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WATER QUALITY ASSESSMENT OF OSSE RIVER, EDO STATE, NIGERIA, USING PHYSICO-CHEMICAL PARAMETERS

EKHATOR, O.[1] OPUTE, F.I.,[2] *AKOMA, O.C.[3] AND MENSAH, J.K.[1]

[1]Department of Botany, Ambrose Alli University, Ekpoma, Edo State
[2]Department of Plant Biology and Biotechnology, University of Benin, Benin City
[3]Department of Basic Sciences (Microbiology Unit), Benson Idahosa University, Benin City
*Corresponding author oakoma@biu.edu.ng

ABSTRACT
This paper reports a sixteen month investigation of the pattern of variation of the physico-chemical parameters of Osse River was carried out from January 2003 to April 2004.Water samples for physical and chemical analysis were collected into a 250ml container and analyzed using standard methods. Results obtained showed marked seasonal fluctuations in the measured parameters with the rainy season months recording higher values than the dry season months. All parameters studied where significantly different among the stations investigated (P<0.05) except pH. There was strong positive correlation between total dissolved solids (TDS) and Electrical Conductivity (EC) and Salinity. Similar trend of correlation was also recorded between TDS on one hand and sulphate, calcium and turbidity. Chloride was also positively correlated with electrical conductivity and salinity.

KEYWORDS: Physicochemical parameters, water quality, seasonality, Osse River

INTRODUCTION
There is no pure water in nature and since water is the universal solvent, it contains a vast array of inorganic and organic compounds which are present as dissolved solids and gases. Water is constantly picking up impurities of all kinds from the air as well as from the land and some of these provides the growth factors needed to support the aquatic food chain (Goldman and Horne, 1983).Maintaining the quality and quantity of aquatic resources is an increasing challenge because of the continued growth of the world's population. Rivers, streams, creeks, lakes and oceans are becoming polluted at an alarming rate, making clean water a scarce resource and endangering aquatic ecosystems, many of which provide economically valuable food resources (Saliu and Ekpo, 2006).Water quality is determined by the physical and chemical limnology of the water body and includes all physical, chemical and biological factors of water that influence the beneficial use of water (Mustapha,2008).Water quality is

important in drinking water supply, irrigation, fish production, recreation and other purposes.

The studies of the physical and chemical hydrology of most environmentally perturbed inland water bodies, both lentic and lotic in Nigeria have been documented Akan *et al.*, (2009), Olajire and Imeokparia (2001), Onwugbutu-Enyi *et al.* ,(2008), Adeyemo *et al.,* (2008), Adefemi and Awokunmi (2010), Adedokun *et al.,* (2008), Osibanjo and Adie (2007), Otokunefor and Obiukwu (2005), Asonye *et al,*.(2007), Emmanuel and Onyema (2007), Arimoro *et al.,*(2006),Fafioye *et al.,*(2005), Rim-Rukeh *et al.,*(2006), Ekhaise and Anyasi (2005), Orisakwe *et al.,*(1999), Olajire and Imeokparia (2001) and Uzoukwu *et al.,*(2005).

Osse River, originates from Akpata hills in Ekiti State. It flows through Ovia North East Local Government into the Benin River. Its importance is seen in transportation, fishing and domestic uses. The river has the problem of being the immediate recipient of the waste products of the inhabitants around it. These include defecations into the water body, bathing and washing of clothes as well as washing of boats by the side of the river.

This study is aimed at assessing the water quality of Osse River for drinking using some selected physico-chemical parameters.The result can also be used to monitor changes in the water quality as a result of human activities.

Study Area

The Osse River originates in the Akpata hills in Ekiti State, Nigeria. It flows through Ovia North-East Local Government Area and empties into the Benin River, which is one on the four major rivers that drains into the Atlantic Bight of Benin. Others being Ramos, Forcados and Escravos River (Fig. 1). The climate has the unique features of the humid tropical wet season and dry seasons. In the wet season, the river is characterized by increased flow rate, high turbidity and muddy water especially after heavy rainfall. The dry season on the other hand is characterized by moderate or slow flow rate and clearer water. Several streams and creeks drain into the river. The river is the major source of drinking water for the inhabitants of these communities (Omoigberale and Ogbeibu, 2006).

Five stations were sampled along the length of Osse River in Edo State. These stations have similar and peculiar human activities taking place in them.

