, glucose, mannitol, maltose, galactose, fructose and sucrose). The results derived from the test for various isolates were collated and the identification was carried out by comparing the characteristics with known taxa using the scheme of Bergy's Manual of Determinative Bacteriology (1994).

Procedures for Biochemical Tests: Morphological and Biochemical Characterization of the Bacterial Isolates: Standard characterization tests (such as Gram staining, catalase, coagulase, motility, starch hydrolysis, methyl-red, Vogues Proskaver, indole, citrate utilization, urease, spore staining, hydrogen sulfide production and sugar fermentation) were performed. The pure culture was identified on the basis of its cultural, morphological and physiological features with those in Bergys Manual of Determinative Bacteriology (De Vos et al., 2009). Details of the methods used in characterization of the isolates are as presented below;

Gram Staining: This differential staining was used to group bacteria in to two major groups; Gram positive and Gram-negative bacteria based on their cell wall composition. In this staining process, a heat-fixed smear was prepared and air-dried.

The smear was covered with crystal violet for 60 seconds, rinsed gently with running water stained with iodine and allowed for 60 seconds, before being rinsed off again. The smear was decolorized with 70% alcohol for 10 seconds and rinsed off immediately.

The smear was counterstained with safranin for 30 seconds and finally washed with clean water and blotted dry. The stained smear was observed under oil immersion objective lens (100x) microscope. Gram positive bacteria-stained purple (the colour of the primary stain) while the Gram-negative bacteria stained red (the colour of the counter stain).

Citrate Utilization Test: This test is used to determine the potential of the bacterial isolate to use citrate as a carbon source and ammonia as its only nitrogen source. The test organisms were inoculated on the surface of sterile molten Simon citrate agar and

incubated for 24 hours at 37°C. Colour change from green to blue around the growth streak indicates a positive reaction for the organism.

Catalase Test: This test was carried out to demonstrate the presence of catalase in the organism. Catalase is an enzyme that catalysis the release of oxygen from hydrogen peroxide (H₂O₂). Two to three drops of hydrogen peroxide were placed on a clean grease free slide. The test organism was transferred to the slide with a sterile loop. Positive result was indicated by an immediate gas bubbling or effervescence off the mixture.

Coagulase Test: This test depends on the ability of some bacteria to produce an extra- cellular coagulase. The coagulase has the ability to coagulate certain blood plasma especially the rabbit and human plasma. It is specifically employed to differentiate *Staphylococcus aureus* from *Staphylococcus* species. A loopful of normal saline was placed on grease free slide. An inoculum of the test organism was emulsified on the saline. A drop of human plasma was added to the suspension and mixed for 5 seconds. Clumping of the plasma indicated a positive result.

Indole Test: This test determines the ability of the test organism to breakdown amino acid (tryptophan) releasing indole. Test tubes containing 1% tryptone was autoclaved at 121°C for 15 minutes and left to cool. Fresh test organism was inoculated and incubated for 48 hours at 37°C. Then 0.5ml Kovac reagent was mixed into the test tube. A red ring colouration on the top of the liquid after 24 hours indicates a positive reaction, negative result still remained yellow.

Oxidase Test: Oxidase enzymes play a significant role in the processes carried out by the electron transport system during aerobic respiration. Cytochrome oxidase uses O₂ as an electron acceptor during the oxidation of reduced cytochrome to form water and oxidized cytochrome. A filter paper was placed on a clean petri dish. Two drops of oxidase reagent was added on the filter paper. With a sterile glass rod, the fresh test organism was smeared on the filter paper. A blue colouration after 10 minutes indicated a positive result.

Methyl Red and Voges Proskauer Test: This test is based on the ability of the test bacteria to ferment glucose with the production of acid. This process lowers the pH of the medium to pH 4.5. Glucose phosphate broth was prepared and autoclaved at 121°C for 15 minutes; it was allowed to cool and inoculated with the test organism. The tubes were incubated for 48 hours at 37°C.

Methyl Red test: Approximately 3 drops of methyl red was added into tube containing 2 ml of the broth culture, shaken gently and observed for the formation of bright red coloration.

Voges Proskauer: Approximately 1ml of the mixture of aqueous potassium hydroxide (KOH) and 30% alcohol alpha-naphthol was added into each test tube and shaken vigorously. Production of a pink colouration indicated a positive reaction.

