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BASELINE STUDIES OF WATER QUALITY OF OKURA RIVER IN KOGI STATE, NIGERIA

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ABSTRACT

Water samples from Okura river in kogi state were analysed for some physicochemical parameters and heavy metals to ascertain the water quality. The samples were collected at six sampling points along the river. Results obtained were compared with WHO and other regulatory standard guidelines. Average nitrate and phosphate levels were higher than regulatory guidelines. Total hardness results upstream and downstream were generally low. Overall average concentrations of heavy metals were at baseline levels except Zn with overall average values of 0.37±0.09 and0.23±0.03 upstream and downstream respectively. Okura river fell in the class III Quality of water based on the Prati scale.

Key words: water quality, Okura river, physicochemical, heavy metals, Kogi State.

INTRODUCTION

River water supports many life forms, provide recreation and fishing to the communities; and it may also be used for drinking purposes and irrigation. However, contamination of river water systems is of major concern and has received great attention for monitoring environmental pollution since the events of Hg and Cd poisoning through fish in Minimata, Japan (Mason, 1996 and Meyer, 1977). Surface water pollution has become a very big issue in the world today, mostly in the developing countries. It is caused by both natural processes and anthropogenic activities. Natural processes impacting water quality include changes in precipitation inputs, erosion, and weathering of crustal materials, whereas anthropogenic effects include urban, industrial and agricultural activities, and increasing exploitation of water resources (Jarvie *et al*., 1998; Yu *et al*., 2001; Simeonov *et al*. 2003; Najafpour *et al*., 2008; Agbaire and Obi, 2009; Baghvand *et al*., 2010 and Bayram *et al*., 2012). These activities often result in the degradation of water quality, and impair their use for drinking and irrigation purposes.

Rivers are the main inland water resources for domestic, industrial and irrigation purposes and often carry large municipal sewage, industrial wastewater discharges and seasonal run-off from agricultural land to the coastal region. It is for this reason that the river water is mostly enriched in nutrients compared to other environments (Panda *et al*., 2006).The ecological state of surface waters is one of the most urgent problems all over the world. The anthropogenic impact on surface waters is increased every year. It causes the deterioration of quality state of surface water resources and the state of the aquatic ecosystem as a living system. This is the reason why more and more countries use the ecosystem approach in investigation of water bodies. That means that water body is perceived not only as a source of water for humans, but also as a habitat of many creatures that are also the elements of the quality of water sources (Karavan *et al*., 2013)

Chemical pollution is one of the most critical threats to human populations and aquatic ecosystems. Many substances from industrial activities are released into natural waters without knowledge of the environmental potential risk. In complex aqueous environments, the chemical speciation of metals plays an important role in its bioavailability (Worms *et al*., 2006). Industries contribute to the environmental pollution through the discharge of toxic obnoxious effluents into the ecosystem setting imbalance in the composition of the water and the aquatic lives thereby causing innumerable health problems to human and animal lives. Since these industries pollute the water bodies through the discharge of effluents into the water bodies, the aquatic organisms require large amount of water to absorb oxygen, and by so doing they take the toxic substances into their body (Ayodele and Abubakar, 2001). The United Nations Environment Programme (UNEP), through its Global Environmental Monitoring Systems (GEMS) Water Programme, has established river water monitoring stations and networks in various regions of the world. However, there is still a significant dearth of information in the scientific literature on the quality of many Africa's numerous rivers and streams (Onianwa *et al*., 2001). In eastern part of Kogi State over 90% of the population rely on river waters. One of such rivers is Okura river and can be likened to Nile river in Egypt. This river provides a source of drinking water to a host of communities because of its clarity as water tankers lift water on daily basis from the river. This river water has been proposed to serve as a possible source of water to the State University in the near future. There are no data in literature on the water quality of the river. Therefore, the aim ofthis study is to determine the quality of Okura river water and to serve as a baseline for future monitoring as the region is being proposed as a state capital for Okura State for the largest ethnic group (Igalas) in Kogi State, Nigeria.

