Original Research Article

Seasonal variations in Physico-chemical and Bacteriological parameters of Ulasi River, Okija, Anambra state

Abstract

The upstream and downstream water quality assessment of Ulasi River, Okija, were evaluated between December 2014 and July 2015 for the influence of rural land use activities. Samples were collected at 50m in triplicates from each location and the physico-chemical properties of these water samples were evaluated. Samples were stored in containers filled with ice packs and immediately taken to the laboratory to investigate some selected physico-chemical characteristics. Also, bacteriological study was carried out on the samples to check for the presence of coliforms. Results obtained were compared with World Health Organization (WHO) standard for permissible drinking water. Results obtained for turbidity are 205 ± 0.70 (downstream), 25.70 ± 0.00 (upstream) for wet season and 138 ±0.60 (downstream), 15.8 ± 0.03 (upstream) for dry season. Turbidity values were significantly higher ($p<0.05$) during wet season than dry season and downstream values were significantly higher ($p<0.05$) than upstream values when compared with WHO standard. pH values were 5.90 ± 0.00 (downstream), 5.91 ± 0.31(upstream) for wet season and 6.10 ± 0.00 (downstream),6.12 ± 0.11(upstream) for dry season.The results of bacteriological study showed that all the sampling locations in downstream and upstream containedsignificantly higher ($p<0.05$)numbers of coliform bacteria and *E. coli* in both wet and dry seasons. The number of coliform bacteria and *E. coli* during wet season was 25.00±0.00, 2.00±0.00 (downstream), 17.00±0.00, 1.00±0.00 (upstream), and 18.00±0.02, 2.00±0.00 (downstream), 7.00±0.01, 1.00±0.00 (upstream) respectively during the dry season. Iron, ammonia and TOC content were significantly higher ($p<0.05$) when compared with WHO standard. This makes the water unsuitable for drinking and human usage and also a threat to the lives of the rural community.

Keywords: Ulasi River, water quality, Wet season, dry season, upstream, downstream.

Introduction

Water is one of the most important of all the natural resources available on the earth. It covers 71% of the earth's surface and is vital for all known form of life. Clean and safe water is both food and health! Potable, adequate and accessible water is therefore a public asset and a vital social welfare facility to measure levels of development in space [1]. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Natural water which contains different types of impurities are introduced into aquatic system by different ways such as weathering of rocks and leaching of soil, dissolution of aerosol particles from the atmosphere and from several human activities, including mining, processing and the use of metal based materials [2].

However, access to safe water supply and sanitation is a global issue and varies significantly across the globe. The World Bank Group in their study argued that nearly half of the world population lack access to safe water supply and basic sanitation, and the situation is most appalling among the developing countries [3].Chemical analysis of the water quality indices of

some Nigerian Rivers reveals that water which was once an abundant natural resources is rapidly deteriorating in quality, owing to population increase and industrialization. Industrial activities, urbanization, exploration activities, refining activities in developing countries like Nigeria are some major ways through which rivers, waterbodies, creeks, swamps have been contaminated. These contaminated rivers had in one way or the other constituted public hazards and socioeconomic hazards to the flora and fauna [4].The greatest microbial risks are associated with ingestion of water that is contaminated with human or animal faeces. Wastewater discharges in fresh waters and costal seawaters are the major source of faecal microorganisms, including pathogens. Confirmation of E. coli in a water system indicates recent faecal contamination, which may pose an immediate health risk to anyone who consumes the water. Access to safe and quality water is very difficult to be obtained by a number of populations throughout the world. According to the WHO [5], the mortality of water associated diseases exceeds 5 million people per year. From these, more that 50% are microbial intestinal infections, with cholera standing out in the first place.The aim of this study is to assess the upstream and downstream water quality of Ulasi River, Okija, for the influence of rural land use activities during the wet and dry seasons. The Ulasi River is the main source of water for domestic and other uses in Okija community in area of Anambra state. It is a widely spread river found in south eastern Nigeria. The Ulasi river starts from the hills in Dikenafai (latitude 050 45'N, longitude 070 10'E), in Imo State, it flows through several towns in both Imo and Anambra States (Ezinifite, Urualla, Akokwa, Okija, Ihiala, Uli, Mgbidi) gathering tributaries in its course. It forms a confluence with the Oguta Lake at Oguta, before flowing parallel to the River Niger. At some point, as the river flows southward, the name changed, due to dialectic pronunciation, to Ulashi (or Orashi). Hence it continued its flow as River Ulashi through Obiakpo, Ebocha, Kreigani, Ukodu (Bayelsa State) and Mbiama. Urashi takes another left at Okarki, flowing east to Igovia and then south-east to Egbama and Agunughan but more southerly into Orashi National Forest and Arukwa. The river overflows its banks every August and gradually recedes by subsequent months, depositing alluvial soils on its banks and floodplains, which are very fertile [6].