Motility: This test demonstrates the ability of an organism to move from one place to the other with the aid of a locomotive structure like the flagella. The test tube method was used where semi solid nutrient agar was stabbed inoculated with fresh test isolate in a straight line. The test tube was covered with a cotton plug and incubated for 3-5 days. The test tube was examined for spread from the line of stab. An observable spread indicated a positive result.

Urease Test: This test demonstrates the ability of an organism to elaborate urease enzyme. The enzyme is responsible for the breaking down urea to produce ammonia and carbon dioxide. Precisely, 24.5g of Christensen's urea agar was suspended in 1,000 ml of water and autoclave for 15mins at 121°C. Ten (10) ml of 20% urea was dissolved into agar and shaken to mix; it was then poured into Petri dishes. The test organism was then inoculated via streaking on the media and incubated for 24 hours at 37°C. Development of pink coloration indicated a positive urease test while not pink color indicated negative urease test.

Starch Hydrolysis: This test demonstrates the ability of an organism to hydrolyze starch. To determine this, the test isolates were streaked on starch supplemented agar plates and incubated for 24 hours. After the 24-hour incubation, iodine was added to the plate and observed. Appearance of transparent clear zones around the colonies indicated positive result, i.e., the test organism is able to hydrolyze starch while dark blue coloration indicates negative result i.e., the unhydrolyzed starch forms the colored complex with starch.

Hydrogen Sulfide (H₂S) Test: This test demonstrates the ability of the isolate to reduce sulfur containing compounds to hydrogen sulfide during metabolism. Here, the test isolates were inoculated into test tubes containing Klinger Iron Agar (KIA) and incubated for 24 hours. After 24 hours incubation the test tubes were observed.

Development of blacken spots indicated positive result while absent of blacken spot indicated negative result. *Sugar Fermentation Tests:* These tests demonstrate the ability of microorganism to ferment different carbohydrate by utilization of the sugar as source of carbon to produce acid and gas. Exactly 1 gram of sugar was added to 1% peptone water. Then 0.01% phenol red indicator was added into the medium and 10 ml were dispensed into the test tubes with inverted Durham's tubes. The test tubes and their contents were sterilized in the autoclave. Each test organism was inoculated into each sugar tube and incubated at 37°C for 24 hours. Tubes with yellow colouration indicated

acid production, while tubes with yellow colouration and gas bubbles in the inverted Durham's tubes indicated both acid and gas production.

RESULTS AND DISCUSSION

Results of laboratory analyses of various water samples are as shown on Table 2. The data obtained from the study were compared with the WHO (2011) and Nigerian Standard for Drinking Water Quality (NSDWQ) (2007) standards to ascertain how safe the bodies of water are for drinking.

Table 2: Physicochemical parameters of water samples from seven streams in Nsit Ibom

Properties/ Sample Id (Location)	Streams							WHO	NSDWQ (2007)
	1	2	3	4	5	6	7		
Temp °C	29.2	29.2	29.1	29.2	29.4	29.3	29.3	25	-
pH	6.6	6.6	6.8	6.7	6.7	6.8	6.9	6.5-8.5	6.5-8.5
Salinity %	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Conductivity μscm^{-1}	18.75	19.73	15.44	18.04	18.13	17.69	15.81	400	1000
Dissolved Oxygen (DO) mg/l	8.79	8.71	76.51	26.22	66.08	45.90	17.04	6.5 - 8.0	
Chemical Oxygen demand (COD) mg/l	*28.46	*23.05	9.21	16.25	15.30	11.90	10.70	10-20	-
Acidity (as CaCO ₃) mg/l	169.33	157.32	118.67	149.33	152.43	113.02	99.97		
Alkalinity (as CaCO ₃) mg/l	40.00	41.87	56.80	46.67	47.20	61.33	66.47	80-120	-
Total Hardness (TH) mg/l	67.54	68.13	29.85	32.11	15.30	30.72	28.62	500	150
Total Dissolved Solid (TDS) mg/l	46.14	46.51	8.22	11.64	11.42	10.82	8.43	500	
Total Suspended Solid (TSS) mg/l	37.19	52.90	10.86	7.93	6.52	4.39	6.60		
Biochemical Oxygen Demand (BOD) mg/l	6.71	6.96	5.71	4.56	4.96	5.24	4.93	10	
SO ₄ ²⁻ (mg/l)	22.83	18.05	3.50	5.71	13.66	1.46	2.03	250	100
PO ₄ ³⁻ (mg/l)	7.27	3.81	0.29	0.98	0.61	0.36	1.36	0.3	0.5
NH ₃ N (mg/l)	35.24	32.27	31.60	32.15	30.79	30.56	33.02	< 1.5	1.0
Ca ²⁺ (mg/l)	148.54	153.18	28.37	40.15	39.63	27.40	31.62	75-200	-
K ³⁺ (mg/l)	1.42	1.77	2.46	3.01	3.66	2.68	3.17		
NO ₃ ⁻ (mg/l)	*51.85	*56.42	17.59	23.85	29.51	*51.95	10.44	10-50	50
Total coliform count TCC (cfu/100ml)	*14	*12	9.5	7.5	5	*22	6	10	10
Fecal coliform FC (cfu/100ml)	ND	ND	ND	ND	ND	1.1	ND	0	0