MATERIALS AND METHODS

Samples for the study were obtained during the month of January, 2011 from six locations (Figure 1). These were collected at distance of 500m between sampling points. Samples for the determination of general physicochemical parameters were collected in plastic bottles and stored in an ice chest, while samples collected for trace metals analysis were fixed in the field with 3 ml analar grade nitric acid per litre of sample. Temperature and pH were determined at locations, using field equipment, while dissolved oxygen was fixed at sample collection points by Winkler's method. All laboratory analyses were carried out using standard methods (APHA-AWWA-WPCF, 1998; Department of the Environment, 1972). Appropriate quality assurance procedures for water analysis (USEPA, 1979) were observed. The specific standard methods used were as follows. The temperature was measured using calibrated mercury in glass thermometer (0 – 100^0C). Hanna H196107 pH meter calibrated with

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buffer solutions 4 and 7 was used for pH determination, alkalinity (acid-base titrimetry), hardness (EDTA titrimetry), chloride (mercurimetric titration), nitrate (phenoldisulphonic acid colorimetric method), dissolved oxygen (Winkler's titration), COD (potassium dichromate oxidation, and titrimetry), sulphate (turbidimetry), and phosphate (molybdenum blue colorimetric method). Metals (Cd, Cu, Fe, Ni, Pb, and Zn) were determined by atomic absorption spectrophotometry (Bulk Scientific model). Quality control of metal measurements was verified by including process blanks and recovery study. The mean percent of spiked samples ranged between 97.3% and 103.2%. Standards for the atomic absorption analysis were obtained as commercial BDH stock metal standards from which working standards were prepared by appropriate dilution. All reagents utilized for sample preparation and analyses for all parameters were obtained from Sigma Aldrich (London). Duplicate determination of each sample was carried out.