Methodology

Sample Collection:

Water samples were collected in triplicates at 50m interval between each sampling points from the upstream and downstream to cover both dry (December 2014) and wet (July 2015) seasons. The distance between upstream and downstream is 1.3km. A total of 36 samples were collected; 9 from the upstream and 9 from downstream in both seasons respectively. The samples were collected on the same day for each season. At the time of sample collection, each sample bottle was held at the base while a gloved hand was use to uncover the bottle. The bottle was them immersed to about 30cm below, with its mouth in upstream direction. The sample bottles were tightly capped, appropriately labelled and immediately conveyed to the laboratory and stored in refrigerator before analyses [7].

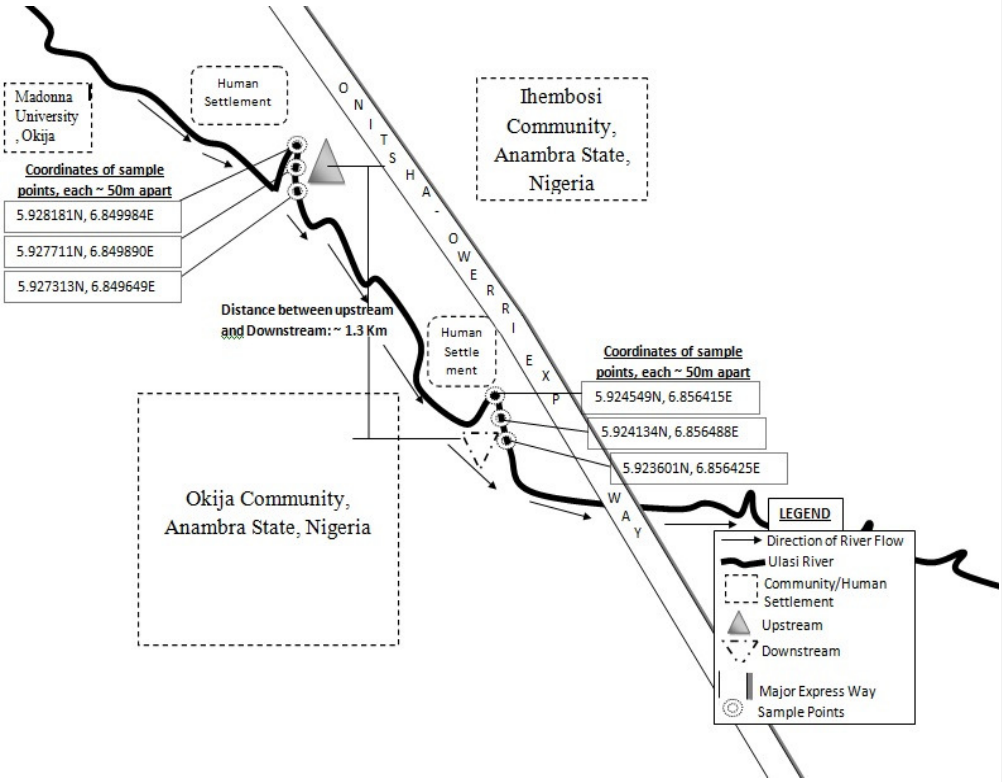

Figure 1: Map of a section of Ulasi River showing upstream and downstream sampling points.

