The Zoologist Vol. 3: 58-67 (2005)

SPATIAL VARIATION IN PHYSICAL AND CHEMICAL PARAMETERS AND BENTHIC MACRO-INVERTEBRATE FAUNA OF RIVER OGUNPA, IBADAN.

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Abstract

A fluviatile ecosystem, River Ogunpa, was studied between the months of May and July, 2000, to assess spatial variations in physical and chemical parameters and benthic macro-invertebrate faunal composition. Water and qualitative benthic samples were collected four times from five stations located along the river for laboratory analysis. High mean values of biochemical oxygen demand (BOD) of 20.15 ± 4.18 mgO_2/l, chemical oxygen demand (COD) of 121.95 ± 19.04 mgO_2/l, ammonia of 1.53 ± 0.44 mg/l, total suspended solids (TSS) of 152.2 ± 12.85 mg/l, lead of 0.126 ± 0.06 mg/l, copper of 0.3 ± 0.07 mg/l and zinc of 0.49 ± 0.07 mg/l were recorded. Analysis of variance (ANOVA) showed significant differences ($P<0.05$) in mean values of pH, dissolved oxygen (DO), COD, turbidity, iron and copper from the five stations. Six benthic macroinvertebrate fauna; *Melanoides tuberculata*, *Physa waterloti*, *Bulinus globosus*, *Tubifex* spp; *Chironomus* spp and *Brachydeutera* spp. were recorded. The results showed that the river is under pollutional stress from oxygen demanding organic wastes. Heavy metals analyzed show that lead, copper and zinc levels may be increasing to dangerous levels in the river. Spatial variations along the river showed some stations to be more polluted than others. All the benthic macro-invertebrate fauna recorded were pollution tolerant species.

Keywords: Fluviatile, spatial, benthic macro-invertebrate, physico-chemical parameters pollution.

Introduction

River Ogunpa, an important river in Ibadan city, is being used for the dumping of domestic waste and raw sewage due to high population pressure and rapid urbanisation (Kinako, 1979; Sridhar and Bammeke, 1985; Ayoade, 1994; Odubela, 1995). The fast rate of pollution of this river is attributable to the absence of, or poor enforcement of water pollution control laws and regulations (Oluwande *et. al.*, 1983).

Organic and heavy metal pollution of river Ogunpa has been reported by Ajayi and Adelaye (1977), Akintola and Nyamah (1978), Mombeshora *et.al.*, (1981; 1983), Sridhar and Bammeke (1985), and Fagade *et. al.*, (1993). Akintola and Nyamah (1978) reported that river Ogunpa is not potable by World Health Organisation (WHO) standards, and that the scarcity of life in many sections of the river was a testimony to its polluted state.

Fagade *et. al.*, (1993) reported that temperature, pH, total alkalinity, conductivity and dissolved oxygen content of river Ogunpa were higher during the dry season and lower during periods of flooding. This phenomenon was attributed to the cooling and diluting effects of rain and it is typical of tropical rivers (Holden and Green, 1960; Egborge, 1970; Adebisi, 1981). Fagade *et. al.*, (1993) also observed that the BOD and ammonia content of part of the river that runs through high density and industrial areas of the town were high during the rains when more wastes were dumped or carried into them.

Ademoroti (1983) and Sridhar and Bammeke (1986) showed that wastes from residential quarters and market places constitute important sources of heavy metal pollution in Ibadan City. The major source of lead was from automobile exhaust fumes washed into the rivers and streams by surface run-offs (Mombeshora *et al.*, 1983). Consequently, the concentration of lead was higher in areas with high traffic density than in areas with low traffic density. Heavy metals, however, have the potential for impoverishing freshwater at concentrations, which are scarcely detectable by even the most recent methods (Schlinder, 1990).

Odiete (1999) opined that the most popular biological method in the assessment of freshwater bodies receiving domestic and industrial wastewaters is the use of benthic macro-invertebrates. Organic loading, substrate alteration and toxic chemical pollution of a river results in a change in the pattern of its benthic macro-invertebrate community structure (APHA, AWWA, WEF, 1992). Severe organic pollution usually results in a restriction in the variety of macro-invertebrate to only the most tolerant species. Pollution – tolerant species have been recorded in River Kubani, Zaria (Oladimeji and Wade, 1984) and at Sasa and Odo Iya Alaro streams in Lagos (Odiete, 1999).

