Physicochemical Analysis and Seasonal Variations of Sediment and Water Samples from Selected Surface Waters in Anambra State, Nigeria

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***Abstract*— *The physiochemical properties of sediment and water samples from four surface waters in Anambra State were investigated and their seasonal variations compared. These Physicochemical properties include; temperature, pH , conductivity, colour, total suspended solids, total solids or residues ,total dissolved solids, alkalinity, carbondioxide, total hardness, chloride, Nitrate and Sulphate. Atomic Absorption Spectroscopy was used to determine the mineral elements of the sediment and water. A total number of 24 samples; 3 samples per sampling station (an average of 8 samples) were examined in this study. The average high iron and zinc content ranged from 6.4-52.55 and 0.70-10.7 respectively, which were greater than the World Health Organization permissible range for drinking water. Other physiochemical seasonal differences observed fell within recommended ranges. Many physicochemical properties (Temperature, Conductivity, TSS, TS, Zn, Cu, Fe) of the sampling stations of the water and sediment increased within the rainy season. This showed that increased rainfall, subsequent soil erosion and surface runoff during the rainy season increased the concentration of ions in surface waters. The't' test analysis showed a significant difference between the average alkalinity values of the rainy and dry season of the water and sediment.*

***Keywords*— Physicochemical, Seasonal variation, Sediment, Surface-water, Water.**

I. INTRODUCTION

Water occupies about 70% of the earth's surface and yet it is one of the scarcest commodities especially in the developing countries of the world. It is one of the most demanded of all urban and rural amenities and it is indispensable for man's activities. Water needs have had serious socio-economic and health influences on urban environment in developing countries where population concentrations have put serious strains on available resources. Amongst the serious environmental problems are waste accumulation and lack of adequate and safe water supply (Buor, 2003; Orji , 2006).

Surface water is a natural water source which collect from water running across the surface of the ground. As this water runs across the ground surface, it picks up microorganisms, organic matter and mineral. Sediment is matter (sand, dirt, gravel) that settles to the bottom of a water. Surface waters in Anambra state serve various purposes ranging from drinking, sources of fish, irrigation to recreation but frequently these waters are polluted. Water pollution is one of the most important environmental problems faced by third world countries (Barry,2000)

The key to effective environmental quality management is the ability to continuously monitor the concentration of various pollutants in the sample of interest. The significance of various substances in water is obvious and it is their level that gives measure of the quality of the water.

II. LITERATURE REVIEW

Water is literally the source of life on earth and is indispensable to man as it is required for both domestic and industrial processes. Chukwura, (2001) stated that because of the numerous uses of water, our bodies of water contain substances introduced directly or indirectly by man, his activities, climate, geophysical or geochemical phenomena whose presence in the water is of such quantity that the quality of the water is impaired or rendered offensive to life hence water pollution results. Effluents which are discharged into the rivers, have increased substantially over the years due to

https://dx.doi.org/10.22161/ijeab.51.30 ISSN: 2456-1878

industrialization. Oyeyiola *et al* (2006) stated that the majority of the compounds released into the water have affinity for particulate matter, therefore the chemical composition of bottom sediments reflects the input of discharged substances to the marine environment. Eutrophication is any increase in the concentration of available nutrients; it may be man-made as in sewage discharge into stream or natural as with rain water washings (Chukwura, 2001).

Eutrophication is any increase in the concentration of available nutrients; it may be man-made as in sewage discharge into stream or natural as with rain water washings (Chukwura, 2001). Accumulation of contaminants in the sediments can be linked to local point sources while sediments in more remote areas reflect the overall level of contamination. Gibbs (1993) pointed out that metals of detectable concentrations are found in the environment; the presence of metals in sediments is unavoidable and at low concentrations, metals play an essential role in many biochemical processes. However, they can be deleterious to living organisms at higher concentrations. Angelidis and Aloupi (1995) also noted that metal inputs are subject to a variety of processes that determine their fate and comparison of metal concentrations in sediments or even water, must take into account the processes likely to affect them such as pH and organic matter content of sediments.