Station I (Nikorogha): This is the first station of the study.The sides of this station are characterized by fallen trees.Stations I and II are the up stream of the study.

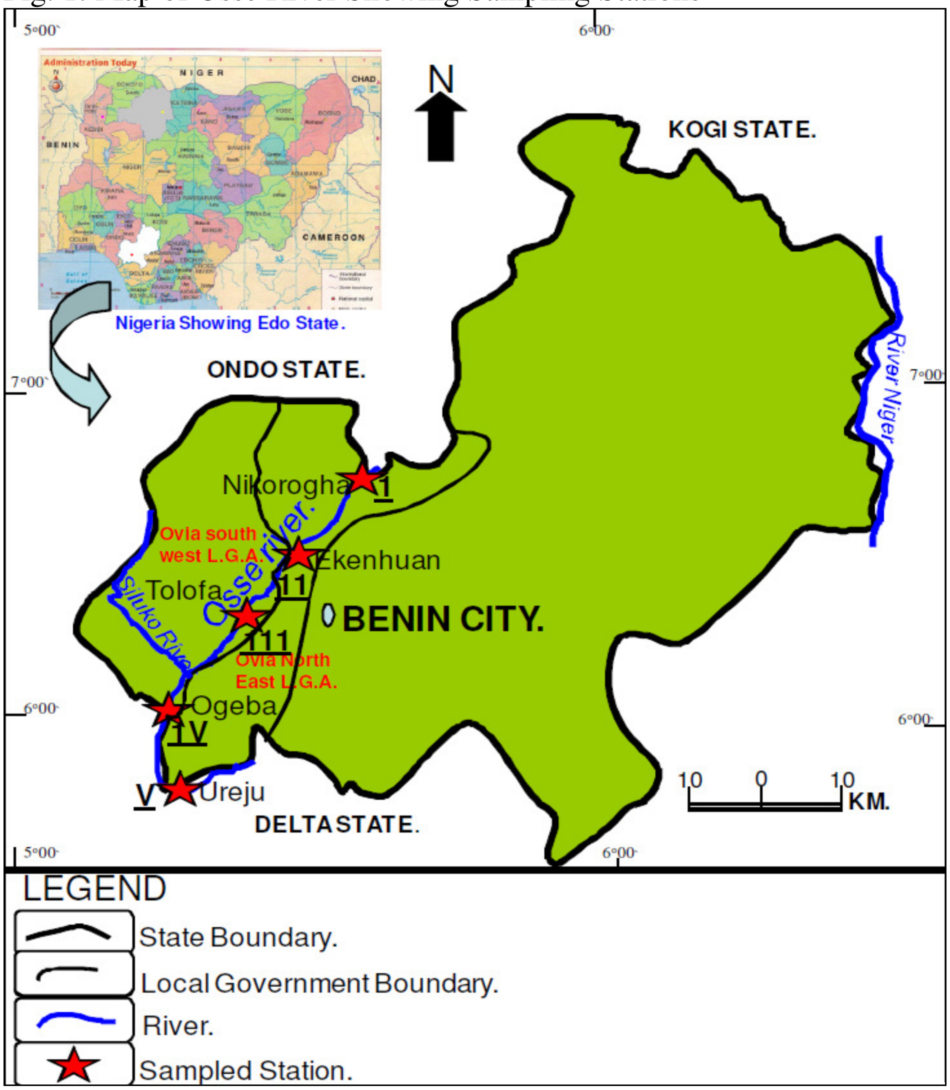
Station II (Ekenhuan): This is the station for commercial activities.

Station III (Tolofa): This is the third station from the take off point of the study sas one approaches the mouth of the Benin river.The villagers mainly inhabit the sides or banks of the river where their huts are built above the water. They carry out different activities like fishing, swimming, washing and repair of local boats since it is the means of transportation on water.

Station IV (Ogeba): This station is close to the mouth of Benin River. *Eicchornia crassipes* dominated the water surface and houses made of palm fronds are abundant. Mangrove trees are the dominant vegetation here. There is turbulence at this station.

Station V (Ureju): This is the last station at the mouth of Benin River, close to the sea. The river here is turbulent. Mangrove trees are the dominant vegetation. *Eicchornia crassipes* are also abundant and travelling vessels are sometimes seen.