This study reassesses the spatial levels of chemical and heavy metal pollution of river Ogunpa

Study Area

River Ogunpa flows through the city of Ibadan in a North-South direction. It is within latitude 3^0 54^1 E of the Greenwich Meridian (Mabogunje, 1968: Udo, 1994). The river has several tributaries, the largest being river Kudeti. The river flows over a stretch of about 20 kilometers from its source (Ashi area) before it joins river Ona (Figure 1). The area is underlain by old metamorphic rocks (Udo, 1978).

Five sampling stations, spanning a distance of about 10 kilometers, were chosen along the course of the river. Station 1 is located 2.5km from source. The river at this point drains residential areas, and flows along a sandy substratum. The main activity around this station is car-wash service.

Station 2 is located about 4.8km from source. The river at this point drains residential areas, University College Hospital (UCH) and the Agodi fishpond. The river at this point flows along a concrete channel. The main activities at this station include swimming, bathing and washing.

Station 3 is about 7.4km from source. It is located within a commercial area (with traffic congestion) and therefore, drains the heart of the city. The river at this point flows over a sandy substratum and is contaminated with human faeces and solid wastes.

Station 4 is about 11.03km from source. The river at this point drains its largest tributary, river Kudeti, it flows over a rocky substratum and is contaminated with solid wastes.

Station 5 is about 12.5km from source. The river at this point drains residential areas and flows over a rocky substratum.

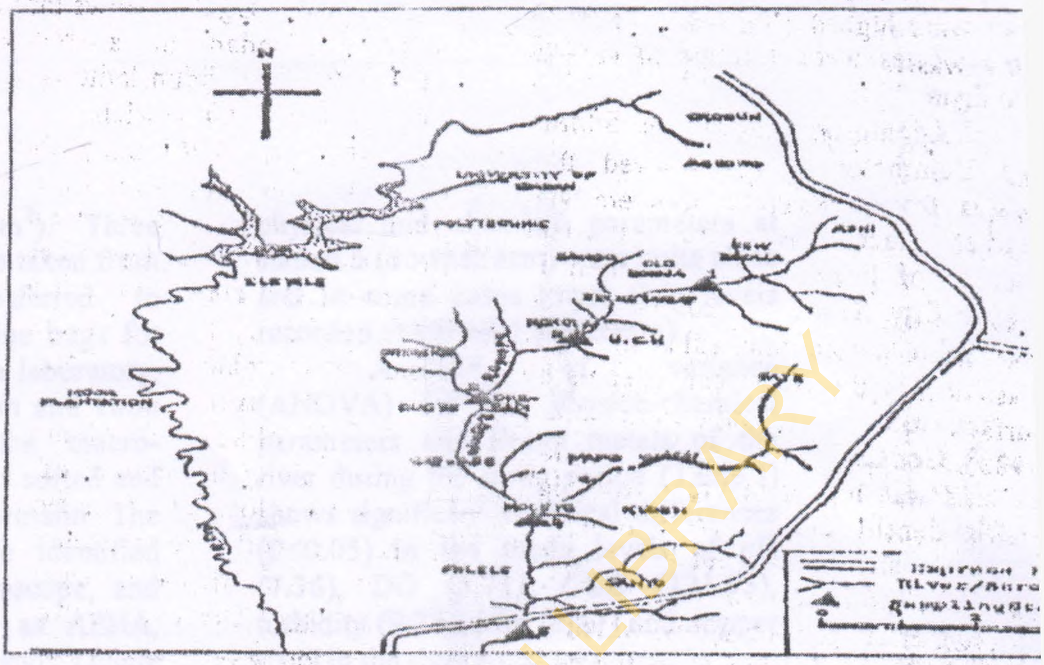

Figure 1: Map of Ibadan Showing Ogunpa River and Sampling Stations.

Materials And Methods

Water samples were collected during the early rainy season, from the months of May to July, 2000.

Current velocity was determined by a modification of the methods employed by Hira (1966) and Egborge (1970). A centigrade mercury-in-glass thermometer was used to measure the temperature of the river at each site. Turbidity was determined by nephelometric method using a nephelometer. Potential Hydrogen ion concentration (pH) was determined by electrometric method using buffered electronic pH meter, Kent 7020 model. Dissolved oxygen was determined by azide modification of the iodometric method. Biochemical oxygen demand (BOD) was determined by dilution method and incubated for 5 days at 20^{0}C in BOD bottles. Chemical oxygen demand (COD) was determined by open reflux method. Total dissolved solids (TDS) and Total suspended solids (TSS) were determined by gravimetric method at 108^{0}C and 103^{0}C-105^{0}C respectively. Nitrate was determined by ultraviolet spectrophotometric (Screening) method, sulphate by turbidimetric method and phosphate by colorimetric method. Alkalinity, hardness and ammonia levels were determined by titration methods. Iron, copper, manganese, zinc and lead levels were determined using atomic absorption spectrophotometry (AAS) after digestion of water samples using nitric acid digestion method (APHA, AWWA, WEF, 1992).