Physiochemical analysis is based on actual measurement of physical parameters such as pH, temperature, colour etc and chemical parameters such as metal copper, lead, iron etc and chemical parameters such as metals copper, lead, iron etc. The physiochemical monitoring provides quantitative information about the presence of pollutants in natural streams.. The World Health Organization (WHO) approved chemical standard for potable water as listed in Table 1 below;

World Health Organization Approved Standard (chemical) for portable water

Parameter		WHO limit
pH at 250C		6.5 – 8.5
Chloride (ppm)	250	
Copper (ppm)		1.0
Nitrate (ppm)		4.0
Manganese (ppm)		0.1 – 0.5
Phosphate (ppm)	10	
Sulphate (ppm)	250	
Iron(ppm)		0.3
Zinc (ppm)		3.0
Hardness (CaCO3)(ppm)	200	

(WHO, 2004)

2.1 pH Value: The pH value or hydrogen ion concentration which is a measure of the acidity or alkalinity of a sample, is one of the most important parameters in water chemistry since many of the processes involved in water treatment are pH dependent (APHA, 1980). The pH values of unpolluted water is mainly determined by the interrelationship between free carbondioxide and the amounts of carbonate and bicarbonate present. Thus, the pH values of the most natural waters are in the range of 4 to 9.

2.2 Colour: Colour in water may result from the presence of natural metallic ions, humus and peat materials, weeds and industrial wastes. Water often appear coloured because of material in suspension, so true colour can only be determined after acceptable pre-treatment such as filtration (Chukwura, 2001).

2.3 Alkalinity: Alkalinity is almost entirely due to bicarbonate, carbonate and hydroxide ions in water, usually in association with calcium, magnesium, sodium and potassium ions. The alkalinity of a water resource is its quantitative capacity to react with a strong acid to a designated pH.

2.4 Total Solids/Residue: Total solids refer to solid matter suspended or dissolved in water or waste water. Highly mineralized water also are unsuitable for many industrial application and for these reason, a limit of 500mg residue/litre is desirable for drinking water (Lawal, 1988).

2.5 Suspended solids: Suspended matters are major carriers of many organic and inorganic pollutants including most toxic heavy metals, pathogens and nutrients. Suspended solid is also known as filtratrable solid because it can be filtered.

https://dx.doi.org/10.22161/ijeab.51.30 ISSN: 2456-1878

2.6 Dissolved solids: Dissolved solid is also known as non-filterable solid because it passes through the filter paper. For a given water, the dissolved solids concentration can be directly related to the conductivity. Dissolved solids is obtained as the difference between total solid and suspended solid in a particular quantity of water sample

2.7 Hardness: Water hardness was originally understood to be a measure of the capacity of water to precipitate soap but in conformity to current practice, Twort *et al* (1986) defined total hardness as the sum of the calcium and magnesium carbonate in milligramme per litre.

2.8 Carbondioxide: This is one of the components of the carbonate equilibrium in water. The free carbondioxide content of a water depends on the alkalinity and can contribute significantly to the corrosive properties of water. According to Twort *et al* (1986), surface waters usually contain less than 10mg/I free carbondioxide while some ground waters may easily exceed that concentration.

2.9 Chloride: Chloride ion is one of the inorganic anions in water. In potable water, the salty taste produced by chloride concentration is variable and dependent on the chemical composition of water. Also, a high chloride content may harm metallic pipes and structures as well as growing plants.

2.10 Sulphate: The concentration of sulphate in natural waters can vary over a wide range from a few mg/l to several thousand mg/l. Sulphate can come from several sources such as dissolution of gypsum and the other mineral deposits containing sulphate, oxidation of sulphites and from industrial effluents where sulphates has been used in the manufacturing processes. Sulphurous fuel gasas discharged to the atmosphere in industrial areas often result in acidic rain containing appreciable levels of sulphates.

2.11Nitrate: surface waters, unless badly polluted with sewage effluents seldom contain myuch nitrate. Nitrate is the final oxidation of ammonia and most of the oxidation in soil and water is achieved by nitrifying bacteria and can only occur in well oxygenated environment. Nitrates discharging into receiving water under proper environmental condition degrades stream quality by encouraging excessive growth of algae.