Fig. 1: Map of Osse River Showing Sampling Stations



MATERIALS AND METHODS

Water samples for physical and chemical analysis were collected into a 250ml container and analyzed at the chemistry division in Nigeria Institute for Oil Palm Research (NIFOR). The methods described by America Public Health Association (APHA, 1998) were used for physical and chemical analysis. Water temperatures were measured *in situ* using a centigrade mercury-in-glass thermometer. The mercury end was dipped into the water for about five minutes and the readings were noted. A turbidity meter, L. International model HANNA 06128 was used to measure the turbidity of the water samples.pH was measured using a glass-electrode pH meter model 370 L. International.The pH meter was calibrated with buffers 4 and 7 solutions. The electrode of the pH meter was inserted into the water sample and the measurement taken.Total dissolved solids (TDS) was determined by using a TDS meter, model 03435 L. International. The electrical conductivity of the water sample was measured with a conductivity meter, L International model 03435.

RESULTS AND DISCUSSION

The physical and chemical conditions in any water body have considerable bearing on the life of lotic organisms. These parameters may act singly or in combination and the response they elicit may differ from species to species and perhaps from stream to stream. In this study, water temperature values ranged from 25.39^{o}C ±0.31 to 27.81^{o}C ±0.41. This can be compared favourably with the temperature reports of Uttah *et al.* (2008), Mustapha (2008), Akoma (2008) and Omoigberale and Ogbeibu (2006). Temperature variations could be due to changes in solar radiation, cloud cover and time of sampling (Akoma, 2008 and Mustapha, 2008). The mean water temperatures were high and nearly uniform. The temperatures of the water body are believed to have been influenced by the intensity of sunlight as temperature rose to 30.10°C in the dry season and lower during the months of rainy season. Thus, a decease or increase in air temperature results in corresponding decrease or increase in surface water. This was also supported by Essien-Ibok *et al.* (2010), for Mbo River. Temperature is very important in waters because it determines the rate of metabolism of aquatic organisms. The growth, feeding, reproduction and migratory behaviour of aquatic organisms are remarkably influenced by water temperature (Deekae *et al.* (2010).

Temperature is an important characteristic that can vary widely and is influenced by a number of variables including geographical location, shading, water source, thermal discharges, water body size and depth (Uttah *et al.* 2008). Temperature variations in tropical water bodies are of minimal effect and also vary according to the seasons (Akoma, 2008).

The pH range of Osse river (6.31±0.08 to 6.52±0.14) falls within the slightly acidic condition typical of tropical forest river. Result from present study compares with previous study by Omoigberale and Ogbeibu, (2006), for Osse River and other Nierian water bodies like Calabar River (Uttah *et al.*, 2008) and Imo River (Akoma, 2008). Most aquatic organisms survive best within this range. By season, pH values recorded were higher in the wet month of July (7.5) than in the dry months (6.0 in December, February and January). The higher pH associated with rains could be due to influx of basic ions (Kadiri, 2000) and a reflection of high amounts of carbon(iv)oxide known to be stored as forms of carbonates in seawater (Onyema, 2010). High water volume, greater water retention and good buffering capacity of total alkalinity may have been the reason why pH was slightly acidic (Mustapha, 2008). Moreso, rivers flowing through forest have been reported to contain humic acid, which is as a result of the decomposition and oxidation of organic matter in them, hence, a slightly acidic pH (Deekae *et el.,* 2010). Most aquatic organisms survive best within a limited pH range. Even small changes in pH are harmful to pH sensitive species. Most fish can tolerate pH values of about 5.0 to 9.0 pH values; outside that range can create problems for reproduction and survival (Uttah *et al.* 2008). Furthermore, pH has a direct impact on the recreational uses of water only at very low or very high pH values. Under these circumstances, it may contribute to irritation of the skin and eyes (WHO, 2003). Using pH as a water quality index, Osse River has good water quality with its range. (pH range of natural water usually 6.5 and 8.2). The pH range will allow survival of fish and its use as drinking water. The maximum turbidity recorded for Osse River in the wet season is attributable to influx of allochthonous organic materials from runoff (Kadiri, 1999). High levels of turbidity could also be attributed to the presence of decaying organic matter (Rim-Rukeh *et al.* 2006). Turbidity values of stations 4 and 5 were higher that those of stations 1, 2 and 3, an indication of deterioration in water quality (Victor and Onomivbori, 1996). This report which has higher turbdity values in the rainy season and compares well with the findings of Onyema *et al.* (2010) in their work on lagos beach, is at variance with the findings of Anuigwo (1998) who reported low turbidity values in rainy months. Turbidity is a measure of the ability of water to absorb light and is caused by small particles. Turbidity affects fish and aquatic life by interfering with sunlight penetration. Water plants need light for photosynthesis. If suspended particles block out light, photosynthesis and the production of oxygen for fish and aquatic life will be reduced. If light levels get too low, photosynthesis may stop altogether and algae will die. Similarly, when the rate of photosynthesis is low, then oxygen concentration becomes low and CO_2 concentration becomes higher (Akan *et al.* 2009).