Analysis of sample

Standard analytical procedures were used in the determination of selected physical, chemical and biological water quality parameters of the sample. The Selected physio-chemical analysis carried out include pH, temperature, turbidity, electrical conductivity (EC), total suspended solids (TSS), Nitrites, Nitrates, total hardness, Magnesium hardness, Chlorides, dissolved CO_2, etc. The pH was determined using the procedure described with Jenway 3015pH meter [8]. Calcium was determined using the flame atomic spectrophotometer. Iron and ammonium content of the sample were determined using spectrophotometer and photometer respectively. Nitrites and nitrates were measured using photometer. Bacteriological study was done using multiple tubes/ most probable number method. Turbidity was measured using tubidometer [9]. Iron, Lead and Aluminium were measured using Spectrometer [10]. Calcium and Magnesium were measured using spectrophotometer [11]. Ammonium was measured using Photometer [12]. Nitrites were measured using spectrophotometer [13]. Bacteriological study was done using most probable number method [14].

Statistical Analysis: Descriptive statistics, as well as T-test were used to statistically analyse the data generated from laboratory investigation.

Results and Discussion:

The mean results and standard error of the water quality parameters recorded from Ulasi River Upstream and downstream during the wet and dry seasons are presented in Tables 1 to 4 respectively.

Table 1: Physico-chemical parameters of Ulasi River water sample (downstream) during the wet season

Parameters	Results	WHO Standards[5]
Appearance	Muddy	Clear
Colour In Hazen Unit	285 ± 0.54	5 Hazen Units
Turbidity (NTU)	205 ± 0.70	5 N.T.U
Odour	-	-
Taste	-	-
Conductivity(Us/Cm)	21.80 ± 10.96	1000 US/CM
Acidity (C.C) Of 0.5% Na_2CO_3 (mg/l)	30.00 ± 0.00	
pH	5.90 ± 0.00	6.5-8.5
Chloride as Cl (mg/l)	35.50 ± 0.00	250mg/l
Chloride as NaCl (Mg/L)	58.50 ± 0.02	
Total Alkalinity as $CaCO_3$ (mg/l)	15.65 ± 0.01	
Total Hardness as $CaCO_3$ (mg/l)	56.00 ± 0.02	500mg/l
Calcium Hardness (mg/l)	22.00 ± 0.00	
Magnesium Hardness (mg/l)	24.00 ± 0.56	
Total Iron as Fe (mg/l)	2.70 ± 0.48	0.30mg/l
Sulphate as SO_4 (mg/l)	12.04 ± 0.04	400mg/l
Sodium as Na (mg/l)	23.00 ± 0.00	
Bicarbonate as HCO_3	21.50 ± 0.00	
Free Saline Ammonia (NH_4) (mg/l)	0.185 ± 0.00	0.05mg/l
Nitrates as N (mg/l)	2.00 ± 0.01	10.00mg/l
Nitrites as N(mg/l)	0.01 ± 0.01	1.00mg/l
T.D.S (mg/l)	11.00 ±0.00	1000mg/l
Dissolved Free Co_2 (mg/l)	10.56 ± 0.03	
Arsenic (mg/l)	0.00 ± 0.00	0.05mg/l
Benzene (mg/l)	0.00 ± 0.00	0.007mg/l
Fat And Oil (Mg/L)	0.00 ± 0.00	0.003mg/l

Biological O_2 Demand (mg/l)	7.50 ± 0.06	
Chemical O_2 Demand (mg/l)	35.00 ± 0.00	
Total Organic Compound (mg/l)	10.00 ± 0.01	5.00mg/l
Coliform	25.00±0.00	Absent in 100ml
E coli	2.00 ±0.00	Absent in 100ml

Table 2: Physico-chemical parameters of Ulasi River water sample (Upstream) during the wet season