2.12 Metals: the effect of metals in water and waste water range from beneficial through troublesome to dangerously toxic depending on their concentratins. Some metals are essential, others may adversely affect water consumers, waste treatment systems and receiving waters.

III. MATERIALS AND METHODS

3.1 Sample sources and collection

Eight samples on average (4 of water and 4 of sediment) were collected from the following locations; Obizi sediment, Obizi water, Nkisi sediment, Nkisi water, Ebenebe river sediment, Ebenebe river water, Agulu lake sediment, Agulu lake water. Each sample for physiochemical analysis was collected using a clean 2-litre plastic container with screw cap. At the point of collection, the container was rinsed with the sample.

3.2 Physiochemical analysis

Temperature and pH Determination: The temperature and pH of the samples were determined with pH/ temperature metre with reference electrode HANNA MODEL HI, 991001.

3.3 Conductivity determination

The conductivity of the water samples was determined with a DIONIC conductivity meter series 3. The test electrode of the metre was immersed into the water sample and the range was taken by turning the testing range selector gradually until sufficient deflection of the pointer was attained.

Test value = Reading x Factor

3.4 Colour Determination

The standard Lovibond Nessleriser disc (BDH, MK) was used to determine the colour of the samples. The unit adopted in this method of measurement is the colour produced by 1 milligram of platinium per litre of water, which is equivalent to 1 ppm of platinium.

3.5 Total Suspended Solids

Whatman filter paper N0 1001150 was dried, weighed anf fitted into a funnel. Hundrd ml of the sample was filtered through it. The filter paper was removed and dried in the oven at 1050C for one hour. It was later allowed to cool and reweighed (Mamta, 1999)

3.6 Total Solids (Residue)

Clean dry evaporating dishes were ignited at 1050C for one hour in an oven. They were allowed to cool, weighed and kept. Hundred ml of each sample was measured and transferred into each of the pre-weighed dishes and were evaporated to dryness in an oven. It was allowed to cool and then reweighed (Pandey and Carney, 1989)

3.7 Total dissolved solids

The total dissolved solids is easily obtained by simple calculation as followed: total dissolved solids = Total solids – Suspended solids.

3.8 Alkalinity Determination

The double titration method according to Bassat *et al* (1978) was used.

3.9 Carbondioxide Determination

The neutralization titration method according to APHA (1980) was used. Hundred ml of the sample was pipette into a 250ml conical flask, then drops of phenolphthalein indicator was added and titrated with 0.01N to NaOH to a light pink end point.

https://dx.doi.org/10.22161/ijeab.51.30 **ISSN: 2456-1878**

3.10 Total hardness determination:
Ethylenediaminetetracetic acid (EDTA) titrimetric method according to APHA (1998) was employed in the determination of the total hardness.

3.11Chloride Determination: The argentometric method described in Lawal, 1998 was used to determine the chloride content of the samples. The principle is that in a neutral or slightly alkaline solution, potassium chromate can indicate the end point of the silver nitration of chloride. Silver chloride is precipitated quantitatively before red silver chromate is formed.

Nitrate Determination-Brucine Colorimetric Method:

3.12 Sulphate determination: The principle is that sulphate ion is precipitated in a hydrochloric acid medium with barium chloride so as to form barium tetraoxosulphate (vi) crystals of uniform size. Light absorbance of the $BaSO_4$ suspension is measured by a transmission photometer and sulphate ion concentration is determined from a standard curve. The absorbance of the standard solution was plotted against their concentrations to obtain a curve from which concentrations of sulphate in the sample was obtained.

3.13 Biochemical Oxygen Demand (BOD) Determination
Biochemical Oxygen demand is an empirical test in which standard laboratory procedures are used to measure the relative oxygen requirements of a water sample.

3.14 Chemical Oxygen Demand (COD) Determination: Chemical oxygen demand is the total oxygen consumed by the chemical oxidation of that portion of organic materials in water which can be oxidized by a strong oxidant.Ten ml of water sample was pipette into 250ml conical flask and the following was added: 5ml potassium dichromate, 15ml concentrated tetraoxosulphate (vi) acid and 40ml of distilled water. Seven drops of phenonthroline ferrous sulphate indicator was added and titration was carried out with 0.025N ferrous ammonium sulphate in the burette. Ten ml of blank was also treated with the same reagents as the sample COD was calculated.