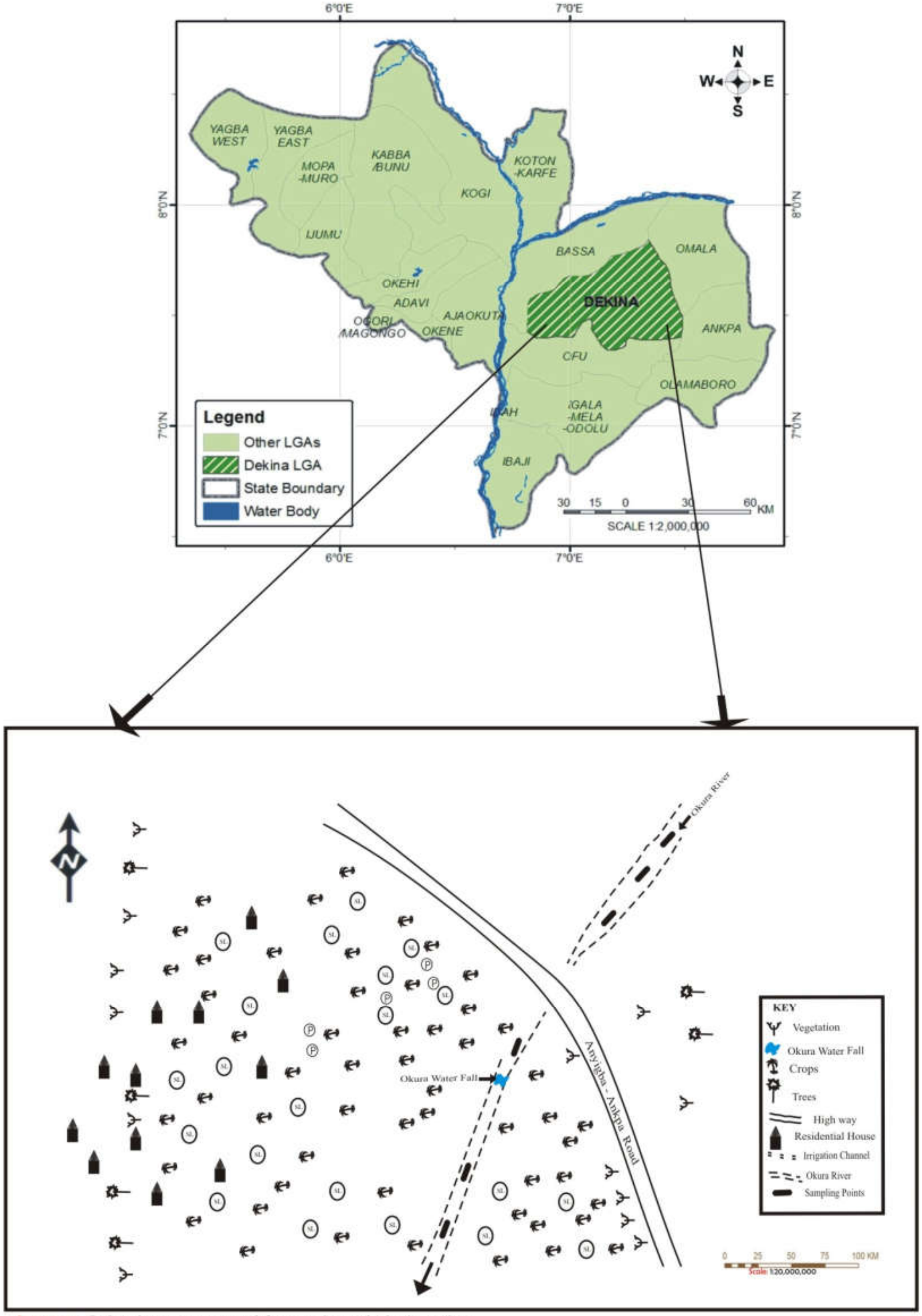
RESULTS

Temperature and pH values

The average water temperature values of 30.0^0C and 26.7^0C were observed at upstream and downstream respectively (Table 1). Downstream temperatures decrease to 25^0C. Temperatures were around the typical river water temperature and within the values of ambient air temperature (Onianwa *et al*., 2001). The average pH upstream and downstream locations were 6.82±0.27 and 7.37±0.01 respectively. The differences observed in upstream and downstream are not significant. Temperature is an important factor controlling the solubility of oxygen in river required to sustain aquatic life and would not slow down the chemical and biological processes occurring in river (McDonald, 1991)

Total dissolved solids (TDS)

The average TDS levels of 67±57 mg/L and 457±414 mg/l (Table 1) for upstream and downstream were lower than 1200 mg/L (WHO, 1996) regulatory standard. The difference between upstream and downstream levels is statistically significant. The TDS content of the river was an indicative of a freshwater environment and the low level of TDS was evident in the transparency of the river water. The total dissolved solids were strongly correlated with pH (r = 0.876) and negatively with temperature (r = -0.874) as given in Table 2. A river with high pH generally contains elevated levels of dissolved solids (Onianwa *et al*., 2001). Higher average TDS levels downstream could be as a result of the increase in human recreation activity such as swimming.



Sources: GIS Lab Department of Geography and Planing KSU

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Table 1: Overall average water quality of Okura river compared with some water quality standards

Parameters	Okura River				Regulatory Guidelines						
	Upstream		Downstream		WHO 1986	CQC 1999	FQC 2000	USEPA 1999	SON 2007	FEPA 1991	FAO 1984
	Mean±SD	Range	Mean±SD	Range							
pH	6.82±0.27	6.53-7.07	7.37±0.01	6.70-7.90	6.5-9.5	6.5-9.0	6.5-8.0	6.5-8.0	6.5-8.0	6-9	6.5-8.4
Temperature (^oC)	30.0	30-30	26.7±2.9	25-30	30-32	-	-	-	-	-	-
TDS (mg/L)	67±57	100-110	457±414	80-900	<1200	500	-	500	500	-	-
Alkalinity (mg/L)	68±10	60-80	93±23	70-115	200	-	-	-	-	-	-
Total Hardness (mg/L)	32.0±2.0	30-34	34.0±7.2	26-40	500	-	-	-	150	-	-
Ca (mg/L)	14.4±1.6	12.8-16.0	15.5±2.4	12.8-17.6	-	-	-	-	-	-	-
Mg (mg/L)	4.22±0.44	3.74-4.61	4.5±1.1	3.17-5.38	-	-	-	-	-	-	-
CL^- (mg/L)	70.5±4.9	64.8-73.1	75.1±3.9	72.2-79.5	250	250	200	250	250	-	-
NO_3^- (mg/L)	24±33	4-62	23±29	5-56	3.0	-	10.0	10.0	50.0	20	10
SO_4^{2-} (mg/L)	7.0±4.4	4-12	16.7±3.1	14-20	250	500	250	-	150	500	-
PO_4^{3-} (mg/L)	12.8±1.5	11.4-14.4	17.2±3.5	13.2-19.8	0.5	-	0.30	-	-	5	8.6
DO (mg/L)	6.28±0.69	5.49-6.76	5.31±0.67	4.83-6.03	5-8	5.5-9.5	≥5.0	-	-	-	-
COD (mg/L)	35±13	25-50.4	61±11	48.2-64.8	-	-	-	-	-	-	-
Cd (mg/L)	0.002±0.001	0.001-0.003	0.002±0.001	0.002-0.003	0.003	-	0.001	0.002	0.003	-	-
Cu(mg/L)	0.02±0.13	0.01-0.03	0.02±0.12	0.01-0.02	2.0	0.02	0.05	0.009	1.0	-	-
Fe (mg/L)	0.14±0.01	0.13-0.16	0.20±0.03	0.17-0.2	-	-	-	-	-	-	-
Ni (mg/L)	0.01	0.01-0.01	0.01	0.01-0.01	0.02	0.025	0.03	0.05	0.02	-	-
Pb (mg/L)	0.01±0.01	BDL-0.01	0.01±0.02	BDL-0.01	0.01	0.017	0.05	0.003	0.01	-	-
Zn (mg/L)	0.37±0.09	0.27-0.42	0.23±0.03	0.21-0.27	0.01	0.03	0.02	0.12	3.0	-	-