ND–Not Detected *Exceeded WHO standard
Source: 2020 Field work

The analysis of the surface waters in Nsit Ibom showed that the temperature ranged between 29.1°C and 29.4°C. The lowest value of 29.1°C was obtained in stream 3 while the highest value of 29.4°C was obtained in stream 5. The values were all above the WHO standard of 25 °C. The pH level obtained for each stream showed the lowest value of 6.7 at stream 5 and the highest value of 6.9 at stream 7. The values were all within the WHO standard of 6.5 – 8.5. All the streams recorded zero for salinity. This shows that the surface waters in Nsit Ibom are fresh waters, while Electrical conductivity of the surface waters showed a minimum value of 15.44 μscm^{-1} at stream 3 and a maximum value of 19.73 μscm^{-1} at stream 2. The

conductivity values for each stream were far below the WHO standard of 400 μscm^{-1} . Stream 3 had the highest value of dissolved oxygen with a value of 76.51mg/l, while stream 2 had the least value of 8.71 mg/l. The DO concentrations in all the streams were above the WHO standard of 6.5 – 8.0 mg/l. The mean values of Chemical Oxygen Demand COD of the different streams showed 28.46 mg/l for stream 1, 23.05 mg/l for stream 2, 10.21 mg/l for stream 3, 16.25 mg/l for stream 4, 15.30 mg/l for stream 5, 11.90 mg/l for stream 6 and 10.70 mg/l for stream 7. The values of COD for streams 1 and 2 were above WHO standards for human consumption. The values for the other five streams were within the WHO standard

range. The mean values of BOD obtained for each stream were between the range of 4.56 mg/l and 6.96 mg/l. The BOD values of the streams were within the WHO permissible standard for human consumption. The alkalinity values for each stream shows 40.00 mg/l for stream 1, 41.87 mg/l for stream 2, 56.80 mg/l for stream 3, 46.67 mg/l for stream 4, 47.20 mg/l for stream 5, 61.33 mg/l for stream 6 and 66.47 mg/l for stream 7. From the above, the alkalinity level of the water samples is within the WHO standard. The total hardness values for each stream are 67.54 mg/l for stream 1, 68.13 mg/l for stream 2, 29.85 mg/l for stream 3, 32.11 mg/l for stream 4, 15.30 mg/l for stream 5, 30.72 mg/l for stream 6 and 28.62 mg/l for stream 7. The values are within the WHO standard required for drinking water. Values of Total Dissolved Solid (TDS), shows a range of 8.22 mg/l to 46.51 mg/l. The values are within the permissible standard set by WHO for human consumption. The value of Total Suspended Solid (TSS) for stream 1 was 37.19 mg/l, for stream 2 was 52.90 mg/l, for stream 3 it was 10.86 mg/l, 7.93 mg/l for stream 4, 6.52 mg/l for stream 5, 4.39 mg/l for stream 6 and 6.60 mg/l for stream 7. The value for streams 1 and 2 indicate a very high level of TSS. The level of Phosphate was higher than the recommended value of 5 mg/l in stream 1 with 7.27 mg/l. In the streams analyzed, the level of Nitrate present was above the WHO standard of 10 – 50 and NSDWQ of 50 mg/l for streams 1, 2 and 6 with values 51.85 mg/l, 56.42 mg/l and 51.95 mg/l respectively. The level of sulphate in all the streams indicated that it was below the WHO recommended limit of 250 mg/l for drinking water. The presence of Calcium in the streams was below the WHO desirable limits of 250mg/l. This did not pose any danger to the health of the users of the water from the streams for any purpose. Total Coliform in water samples obtained from the streams showed values of 14 cfu/100ml for stream 1, 12 cfu/100ml for stream 2, 9.5 cfu/100ml for stream 3, 7.5 cfu/100ml for stream 4, 5.0 cfu/100ml for stream 5, 22.0 cfu/100ml for stream 6 and 6.0 cfu/100ml for stream 7. High concentration above the WHO recommended limits (10.0cfu/100 ml) was observed in Streams 1, 2 and 6. All the streams except stream 6 showed no detectable levels of fecal coliform. Water from stream 6 showed a fecal coliform level of 1.1 cfu/100ml at the time of analysis. This indicates fecal contamination of the stream 6 water which may have been possible due to dumping of sewage in the stream which is located close to a highway. Water drawn from stream 6 needs to be properly treated before consumption. From the results of the analysis of the samples from the different streams, the level of dissolved Oxygen is high enough for use by living organisms. Aquatic life in the streams stands to benefit from the dissolved oxygen. However, the values of