Electrical conductivity (µs/cm), salinity ($^o/_{oo}$) and chloride (mg/l) concentrations showed significant decreases in the raining months and increase in the dry months. Seasonal variations in conductivity were observed with high values in the dry months and low values in the rainy months. Similar trends have been observed in many African rivers in the investigations of Onyema *et al.* (2010) for Lagos beach, Onuoha *et al.* (2011), for Ologe Lagoo, Lagos, Akan *et al*. (2009), for river Challawa, Egborge *et al.* (1986), for Jamieson river and Imoobe and Oboh, (2003), for Jamieson river. This report is at variance with the findings of Mustapha (2008) and Kadiri (2000a) who observed high conductivity values in the wet season than dry season. High ionic content in the dry season was due to the concentration of nutrients by evaporation (Edokpayi, 2005, Essien-Ibok *et al*. 2010 and Akan *et al*. 2009). The lower conductivity observed during the rainy season is not an indication of ionic paucity but a reflection of dilution by rainfall (Edokpayi, 2005, Kadiri, 2000, Akan *et al.* 2009 and Imoobe and Oboh, 2003). The mean conductivity, salinity and chloride ranges showed that the water is fresh in stations 1, 2 and 3. Stations 4 and 5 have brackish tendencies. Stations 1, 2 and 3 fall within the class of the popular classification of African waters by Talling and Talling (1965), (cited by Kadiri, 1999). Class I waters are those with conductivity <600µs/cm, while class II and III water types have respective conductivity value of 600-6000 and 6000-160000µs/cm. Conductivity of salt waters is usually higher than freshwater because the former contains more electrically charged ions than the latter. The freshwater zones of the rivers in the Niger Delta can thus be said to be low in ions (Deekae *et al.* (2010). Class III waters bodies are usually saline. Salinity like conductivity was higher in stations 4 and 5. Conductivity of water is dependent on its ionic concentration and temperature (Deekae *et al.* 2010). The recorded salinity indicates brackish environment. Phytoplankton found in low salinity range (<1‰) are predominantly Chlorophytes, while those occurring at high salinity range include some diatoms. Salinity is one of the major factors influencing algae zonation and distribution within estuaries, both in terms of range of values and rate of changes (Davies *et al.* 2009). Similar observation of low salinity values in the wet season was reported by Onwugbuta-Enyi *et al.* (2008). The low wet season values compared to dry season values is attributed to high rainfall and fresh water discharge. During the dry season, rainfall recedes and discharge from most creeks cease so that marine influences and salt water intrusion dominates, leading to significant increases in salinity towards the sea (Akpan *et al.* 2002). The relationship between the three parameters is evident in r = 0.9.

From this study, TDS showed a negative correlation with conductivity. This is at variance with the findings of Essien-Ibok *et al.* (2010), who reported that as more dissolved solids are added, water's conductivity increases. High value of TDS in the rains may be attributed to run offs from sediment and catchment watershed. The settling of dissolved salts coupled with uptake of ions may be adduced for lower TDS values in the dry season as also observed by Mustapha (2008). TDS was higher in the downstream site because of salt intrusion from the sea. The high dry sea result is probably as a result of evapo-crystalization process and low precipitation signifying low dilution. This is consistent with the work carried out by Essien-Ibok *et al.* (2010) for Mbo river. The range of TDS (24.26±2.09mg/l to 123.72±10.53mg/l) falls within tolerable limits for drinking water as it did not exceed 500mg/l (EPA, 1976).