Parameters	**Results**	**WHO Standards**[5]
Appearance	MUDDY	CLEAR
Colour in Hazen Unit	33.00 ± 0.00	5 Hazen Units
Turbidity (NTU)	25.70 ± 0.00	5 N.T.U
Odour	-	-
Taste	-	-
Conductivity (Us/Cm)	23.90 ± 0.00	1000 US/CM
Acidity (C.C) of 0.5% NA_2CO_3 (mg/l)	28.00 ± 0.00	
pH	5.91 ± 0.31	6.5-8.5
Chloride as CL (mg/l)	42.60 ± 0.00	250mg/l
Chloride as NaCL (mg/l)	70.20 ± 0.09	
Total Alkalinity as $CaCO_3$ (mg/l)	20.00 ± 0.00	
Total Hardness as $CaCO_3$ (mg/l)	28.00 ± 0.06	500mg/l
Calcium Hardness (mg/l)	21.00 ± 0.00	
Magnesium Hardness (mg/l)	7.00 ± 0.10	
Total Iron as Fe (mg/l)	0.70 ± 0.04	0.30mg/l
Sulphate as SO_4 (mg/l)	13.86 ± 0.21	400mg/l
Sodium as Na (mg/l)	27.60 ± 0.05	
Bicarbonate as HCO_3 (mg/l)	15.65 ±0.00	
Free Saline Ammonia (mg/l)	0.270± 0.00	0.05mg/l
Nitrates as N (mg/l)	0.092 ± 0.01	10.00mg/l
Nitrites as N (mg/l)	0.001 ± 0.00	1.00mg/l
T.D.S (mg/l)	11.30 ± 0.00	1000mg/l

Dissolved CO_2 (mg/l)	17.60 ± 0.11	
Arsenic (mg/l)	0.00 ± 0.00	0.05mg/l
Benzene (mg/l)	0.00 ± 0.00	0.007mg/l
Fat And Oil (mg/l)	0.00 ± 0.00	0.003mg/l
Biological O_2 Demand (mg/l)	4.50 ± 0.01	
Chemical O_2 Demand (mg/l)	21.00 ± 0.00	
Total Organic Compound (mg/l)	6.00 ± 0.04	5.00mg/l
Coliform	17.00±0.00	Absent in 100ml
E coli	1.00±0.00	Absent in 100ml

Table 3: Physio-chemical parameters of Ulasi River water sample (Downstream) during the dry season

Parameters	**Results**	**W.H.O Standards**[5]
Appearance	Muddy	Clear
Colour In Hazen Unit	325 ± 0.54	5 Hazen Units
Turbidity (NTU)	138 ±0.60	5 N.T.U
Odour	-	-
Taste	-	-
Conductivity (Us/Cm)	29.80 ± 0.00	1000 US/CM
Acidity (C.C) OF 0.5% NA_2CO_3 (mg/l)	33.50 ± 0.00	
pH	6.10 ± 0.00	6.5-8.5
Chloride as CL (mg/l)	39.00 ± 0.39	250mg/l
Chloride as NaCL (mg/l)	64.50 ± 0.00	
Total Alkalinity as $CaCO_3$ (mg/l)	20.00 ± 0.06	
Total Hardness as $CaCO_3$ (mg/l)	67.80 ± 0.05	500mg/l
Calcium Hardness (mg/l)	43.10 ± 0.00	
Magnesium Hardness (mg/l)	24.80 ± 0.46	
Total Iron as Fe (mg/l)	2.90 ± 0.00	0.30mg/l
Sulphate as SO_4 (mg/l)	25.20 ± 0.00	400mg/l
Sodium as Na (mg/l)	25.00 ± 0.00	

Bicarbonate as HCO_3 (mg/l)	27.70 ± 0.00	
Free Saline Ammonia (mg/l)	0.19 ± 0.00	0.05mg/l
Nitrates as N (mg/l)	4.20 ± 0.20	10.00mg/l
Nitrites as N (mg/l)	0.004 ± 0.00	1.00mg/l
T.D.S (mg/l)	21.00 ± 0.45	1000mg/l
Dissolved CO_2 (mg/l)	12.70 ± 0.00	
Arsenic	0.00 ± 0.00	0.05mg/l
Benzene	0.00 ± 0.00	0.007mg/l
Fat and Oil	0.00 ± 0.00	0.003mg/l
Biological O_2 Demand (mg/l)	8.40 ± 0.07	
Chemical O_2 Demand (mg/l)	35.00 ± 0.00	
Total Organic Compound (mg/l)	11.00 ± 0.00	5.00mg/l
Coliform	18.00±0.02	Absent in 100ml
E coli	2.00±0.00	Absent in 100ml

Table 4: Physico-chemical parameters of Ulasi River water sample (Upstream) during the dry season