3.15 Determination of Mineral Elements
The mineral elements iron, sodium, calcium, lead, copper and zinc were determined by atomic absorption spectrophotometry according to APHA (1998).

Statistical Analysis
The't' test was used to analyse the rainy and dry season alkalinity values of the water and the sediments

IV. RESULTS

Table 1. Physiochemical properties of the sediment and water (rainy season)

	Sampling Stations							
Parameters	**1a**	**1b**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**
Temperature(oC) 26	28.4	22	26.1	23.5	27	24	28	
pH	5.1	5.45	5.8	6.47	5.23	5.79	6	6.75
Conductivity(uS/cm)	-	1300	-	1500	-	2500	-	1700
Colour(Pt-Co/L) -	5	-	50	-	25	-	25	
TDS (mg/L)	-	178.2	-	148.6	-	178.3	-	168.4
TSS (mg/L)	-	1.8	-	1.4	-	1.70	-	1.60
TS (mg/L)	386	180	450	150	620	180	420	170
Total Hardness (mg/L)20.5		52	9.6	472	14.7	280	24	124
CL (mg/L)	0.32	4	0.24	10	0.16	2	0.4	2
CO_2 content (mg/l)	4.22	14.08	1.48	31.68	6.83	10.56	1.48	8.80
Alkalinity (mg/L)52	140	24	160	28	120	99	120	
SO_4^{2-} (mg/L)	42.5	0.45	22.5	0.6	3.75	1.15	28.75	0.75
NO_3 (mg/L)	67.5	2.7	130	3.7	92.5	4.20	110	2.90
Fe (mg/L)	32.9	6.1	27.4	51.6	48.5	10.30	40.00	13.20
Pb (mg/L)	0.08	0.04	0.16	0.15	0.06	0.10	0.04	0.07
Cu (mg/L)	0.95	5.8	2.2	0.6	3.2	2.10	6.40	2.40
Zn (mg/L)	6.3	0.6	10.6	8	1.9	0.40	5.00	3.41
Ca (mg/L)	3	11.3	0.85	2.1	6.91	7.25	4.62	4.06
Na (mg/L)	4.03	7.01	5.14	3.65	5.32	3.96	3.66	2.90

Table 2. Physicochemical properties of the sediment and water (Dry Season)

Parameters	Sampling Stations							
	1a	1b	2a	2b	3a	3b	4a	4b
Temperature(oC)	27	31	24	28	26	30	22	27
pH	5.00	5.30	6.20	6.50	6.10	6.70	6.42	6.85
Conductivity(uS/cm)	-	900	-	1500	-	1400	-	1300
Colour(Pt-Co/L)	-	5	-	25	-	10	-	5
TDS (mg/L)	-	158.36	-	128.7	-	153.48	-	148.6
TSS (mg/L)	-	1.64	-	1.30	-	1.52	-	1.40
TS (mg/L)	320	160	365	130	410	155	400	150
Total Hardness (mg/L)	5.60	248	4.96	420	17.76	348	10.88	332
BOD		1.80		2.10		3.00		3.10
COD		7		12		16.75		38.25
CL (mg/L)	0.25	3.98	0.16	7.95	0.24	49.70	0.16	5.96
CO2 content (mg/l)	1.83	10.56	2.96	17.60	3.10	22.88	0.99	5.28
Alkalinity (mg/L)	3.2	20	3.2	120	9.60	60	6.40	20
SO42- (mg/L)	48.75	0.45	22.50	0.55	6.25	1.10	3.75	0.75
NO3- (mg/L)	70	2.80	125	3.75	88.75	4.10	107.50	3.20
Fe (mg/L)	34.80	6.70	30.20	53.50	45.00	11.10	38.20	14.43
Pb (mg/L)	0.10	0.02	0.12	0.11	0.04	0.08	0.03	0.05
Cu (mg/L)	0.15	6.00	2.50	0.68	3.00	2.50	6.85	3.10
Zn (mg/L)	6.00	0.80	9.73	6.42	2.60	0.30	5.40	3.85
Ca (mg/L)	2.30	10.20	0.52	2.60	6.10	6.50	3.00	3.43
Na (mg/L)	3.85	7.55	3.64	4.20	4.83	3.52	2.78	2.35