The dissolved oxygen concentration of the river showed it was a well aerated system irrespective of season and station. This is expected as it is running water where dissolved oxygen is usually not a limiting factor due to direct diffusion at the surface and various forms of surface water agitation such as wave actions and turbulence as well as photosynthetic activities. The highest value of dissolved oxygen was recorded in the wet season and this agrees with the findings of Imoobe and Oboh (2003), for Jamieson River, Chindah *et al*. (2006), for Rivers State municipal stream and Mustapha (2008), for Oyun reservoir, that dissolved oxygen is generally higher in the wet season in tropical waters. This report is however and variance with the findings of Kadiri (2000a) and Akpan *et al.* (2002), for Great Kwa River who reported higher dissolved oxygen values in the dry season than the wet season. Dissolved oxygen is an important indicator of water quality, ecological status, productivity and health of a river. This is due to its importance as a respiratory gas and its use in biological and chemical reactions. Higher dissolved oxygen recorded in the rains could be as a result of low temperature and increased mixing of water (Mustapha, 2008). The solubility of oxygen in water is controlled by some major factors like temperature, salinity, pressure and turbulence in the water caused by wind, current and waves (Deekae *et al.,* 2010). The range of dissolved oxygen recorded in this study 8.65±0.43mg/l to 9.72±0.20mg/l shows the water to be of good quality and will support fish production.

BOD values ranged from 1.66±0.04mg/l to 3.71±0.13mg/l, with a consistent increase from station I to station V throughout the period of study. BOD has been a fair measure of cleanliness of any water on the basis that values less than 1.2mg/l are considered clean, 3mg/l fairly clean, 5mg/l doubtful and 10mg/l serious. (Rim-Rukeh *et al,* 2006). In this study, BOD was found to increase significantly in the wet season compared to the dry season. High wet season levels are ascribed to input of decaying organic matter from surface run off and swamps during the rains. This is also reflected in the findings of Akpan, *et al.* (2002) and Essien-Ibok *et al.* (2010). This result shows that although higher values were recorded in the wet season and the river is considered clean against existing standards, Osse River is cleaner in the dry season than the rainy season. BOD directly affects the amount of dissolved oxygen in rivers and streams. The more rapidly oxygen is depleted in the stream, the greater the BOD. A high BOD measure harms stream's health in the same way as low dissolved oxygen.

Alkalinity values ranged between 36.73 ± 1.37mg/l and 68.23±3.52mg/l in this study. This relatively high value agrees with the findings from many other water bodies in Nigeria; Adebisi (1981), recorded 77.9mg/l $CaCO_3$ for Ogun River, Ogbeibu and Victor (1995) recorded 120mg/l $CaCO_3$ for Okomu Forest Reserve and Chindah,*et al.* (2006) also recorded a range of 50.7 – 14.7mg/l for Ntawogba Stream System, Port-Harcourt. Higher alkalinity values were obtained in the wet season than dry season. This compares well with Kadiri (2000a) who had a similar report but at variance with the findings of Chindah *et al.* (2006), who reported high values in the dry season. The higher alkalinity recorded during the rains was probably as a result of input of some bicarbonates from the drainage area (Kadiri, 2000a), while the high alkalinity observed in the dry season could be due to higher carbondioxide concentration and release of biocarbonate ions by sediments. The total alkalinity of a water body is a reflection of its carbonate and bicarbonate profiles with the likelihood of silicates and phosphates contributing to it. However, low alkalinity values are indications of low carbonate and bicarbonate ions in the water, a reflection of the absence of limestone in the drainage basin (Imoobe and Oboh, 2003). Alkalinity is also a buffer for pH changes that helps to stabilize the pH of a water body (Mustapha, 2008).

The nitrate, sulphate, phosphate and silica are some of the constituents of the nutrient composition in any body of water and their means and standard errors are shown in table I. In the present study, nitrate and phosphate (the major limiting nutrients for phytoplankton growth and primary productivity) recorded higher values in the wet season than dry season and these high values were observed for the freshwater stations. High nitrate level could be due to the leaching of allocthonous leaf litter that covers the bottom sediment in addition to the contributions from human waste deposited directly into the water and flood rich in nitrates. This is in line with findings of (Edokpayi, 2005, Mustapha, 2008, Adedokun,*et al.* 2008 and Kadiri, 2000a), who reported similar values in their investigations. Lower values for nitrate have also been reported for other Nigeria waters (Chindah, *et al*, 2006; wet season, 0.17 to 1.8mg/l and dry season 0.27 – 1.86mg/l) and (Kadiri and Omozusi, 2002; 0.02±0.02mg/l). Nirates are important for growth of plants and aquatic organisms such as algae. Small concentrations of nitrates are sufficient to stimulate phytoplankton growth. It is the major form of nitrogen found in natural waters. Although phosphate concentration was generally low, its concentration was higher during the rainy season because the rainy period is usually the peak of agricultural activities where trees and grasses are removed from an area and soil erodes into the water ways, carrying the phosphorous that stick to soil.