BDL= Below detection limit, WHO = WHO drinking water guidelines, CQC = Canadian water quality criteria for aquatic freshwater life,FQC = Flemish quality criteria for aquatic freshwater. USEPA = US Environmental Protection Agency. SON= Standard Organization of Nigeria. FEPA= Nigeria Federal Environmental Protection Agency, FAO= Food and Agriculture Organisation.

Table 2: Correlation coefficient among physicochemical properties

	Tempt	*pH*	*alkal*	*T.hard*	*Ca hard*	*Mg hard*	*Cl*	*No_3-*	*DO*	*COD*	*SO_4*	*PO_3*	*TDS*
Tempt	1												
pH	-0.91103	1											
alkal	-0.89839	0.981348	1										
T.hard.	-0.79724	0.914199	0.859478	1									
Ca hard.	-0.7462	0.834983	0.858614	0.883856	1								
Mg hard	-0.74164	0.86322	0.768146	0.960678	0.719229	1							
Cl	-0.01918	0.126491	0.146367	-0.21849	-0.26877	-0.16249	1						
No_3-	0.470302	-0.26426	-0.16676	-0.41281	-0.14097	-0.52804	0.5397	1					
DO	0.32886	-0.48731	-0.62244	-0.21534	-0.44042	-0.0609	-0.52257	-0.54081	1				
COD	-0.8312	0.814482	0.86232	0.59726	0.739076	0.449511	0.316325	0.08377	-0.65017	1			
SO4	-0.76131	0.826216	0.896214	0.557736	0.666795	0.434572	0.473222	0.173993	-0.83965	0.93248	1		
PO3	-0.95258	0.883321	0.893728	0.752203	0.812362	0.635468	0.073097	-0.23572	-0.43101	0.943482	0.82881	1	
TDS	-0.87357	0.875972	0.89672	0.788966	0.722952	0.743689	-0.05187	-0.46848	-0.47103	0.636916	0.720721	0.752776	1

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DISCUSSION

Alkalinity and total hardness

The pH values suggested that the alkaline nature of the water was particularly from bicarbonates, with hydroxide alkalinity being zero. The alkalinity level gave a strong positive correlation (r = 0.897) with TDS (Table 2). Alkalinity is also strongly correlated with calcium (r = 0.859) and magnesium (r = 0.768) (Table 2). Alkalinity values ranged from 60 mg/l to 115 mg/L with average levels of 68±10 mg/L and 93±23 mg/L (Table 1) in upstream and downstream respectively. All alkalinity values were all within WHO mg/L standard regulatory limits. Overall average alkalinity level of Okura river (81±20 mg/L) is lower than 174 reported for Ibadan rivers (Onianwa *et al*., 2001). Water hardness levels were moderate and lower than 40 mg/L. Water hardness level 50-100 mg/l is classified as moderately soft (Onianwa, 1999).The pH and alkalinity values indicate that acidification of the river water is not yet a problem.