Table 3. Average physicochemical properties of sediment and water (rainy and dry season)

Parameters	Sampling Stations							
	1a	1b	2a	2b	3a	3b	4a	4b
Temperature(oC)	26.50	29.70	23	27.05	24.75	28.50	23	27.5
pH	5.05	5.38	6	6.49	5.67	6.25	6.21	6.80
Conductivity(uS/cm)	-	1100	-	1500	-	1950	-	1500
Colour(Pt-Co/L)	-	5	-	37.5	-	17.5	-	15
TDS (mg/L)	-	168.28	-	138.65	-	165.89	-	158.50
TSS (mg/L)	-	1.72	-	1.35	-	1.61	-	1.50
TS (mg/L)	353	170	407.5	140	515	167.5	410	160
Total Hardness (mg/L)	13.05	150	7.28	446	16.23	314	17.44	228
CL (mg/L)	0.28	3.99	0.20	8.98	0.20	51.70	0.28	3.98
CO2 content (mg/l)	3.03	12.32	2.22	24.64	4.97	16.72	1.24	7.04
Alkalinity (mg/L)	27.60	80	13.60	140	18.80	90	52.70	70
SO42- (mg/L)	45.63	0.45	22.50	0.58	5	1.13	16.25	0.75
NO3 (mg/L)	68.75	2.75	127.50	3.73	90.63	4.15	108.75	3.01
Fe (mg/L)	33.85	6.40	28.80	52.55	46.75	10.70	39.10	13.82
Pb (mg/L)	0.09	0.03	0.14	0.13	0.05	0.09	0.035	0.06
Cu (mg/L)	0.05	5.90	2.35	0.64	3.10	2.30	6.63	2.75
Zn (mg/L)	6.15	0.70	10.17	7.21	2.25	0.35	5.20	3.63
Ca (mg/L)	2.65	10.75	0.69	2.35	6.51	6.88	3.81	3.75
Na (mg/L)	3.94	7.28	4.39	3.93	5.08	3.74	3.22	2.63

V. DISCUSSION

The investigation revealed that majority of the inhabitants of the catchment communities depend on these surface waters for their domestic uses. There was a relative increase in temperature of the sampling stations for water in the dry season. The accumulated organic load may lead to increase in absorption of heat with a concomitant increase in temperature at these stations. This explanation is in accordance with observations made by Alabaster and Lloyd (1980). The average water temperature observed from sampling stations lies between 25^0C and 35^oC, that is the temperature of natural waters in the tropics as reported by Alabaster and Lloyd (1980).

The average pH values (water) of the surface waters (rainy and dry season) did not fall within the WHO range of 6.5 to 8.5 and therefore not fit for human consumption.

For hardness, only one of the surface water (Obizi River Water) met the WHO limit of 200mg/L, as the average total hardness (seasonal) of others were above limit.

The study also revealed that the average sulphate and nitrate concentrations of surface waters (water) are partly within the WHO limit. This may be attributed to the steady free flowing of the rivers. The higher average seasonal concentration of zinc from Nkisi river (water) might be due to its location. The eutrophication of the river during rainfall from surrounding industrial sites in Onitsha, (a major nearby city) is a key factor. The average seasonal copper concentrations are higher than the WHO limit of 1mg/L, indicating that most of the surface waters have higher concentrations of copper and therefore not fit for drinking. The average seasonal Lead (heavy metal) concentrations are generally high indicating that these surface waters are contaminated.

Conductivity values were higher during the rainy season. This showed that increased rainfall, subsequent soil erosion and surface run offs during the rainy season increased the concentration of ions in the surface waters. This is in accordance with observations made by Odokuma and Okpokwasili (1997). Camp and Messerve (1974) reported that waters with conductivity values in the range of 750 to 2250us/cm are satisfactory for agricultural purposes (irrigation). The surface waters are good for irrigation since their average conductivity values falls within this range. Other physiological seasonal differences observed here were similar to those previously reported by Vila et al (2000).

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