Moreso, washing of cow dung, bathing and washings with phosphate based detergents and soaps in the fresh water zone could have caused the concentration of ions observed (Mustapha, 2008). A combination of environmental impact through surface run off, domestic sewage containing human excrement, precipitation, run offs from fertilized lands and leaching of dead macrophytes are capable of contributing to high phosphate levels. The importance of dead macro vegetation as a source of phosphorus in aquatic ecosystems and phosphate recycling from sediments as a source of phosphate have also been reported (Edokpayi, 2005). Higher phosphate values have been reported for Orogodo River (Rim-Rukeh,*et al.* 2006) and Ikpoba reservoir (Kadiri, 2000a), lower values have also been reported to Okuaihe River (Kadiri and Omozusi, 2002). Low phosphate could result from uptake by benthic algae and macrophytes, sediment sorption and storage (Kadiri, 1999). The total concentration of phosphorus in uncontaminated waters is reported to be 0.01mg/l. The phosphate concentration of the waters of the Niger Delta is low (Deekae *et al.,* 2010).

Generally, the nutrients variations were subject to seasonal changes due to flood influx from land drainage and tributary stream during the rainy season. Higher sulphate values were recorded in the rainy season than dry season for stations 4 and 5 in this study. The sulphate mean values reflect that sulphate concentration gradually increases as one move towards the sea. This report is corroborated by the findings of Akoma

(2008),in his study on Imo River estuary. High sulphate concentration may be attributed to the effect of effluents from municipal sources which may be characteristically rich in sulphate related compound (Chindah, *et al.* 2006). The low sulphate content of the river in the freshwater zones agrees with the general deficiency in the ion due to its low concentration in the non-sedimentary rocks of the drainage areas as reported by Kadiri (1999). Victor and Onomivbori (1996), also reported that sulphate concentrations are generally low in African inland waters. However, Egborge (1973) has reported sulphate levels as high as 5mg/l for Osun river. In this study, silica concentration was higher in the freshwater zone of the river than the brackish environment. Similar report has been given by Akoma (2008), in his investigation on lmo river estuary. The concentration increased during the rainy season and reduced during the dry season. Silica plays an important role in the ecology of aquatic systems as it is an essential element for diatoms (Bacillariophyceae) comprising 26-69% of cellular dry weight (Husnain,*et al.* 2009). This may have accounted for the low concentration of silica in the dry season in stations 4 and 5, as the diatoms present at these stations may have used them up in the build up of their frustule. Silica supplies may be enhanced when rain waters percolates into the soil of the basin, carrying minerals to the river channels. There are multiple forces acting during the rainy season, including mobilization of minerals from the surrounding watershed and soils, erosion and dilution of existing concentrations.

This view is consistent with the report of Husnain,*et al.* (2009). High silica concentration in the freshwater zones could also have come from washing of alumino-silicate minerals present in the catchment area aided by dilution from the rains as observed by Mustapha (2008). The high silica concentration will be an advantage for fish in the river as it promotes high diatom population which is an important food source for fish.

Calcium has a mean range from 7.67±0.26mg/l to 25.13±1.63mg/l and magnesium, a mean range of 3.74±0.27 mg/l to 20.27±1.54mg/l. Calcium was the dominating cation. Mustapha (2008), also reported calcium as the dominating cation followed by magnesium in his investigation. Calcium means recorded in this study is moderately high when compared with findings from Okhaihe River with 2±0.04mg/l (Kadiri and Omozusi, 2002) and lower Niger River with a range of 4.4 – 7.6mg/l (Kadiri, 1999). Calcium was also dominating cation over magnesium in the investigation of Kadiri (2000a),on Ikpoba Reservoir, Mustapha (2008),on Oyun Reservoir and Egborge,*et al.* (1986) on Jamieson River. The chemical denudation due to dilution from heavy rains coupled with the river circulation and weathering from rock and run-offs from surrounding watershed might have contributed to the high availability of calcium and magnesium ions in the rainy season (Mustapha, 2008).