Anions (chloride, nitrate, phosphate and sulphate)

The average chloride levels upstream and downstream (70.5±4.9 mg/Land75.1±3.9 mg/L respectively) of Okura river (Table 1), are higher than those obtained for Ibadan rivers (Onianwa *et a*l., 2001) and those obtained by UNEP/GEMS (1999) for Asia rivers (19.7 mg/l), North America rivers (17.5 mg/L), but lower than those obtained for European rivers (103 mg/L).The average chloride contents of 70.5±4.9 mg/L and75.1±3.9 mg/L are within regulatory standards of 250 mg/l (Table 1) for aquatic life and drinking water quality.

The average nitrate levels upstream (24±33 mg/L) and downstream (23±29 mg/L) locations are higher than regulatory standard limit of 10 mg/L (Table 1) for supporting aquatic life in freshwater. Nitrate nitrogen is a commonly used lawn and agricultural fertilizer. It is also a chemical formed in the decomposition of waste materials. If infants under six months of age drink water (or formula made with water) that contains more than 10 mg/L nitrate-nitrogen, they are susceptible to methemoglobinemia, a disease which interferes with oxygen transport in the blood. Pregnant women should also avoid drinking water high in nitrate (Mechenich and Andrews, 2014). Recent studies suggest connections between high-nitrate water and birth defects or miscarriages (Mechenich and Andrews, 2014). High nitrate levels also suggest that other contaminants may be present. Nitrate was moderately correlated with chloride (r = 0.540). The average phosphate level in upstream was 12.8±1.5 mg/L while average level in downstream was 17.2±3.5 mg/L. These values are significantly higher than 0.5 mg/L WHO and FEPA (5.0 mg/L) regulatory standard limit (Table 1). The release of detergent as a result of human activity could be the probable source of high level of nitrate in Okura river. It has been reported that phosphate level higher than 0.1 mg/L is regarded as unacceptably high in most freshwater system (Correl, 1998). It has also been reported that the presence of high levels of phosphate phosphorus is present in water, as well as high levels of nitrate cause an increase in algae growth and lead to eutrophication process. This is evident in some parts of the river downstream.

Average values for sulphate upstream (7.0±4.4 mg/L) and downstream (16.7±3.1 mg/L) are lower than WHO and SON regulatory standard limits of 250 mg/L and

150 mg/L respectively (Table 1). Sulphate was strongly correlated with phosphate (r =0.829) but moderately correlated with chloride (r = 0.473) as in Table 2. Other correlation values were generally lower than r = 0.5, and did not point to a common primary source of the anions (Onianwa, 2001).

Measures of organic pollution (Dissolved Oxygen, COD)

Dissolved oxygen (DO) levels ranged from 4.83 mg/L to 6.76 mg/L with average levels of 6.28±0.69 mg/L (upstream) and 5.31±0.67mg/L (downstream).The dissolved oxygen average levels were within the regulatory DO limit (5.5- 9.5mg/L) essential for the support of aquatic freshwater life. These also compares with values obtained for many major river systems around the world, where values are typically as high as 6.0-9.5 mg/L (van der Leeden *et al*., 1990).The COD values were generally low. Average levels upstream and downstream were 35±13 mg/L and 61±11 mg/L respectively (Table 1). These low values are indicative of the absence of high decomposable organic matter in the water.

Metals

Table 1 shows the ranges of variation, mean and standard deviation of metals in surface water of Okura river. The concentrations of the heavy metals (Cd, Cu, Fe, Ni, Pb and Zn) were generally low and comparable with those of many rivers world-wide (UNEP/ GEMS, 1999) except for zinc. Zinc is an essential micro-nutrient and has a variety of biochemical functions in all living organisms and crops but can be toxic when in excess (Bolann *et al*., 2007 and Soylak and Tuzen, 2008). The current level of zinc is normal for the natural abundance in water.

Quality classification for utility

The water quality determines the suitability of water for a particular purpose. No water classification index has been established for Nigerian rivers. In this study the well-known index of Prati *et al*. (1971) was applied to the data generated using the parameters pH, dissolved oxygen and COD. The classification scheme is based on a scale of I to V, which corresponds to variations from very good quality water suitable for drinking, swimming, irrigation and industrial use even without treatment, to very bad quality water, which is not fit for any of these purposes. Based on the Prati scale, Okura river fell in the class III, which indicates that the water is slightly polluted and can be treated for use without much expenses by private consumers for drinking and industrial use.

The study has shown that water from Okura river was typical of slightly polluted freshwaters. Except Zn all other metals determined were within permissible limit and do not pose threat to human life at the moment.

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