COD for streams 1 and 2 were above WHO standards for human consumption thus the water needed pre-treatment. The Alkalinity of water represents the buffering capacity for water and its ability to resist a change in pH (Gawas *et al.*, 2006). It is the total measure of the substance in water that has “acid-neutralizing ability”. The alkalinity level of the water samples from the different sites in Nsit Ibom is within the WHO standard and is not detrimental to health. Total Suspended Solid in water TSS in streams 1 and 2 indicate a very high level above the WHO and NSDWQ thus the water need treatment before utilization or consumption. This is because according to University of Arizona (2007), Suspended solids can clog fish gills, either killing them or reducing their growth rate. They also reduce light penetration. This reduces the ability of algae to produce food and oxygen. Indirectly, the suspended solids affect other parameters such as temperature and dissolved oxygen. Because of the greater heat absorbency of the particulate matter, the surface water becomes warmer and this tends to stabilize the stratification (layering) in stream pools, embayments, and reservoirs. This, in turn, interferes with mixing, decreasing the dispersion of oxygen and nutrients to deeper layers. Presence of Phosphate at a value higher than recommended in stream 1 causes need for for identification of sources of contamination. Surface waters and groundwater become contaminated from both natural and anthropogenic sources of phosphates. Though according to Fadiran, Dlamini and Mavuso (2008), naturally occurring levels of phosphates in surface and ground water bodies are not harmful to human health, animals or the environment, conversely, extremely high levels can cause digestive problems and even eutrophication, a condition of accelerated, algal production to extreme quantities until they die off and pollute the water. The high level of Nitrate in streams 1, 2 and 6 calls for identification of source of pollution. Nitrate shows presence of organic pollution in water. In excessive limits, it contributes to the illness known as methenoglobinemia in infants (Fewtrell 2004). Water from these streams deserves to be treated before human consumption.

Conclusion: Physicochemical and Microbiological baseline data of surface waters which residents of villages within Nsit Ibom local government area use as sources of drinking water have been determined and found to be safe for human consumption in four of the seven streams sampled while unsafe in three, according to World Health Organization WHO and Nigerian Standard for Drinking Water Quality (NSDWQ) recommendations. The water quality parameters assessed were DOC, pH, conductivity, turbidity, PO_4^{3-} and NO_3^- concentrations, BOD, COD,

TSS, Cations, Anions and coliform counts as well as TDS using recommended standard procedure for water quality analysis. Regular assessment of baseline data of surface waters, proper sensitization on water management strategies and revitalization of public water supply project located at Afaha Nsit for safe drinking water delivery are recommended.

Acknowledgements: The authors wish to acknowledge the support of Tertiary Education Trust Fund TETFUND for the grant of TETFUND/IPR/COE/AFAHA NSIT/PR/VOL 3/038 granted to the authors as listed.