Calcium peaks in the rainy season might be explained in terms of influx of floodwaters that bring in calcareous materials. Similar observation was made by Imoobe and Oboh (2003). The upsurge in the level of magnesium observed in the wet season in this study is due both to the natural processes of organic mineralization both *insitu* and those washed in by surface run-off from adjacent forest and human communities. This is consistent with the observation by Imoobe and Oboh (2003).

Hardness is a related measure used in evaluating water quality and it refers to the calcium and magnesium salts combined with the bicarbonate/carbonate and other ions which compensate for acidity (Victor and Al-Harassi, 1997). Higher total hardness levels in the rains could be due to higher concentration of calcium and magnesium. The utilization of these ions by organisms must have caused the decrease in the concentration of the total hardness in the dry season. Mustapha (2008), also has this same view. Hardness is classified into the following categories; 0-50mg/l for soft; 50-150mg/l for moderately hard; 150-300mg/l for hard; and 300mg/l and above, very hard. The mean values for hardness in the various stations studied put Osee River under soft water body.

The Correlation coefficient matrix (Table 2) revealed strong positive correlation between total dissolved solids (TDS) and electrical conductivity (r=0.9939).Salinity had strong positive correlation with electrical conductivity (r=0.9648) and TDS (r=0.9544),sulphate with turbidity (r=0.8616),calcium with turbidity (r=0.8280),alkalinity (r=0.8044) and sulphate (r=0.8089).Magnesium with turbidity (r=0.8346),sulphate (r=0.8090) and calcium (r=0.9958).Chloride was strongly correlated with electrical conductivity (r=0.9498) and salinity (r=0.9753).

There was a negative correlation between dissolved oxygen and water temperature (r=-0.2393), acidity with TDS (r=-0.0351).There a strong negative correlation between biochemical oxygen demand (BOD) and silica (r=-0.8542), while calcium and magnesium were negatively correlated with silica (r=-0.7823 and -0.7831 respectively).

Correlation analysis revealed that the chemical composition of Osse River was influenced by seasonal and environmental conditions. The strong positive correlation between some parameters observed indicates that an increase in the concentration of one parameter enhanced the concentration of the other. Negative correlation could also be accounted for by the dilution effect of water iflux from the drainage basin of the river during the rainy season.

Table 1: Summary of physical and chemical parameters of Osse River

Parameters	Station I	Station II	Station III	Station IV	Station V	P- value
Temperature (^oC)	25.39±0.31	25.66±0.29	26.01±0.31	27.17±0.37	27.81±0.41	P<0.05
pH	6.46±0.08	6.48±0.07	6.31±0.08	6.41±0.09	6.52±0.14	P>0.05
Turbidity (NTU)	13.59±2.01	12.82±1.73	9.96±1.42	26.89±2.89	48.23±4.28	P<0.05
EC (µs/cm)	36.64±1.88	35.54±1.74	33.06±1.85	1065.45±341.30	2548.23±802.53	P<0.05
Salinity ($^o/_{oo}$)	0.25±0.12	0.28±0.12	0.35±0.02	2.06±0.45	3.90±0.93	P<0.05
Chloride (mg/l)	126.08±7.88	140.41±9.45	174.27±10.68	982.10±229.76	1921.35±482.65	P<0.05
DO (mg/l)	8.65±0.43	9.77±0.18	9.01±0.31	9.51±0.18	9.72±0.20	P<0.05
BOD (mg/l)	1.66±0.04	2.53±0.12	2.97±0.11	3.36±0.16	3.71±0.13	P<0.05
Alkalinity (mg/l)	36.73±1.37	38.39±1.29	43.83±1.41	55.03±2.12	68.23±3.52	P<0.05
Acidity (mg/l)	0.08±0.003	0.08±0.01	0.11±0.01	0.15±0.02	0.18±0.02	P<0.05
Nitrate (mg/l)	3.47±0.34	2.59±0.32	1.95±0.16	1.82±0.15	2.07±0.11	P<0.05
Phosphate (mg/l)	0.02±0.00	0.02±0.00	0.01±0.00	0.01±0.00	0.01±0.00	P<0.05
Sulphate (mg/l)	0.26±0.01	0.28±0.01	0.40±0.03	1.08±0.11	2.82±0.17	P<0.05
Silica (mg/l)	11.21±0.16	9.86±0.11	7.81±0.13	6.54±0.17	5.93±0.15	P<0.05
TH (mg/l)	11.99±0.59	11.71±0.48	12.63±0.47	41.29±3.54	45.86±3.07	P<0.05
Magnesium (mg/l)	3.80±0.27	3.77±0.29	3.74±0.27	17.67±1.62	20.27±1.54	P<0.05
Calcium (mg/l)	7.67±0.26	8.01±0.24	8.47±0.34	22.20±1.99	25.13±1.63	P<0.05
TDS (mg/l)	24.26±2.09	23.88±1.90	22.92±1.67	107.75±11.53	123.72±10.53	P<0.05