Qualitative benthic samples were collected four times near the margin of the river at each station where it was not rocky using a corer (with a surface area of $0.004m^2$). Three replicate core samples were taken from each station and transferred to separately labelled polythene bags for laboratory analysis. In the laboratory, sieves with mesh sizes 2mm and 1mm were used to screen the macro-invertebrates that were later sorted and preserved in 5% buffered formalin. The individual organisms were identified using a stereoscopic microscope, and identification guides such as APHA, AWWA, WEF (1992) and Odiete (1999).

Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physical and chemical parameters of the five sampling stations. Duncan's Multiple Range Test (DMRT) was used for multiple comparison of means so as to measure similarities of the sampling stations.

Results

A summary of the physical and chemical parameter of the study stations is given in Table I. The spatial trend in the pattern of each physical, chemical and heavy metal characteristic was similar along the river (increasing from stations 1 to stations 2 and 3 and later decreasing towards station 5) except for temperature, alkalinity and manganese. Both alkalinity and manganese recorded higher mean levels at station 5(190.18±71.5mg/l and 0.6±0.17mg/l respectively) than at station 1 (146.43±41.9mg /l and 0.29±0.08 mg/l respectively). The levels of the other physical and chemical parameters at station 5 (downstream) were quite close and in some cases lower than levels recorded at station 1 (upstream).

Analysis of variance (ANOVA) for the physico-chemical parameters and heavy metals of the river during the study period (Table I) shows significant statistical differences ($P<0.05$) in the mean levels of pH (7.36), DO (5.71), COD (121.95), turbidity (9.23), iron (2.17) and copper (0.3) in the river.

Spatial studies show station 2 and 3, which correspond to the high residential area and commercial centre (core) of Ibadan City, to be the worst polluted. The lowest pH, highest TDS, TSS and COD values were recorded at station 2 while the lowest DO and highest BOD were recorded at station 3 (Table 1).

Table II shows that the mean pH levels of the river were significantly different ($p<0.05$) between stations 2 and 4, while the mean levels of DO showed significant difference ($P<0.05$) between stations 1 and 3. Stations 2 and 3 showed significant differences ($P<0.05$) in mean levels of COD from stations 1 and 5. There was also significant difference ($p<0.05$) in mean turbidity levels between station 2 and stations 1 and 5, while mean iron levels showed significant difference ($P<0.05$) between stations 1 and 2. Significant difference ($p<0.05$) was also recorded between stations 2 and 5 for mean copper levels of the river.

Table 1: Mean variations and F-values of the analysis of variance (ANOVA) of physico-chemical parameters measured at the five stations along river Ogunpa

STATION	1	2	3	4	5	TOTAL		ANALYSIS OF VARIANCE	
PHYSICO-CHEMICAL PARAMETER	Mean	Mean	Mean	Mean	Mean	Mean	Standard Error	Calculated F-Value	Tabulated F-Value
Current velocity (m/s)	0.22	0.30	0.30	0.23	0.24	0.26	0.02	0.65	3.06
Temperature (^oC)	26.88	27.00	28.13	28.75	28.88	27.93	0.46	0.83	3.06
pH	7.34	6.98	7.21	7.72	7.57	7.36	0.09	3.70*	3.06
Dissolved oxygen (mgO_2/l)	7.11	7.15	3.95	4.57	5.76	5.71	0.42	6.21*	3.06
Total dissolved solids (mg/l)	223.00	957.00	750.25	541.50	349.50	564.25	115.50	1.44	3.06
Total suspended solids (mg/l)	136.60	199.90	179.20	127.10	118.20	152.20	12.85	1.29	3.06
Biochemical Oxygen demand (mgO_2/l)	15.48	25.80	26.78	16.91	15.76	20.15	4.18	0.31	3.06
Chemical Oxygen demand (mgO_2/l)	69.25	195.00	173.00	108.00	64.50	121.95	19.04	8.78*	5.19
Alkalinity (mg/l)	146.43	188.23	187.23	171.55	190.18	176.72	20.76	0.13	3.06
Turbidity (NTU)	6.40	13.25	11.25	8.50	6.75	9.23	0.96	6.56*	5.19
Hardness (mg/l $CaCO_3$)	87.25	127.50	86.75	81.88	65.23	89.66	8.77	1.51	3.06
Conductivity (µmhos/cm)	414.75	1195.25	1091.25	813.50	581.75	819.30	140.11	1.14	3.06
Nitrate (mg/l)	0.68	0.68	0.95	0.34	0.33	0.59	0.09	3.78	5.19
Sulphate (mg/l)	32.65	44.75	46.10	39.10	20.40	36.60	4.52	1.15	5.19
Phosphate (mg/l)	0.40	0.71	0.65	0.31	0.08	0.43	0.09	4.03	5.19
Ammonia (mg/l)	0.66	3.46	2.12	1.10	0.32	1.53	0.44	3.38	5.19
Iron (mg/l)	0.85	3.63	3.78	1.94	0.63	2.17	0.48	6.67*	5.19
Copper (mg/l)	0.18	0.60	0.47	0.18	0.08	0.30	0.07	5.20*	5.19
Manganese (mg/l)	0.29	0.69	0.62	0.49	0.60	0.56	0.07	0.89	5.19
Zinc (mg/l)	0.30	0.43	0.69	0.69	0.41	0.49	0.07	1.13	5.19
Lead (mg/l)	0.03	0.07	0.42	0.08	0.05	0.13	0.06	2.91	5.19