Parameters	**Results**	**W.H.O Standards**[5]
Appearance	Muddy	Clear
Colour In Hazen Unit	45 ± 070	5 Hazen Units
Turbidity NTU	15.8 ± 0.03	5 N.T.U
Odour	-	-
Taste	-	-
Conductivity (Us/Cm)	31.20 ± 0.00	1000 US/CM
Acidity (C.C) of 0.5% NA_2CO (mg/l)	30.20 ± 0.01	
pH	6.12 ± 0.11	6.5-8.5
Chloride as CL (mg/l)	48.20 ± 0.00	250mg/l
Chloride as NaCL (mg/l)	74.60 ± 0.03	
Total Alkalinity as $CaCO_3$ (mg/l)	23.00 ± 0.00	
Total Hardness as $CaCO_3$ (mg/l)	41.20 ± 0.00	500mg/l

Calcium Hardness (mg/l)	41.00 ± 0.32	
Magnesium Hardness (mg/l)	25.00 ± 0.00	
Total Iron as Fe (mg/l)	0.90 ± 0.00	0.30mg/l
Sulphate as SO_4 (mg/l)	27.80 ± 0.30	400mg/l
Sodium as Na (mg/l)	28.00 ± 0.00	
Bicarbonate as HCO_3 (mg/l)	17.30 ± 0.55	
Free Saline Ammonia (mg/l)	0.29 ± 0.78	0.05mg/l
Nitrates as N (mg/l)	1.90 ± 0.05	10.00mg/l
Nitrites as N (mg/l)	0.20 ± 0.08	1.00mg/l
T.D.S (mg/l)	21.60 ± 0.20	1000mg/l
Dissolved CO_2 (mg/l)	15.00 ± 0.00	
Arsenic (mg/l)	0.00 ± 0.00	0.05mg/l
Benzene (mg/l)	0.00 ± 0.00	0.007mg/l
Fat And Oil (mg/l)	0.00 ± 0.00	0.003mg/l
Biological O_2 Demand (mg/l)	5.00 ± 0.00	
Chemical O_2 Demand (mg/l)	23.00± 0.05	
Total Organic Compound (mg/l)	8.90 ± 0.00	5.00mg/l
Coliform	7.00±0.01	Absent in 100ml
E coli	1.00±0.00	Absent in 100ml

Discussion

The concentration of various quality parameters varied with seasons and areas (downstream and upstream), with dry season having higher values. Results obtained from this study shows a significant increase ($p<0.05$) in temperature during the dry season than wet season and this could be attributed to the hot weather experienced during the dry season (hot season). Water temperature regulates the metabolism of the aquatic ecosystem. High water temperature makes metal more toxic to aquatic life. Toxicity of metals is affected by water temperature which causes stress to aquatic life by reducing the ability of water to hold dissolved gases like oxygen [15]. Also growth of micro-organism, taste, odour, colour and corrosion problem may increase [16].Low temperature has the effect of decreasing the efficiency of treatment.

Turbidity values were significantly higher ($p<0.05$) during wet season than dry season. However, turbidity of both dry and wet season was higher than the standard limit for drinking water as recommended by WHO [5]. According to Park [17], turbidity affects fish and aquatic life by interfering with sunlight penetration. In drinking water, the higher the turbidity level, the higher the risk that people in that area may develop gastro intestinal disease [18]. In aquatic life, high turbidity level affects the ability of fish gills to absorb dissolved oxygen [19]. Thus

Comment [S1]: State year of reference

Comment [S2]: References is required for these statements

high turbidity obtained during both seasons is probably due to the indiscriminate dumping of domestic waste material**,** agricultural waste material and soil particles transported by runoff water from urban activities into the river.

The total organic carbon values obtained for the dry season were significantly higher ($p<0.05$) than the value for the wet season. The higher value observed during the dry season could be as a result of the influence of season, dry season is characterized by low precipitation, higher atmospheric temperature and evaporation but during wet season there the water dissolves the organic compounds. Organic compounds causes eutrophication of the river which is the sudden bloom of algae due to the presence of limiting nutrients in excess [20]. Lopez-Sanchez *et al*., [21] observed that both anthropogenic and natural processes have resulted in elevated concentrations of organic carbon in sediments.