Table 2: Spearman's Correlation Coefficient Matrix

Table 2:CORRELATION COEFFICIENT ANALYSIS

	ph	*WATER TEMP*	*DO*	*BOD*	*EC*	*TDS*	*TURBIDITY*	*ACIDITY*	*TOTAL HARDNESS*	*ALKALINITY*	*SALINITY*	*SULPHATE*	*SILICA*	*CALCIUM*	*MAGNESIUM*	*PHOSPHATE*	*NITRATE*	*CHLORIDE*
Ph	1.0000																	
WATER TEMP	-0.1229	1.0000																
DO	0.1176	**-0.2393**	1.0000															
BOD	-0.1758	**0.2414**	**0.4540**	1.0000														
EC	**0.5550**	**0.4868**	0.0514	**0.2210**	1.0000													
TDS	**0.5537**	**0.4800**	0.0717	**0.2277**	**0.9939**	1.0000												
TURBIDITY	0.2140	0.1446	**0.3964**	**0.6579**	**0.4635**	**0.4643**	1.0000											
ACIDITY	-0.2108	-0.0166	0.1434	**0.2968**	-0.0371	**-0.0351**	**0.2919**	1.0000										
TOTAL HARDNESS	**0.3404**	**0.5008**	0.1268	**0.4587**	**0.7558**	**0.7650**	**0.6548**	0.1409	1.0000									
ALKALINITY	**0.2485**	**0.3728**	0.2076	**0.6267**	**0.5958**	**0.5901**	**0.7799**	0.2168	**0.7178**	1.0000								
SALINITY	**0.4667**	**0.6151**	0.0367	**0.2575**	**0.9648**	**0.9544**	**0.4400**	-0.0289	**0.7918**	**0.5991**	1.0000							
SULPHATE	-0.1183	**0.3705**	**0.2365**	**0.7051**	**0.3632**	**0.3701**	**0.8616**	**0.3354**	**0.6243**	**0.6992**	**0.4183**	1.0000						
SILICA	0.1851	**-0.5147**	-0.1829	**-0.8542**	**-0.3243**	**-0.3143**	**-0.5589**	**-0.3107**	**-0.6126**	**-0.6465**	**-0.4290**	**-0.6957**	1.0000					
CALCIUM	0.0695	**0.4598**	**0.2430**	**0.7234**	**0.5016**	**0.4972**	**0.8280**	**0.3206**	**0.7934**	**0.8044**	**0.5591**	**0.8089**	**-0.7823**	1.0000				
MAGNESIUM	0.0447	**0.4485**	**0.2564**	**0.7320**	**0.4806**	**0.4743**	**0.8346**	**0.3295**	**0.7700**	**0.7919**	**0.5387**	**0.8090**	**-0.7831**	**0.9958**	1.0000			
PHOSPHATE	-0.1924	**-0.2504**	0.0105	0.0848	-0.1935	-0.1888	0.0757	0.1712	0.0547	-0.1812	-0.2118	0.0707	-0.0140	0.0688	0.0731	1.0000		
NITRATE	**0.5248**	-0.0770	**0.2929**	**0.3566**	**0.4647**	**0.4603**	**0.5368**	0.0784	**0.4914**	**0.5834**	**0.4480**	**0.3751**	**-0.3569**	**0.4263**	**0.4148**	-0.0970	1.0000	
CHLORIDE	**0.4456**	**0.6018**	0.0457	**0.2523**	**0.9457**	**0.9498**	**0.4180**	-0.0375	**0.7992**	**0.5772**	**0.9753**	**0.4233**	**-0.4117**	**0.5381**	**0.5165**	-0.2080	**0.4263**	1.0000

BOLD LETTERS INDICATES VALUES THAT ARE SIGNIFICANT AT P<0.05

DF = 78, $r_{(0.05)}$ = 0.220

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