REFERENCES

- Ahmed, R (2010). MPHP 429: Introduction to Environmental Health. <https://case.edu/med/epidbio/mphp439/DrinkingWater.pdf>
- Altieri, D (2016). The Effects of Overpopulation on Water Resources and Water Security. <http://fubini.swarthmore.edu/~ENVS2/dan/Essay4.html>
- American Public Health Association APHA (1998). Standard methods for the examination of water and wastewater. 19th edition. New York: American Water Works Association (AWWA) and Water Pollution Control Federation (WPCF).
- Auroville (n.d.) Micro Biological analysis of drinking water. http://www.auroville.info/ACUR/documents/laboratory/report_microbiological_tests_of_water.pdf
- Bartram, J; Pedley, S (1996). Microbiological analyses in J. Bartram, and R. Balance, (Eds) Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. UNEP/WHO; 229-255.
- Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries. (Part II). Cambridge Universities. Pp 80-81.
- De Vos P; Garrity G; Jones D; Krieg NR; Ludwig W; Rainey FA; Schleifer, KH; Whitman, W (2009) Bergey's Manual of Systematic Bacteriology. Vol. 3: The Firmicutes. United States, Springer Science. Pp. 1450.
- Denise, EM; John, VS (2014). Water quality assessment: A case study of Odiok Itam and Ibiaku Uruan Rivers in Itu and Uruan local government area of Akwa Ibom, Nigeria. *Arch. App. Sci. Res.*, 6(6):7-15
- Fewtrell, L (2004). Drinking-water nitrate, methemoglobinemia, and global burden of disease: a discussion. *Environ Health Perspect.* 112(14):1371-1374.
- Galadima, A; Garba, ZN; Leke, L; Almustapha, MN; Adam, IK (2011). Domestic water pollution among local communities in Nigeria: Causes and consequences. *Eur. J. Sci. Res.*, 52(4): 592-603.
- Ghose, T. (2015). Why Is Water So Essential for Life? Retrieved from <https://www.livescience.com/52332-why-is-water-needed-for-life.html> March 17, 2020
- Harrigan, WF; McCance, ME (1990). Laboratory Methods in Foods and Dairy Microbiology. London Academic Press. Pp 210.
- Hussain, I; Shakeel, M.; Faisal, M; Soomro, ZA; Hussain, M; Hussain, T (2014). Distribution of Total Dissolved Solids in Drinking Water by Means of Bayesian Kriging and Gaussian Spatial Predictive Process. *Water Qual Expo Health* 6(4): 177 – 185
- Jaradat, QM; Monami, KA; Jiries, AG (1997). Ion Chromatographic analysis of water soluble anions in the atmosphere in Amman, Jordan. *Tr. J. Chem.* 21: 92-99
- Ituen, UJ; Johnson, IU (2015). Kwa Iboe River: Its physical characteristics and economic potentials to host communities in Abia and Akwa Ibom States, Nigeria. *Int. J. Soc. Sci. Hum. Inv.* 2(01): 922-934
- Liyanage, CP; Yamada, K. (2017). Impact of Population Growth on the Water Quality of Natural Water Bodies. *Sustainability* 9: 1405;
- Meme, FK; Arimoro, FO; Nwadukwe, FO (2014). Analyses of physical and chemical parameters in surface waters nearby a cement factory in North Central Nigeria. *J.Env. Pro.*, 5: 826-834.
- Obeta, MC; Ocheje, JF; Nwokocha, VC (2015). Analysis of the physico-chemical and microbiological quality of Imabolo stream water in Ankpa urban area of Kogi State, Nigeria. *Mediterr J. Soc. Sci.* 6(S4): 549-557.

- Sofos, JN (2014). Safety of Food and Beverages: Meat and Meat Products. Encyclopedia of Food Safety 3; 268-279
- UNICEF (2018). Water, Sanitation and Hygiene. <https://www.unicef.org/nigeria/water-sanitation-and-hygiene>
- U. S. Environmental Protection Agency (2016). Water Quality Standards Handbook. <https://www.epa.gov/wqs-tech/water-quality-standards-handbook>
- WHO (2011). *Drinking Water: Equity, Safety and Sustainability*; UNICEF: New York, NY, USA. http://www.unicef.org/wash/files/JMP_Report_DrinkingWater_2011.pdf
- Wither, A; Rehfisch, M; Austin, G (2005). The impact of bird populations on the microbiological quality of bathing waters. *Water Science and Technology: J. Int. Asso. Water Poll.Res.* 51: 199-207. DOI: <https://doi.org/10.2166/wst.2005.0592>