The general concentration of iron from this study were within 0.30mg/l, however there was significant difference ($p<0.05$) between the dry (2.70) and wet season (2.70). The presence of iron in water aids iron utilizing and reducing bacteria like *thiobacillu sferrooxidans* and *leptospirillum ferrooxidans* to increase causing diseases relating to the microorganism. Iron bacteria in water can cause unpleasant odour and taste. Chinedu *et al*., [22] reported the presence of iron in water samples taken from different points in Canaanland and Iju River. Similarly, Asaolu and Olaofe, [23]; Nwajei and Gagophien, [24] also reported that iron occurs in high concentration in Nigerian soils.

The values of pH for dry season (6.10) were significantly higher ($p<0.05$) than wet season (5.90). The values for both dry and wet season did not fall within the stipulated limits for drinking water which is 6.5-8.5 according to WHO (2004), pH standard for drinking water. The low pH value may probably due to built-up of organic materials. Yerel, [25] reported that anaerobic conditions in Porsuk River was due to the loading of organic matter and organic acids which lead to an increase in pH. Similarly, Keith [26] reported that degradation of organic wastes by aerobic microbes produces carbon dioxide as a by-product, carbon dioxide then dissolves in water to yield carbonic acid, hence, increasing the acidity of the water. Some fish cannot tolerate low pH [27] and pH has synergistic effect on heavy metal activity. Acidic pH encourage the growth of acidophiles which are organism that are able to live at pH below 7, and such organisms are dangerous to human health, since freshwater is buffered at pH of 7.

Result of Sulphate concentration of SO_4 obtained from this study was within the 400mg/l limit recommended by WHO [28]. However there was significant difference ($p<0.05$) between the dry and wet season value. The value vary along the sampling point with the uphill having higher value than the downhill. The source of sulphate to the water could be from effluents from industries, runoffs, dumpsites and organic matters decomposition. According to WHO [28] the presence of sulphate in drinking-water can also result in a noticeable taste; the lowest taste threshold concentration for sulphate is approximately 250mg/litre as the sodium salt. Sulphate may also contribute to the corrosion of distribution systems. In the light of these considerations, no health-based guideline value for sulphate in drinking water was proposed. However, there is an increasing

Result of Chloride concentration obtained was generally below WHO [28] permissible limit (250mg/g) for both dry and wet season. Although there were inputs of pollutants from municipal waste into the river, the level was not high enough to significantly increase chloride level above limit. Thus the negative impact of high concentration of chloride in water such as causing canned or frozen food to taste funny, killing aquatic lives and giving salty taste to water will not be experienced [29].

Water in the study area varied in their microbial quality especially the coliform group. The values were significantly higher ($p<0.05$) in downstream but low in upstream. The variation was probably due to the level of municipal waste received by the respective area. Similarly, there was significant difference ($p<0.05$) between the dry season and wet season bacterial count, with the wet season having higher value due to the significant increase in organic and bacterial load after rain storm [30].Coliform count was higher than the permissible limit of 0.2mpn/100ml and could be considered polluted. The presence of coliform bacteria in Ulasi River is an index of the presence of other pathogenic microbes in the river. This result agrees with the reports of Akpan – Idot *et.al.,* [31]; their study revealed that Okpauku River in Yala, Cross River State contains high number of coliform bacteria. Similarly, a study by Onyegeme-Okerenta *et al.,* [32] reported the presence of coliform bacteria in Otamiri-oche River in Etche Ethnic Nationality of Rivers State, Nigeria. Faecal contamination of water is also a significant cause for various infections caused by pathogenic bacteria, fungi, viruses, protozoa, helminthes. Natural microflora of the human intestine is also found to be present in water contaminated with pathogenic species [33].

Conclusion

This study demonstrates the influence of rural land use and seasonal effect on water quality in Ulasi River. The data clearly shows that the downstream is more polluted than upstream. The upstream though less polluted than the downstream is not still suitable for aquatic life and drinking and human consumption, the downstream too is highly polluted and should not be used for agricultural or human use.

A management plan to restrict the dumping of wastes into Ulasi River is needed in order to reduce the impact on water quality and pollution related health problem. This can be achieved through effective waste management strategy and provision of reliable public water supply. Educating people in Okija on the health effect of Ulasi River and the effect on crops is suggested to avoid diseases and mortality rate in Okija.

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