*Significant at $P<0.05$

Table II: Physico-chemical parameters that show significant difference in mean values at the stations along the river

	STATION				
	1	2	3	4	5
Ph	7.34ab	6.98b	7.21ab	7.72a	7.57ab
D.O	7.11a	7.15ab	3.95b	4.57ab	5.76ab
C.O.D.	69.25bc	195a	173a	108ac	64.5bc
TURBIDITY	6.4b	13.25a	11.25ab	8.5ab	6.75b
IRON	0.845b	3.63a	3.78ab	1.94ab	0.63ab
COPPER	0.175ab	0.60a	0.47ab	0.175ab	0.08b

Means with the same letter along the row (stations) for a particular parameter are not significantly different (Duncan's test) $p < 0.05$

The ranges in the levels of heavy metals recorded in the river were copper (40-720μg/l), iron (460-4310 μg/l), manganese (210-950 μg/l), lead (0.00-630μg/l) and zinc (250-960μg/l).

A total of six genera belonging to five families were recorded. These were *Tubifex* spp (Tubificidae), *Chironomus* spp (Chirobomidae), *Brachydeutera* spp (Ephydriidae), *Melanoides tuberculata* (Melaniidae), and *Physa waterloti* and *Bulinus globosus* (Planorbidae).

Table III shows that the gastropod, *M. tuberculata* and the dipteran *Chironomus* spp. were the only macro-invertebrate found in all the stations. The Oligochaet, *Tubifex* spp. was absent only in station 2 while the gastropod, *B. globossus* was found only in station 2. The gastropod, *P. waterloti* was found at stations 1 and 4 while *the dipteran, Brachydeutera* sp. was found at stations 3 and 5.

Discussion

The range in water temperature during the study period was within limits recorded for tropical rivers (Adebisi, 1981). The similar pattern in the mean levels of physico-chemical and heavy metals (increasing beyond station 1 toward the city centre and later decreasing toward station 5) may suggest that the self-purification capacity of the river can accommodate pollution stress. Cairns and Pratt (1990) and Haslam (1990) reported similar occurrences in polluted rivers.

Table III: Distribution of benthic macro invertebrates of the five stations along Ogunpa River.

		Stations				
	Organisms	1	2	3	4	5
1.	*Tubifex* spp	+	-	+	+	+
2.	*Bulinus globosus*	-	+	-	-	-
3.	*Physa waterloti*	+	-	-	+	-
4.	*Melanoides tuberculata*	+	+	+	+	+
5.	*Brachydeutera* spp	-	-	+	-	+
6.	*Chironomus* spp	+	+	+	+	+

\+ Present
\- Absent

The increase in mean alkalinity level at station 5 may be as a result of the decreasing pH value at this station. This suggests an increase in the buffering capacity of the river with corresponding decrease in pH since alkalinity of a waterbody is its acid neutralising capacity (John De Zuane, 1990; APHA, AWWA, WEF, 1992). However, Adebisi (1981) reported an increase in alkalinity of water with decreasing water level.

According to the classification of Pratt *et. al.*, (1971), surface waters with BOD of 12.0 mg/l /5 days, COD of 80 mg O_2/l, ammonia of 2.7mg/l and TSS of 278mg/l can be classified as being grossly polluted. Similar results were recorded by Fagade *et. al.*, (1993) for BOD and ammonia levels of Ogunpa river. The river can, therefore, be said to be under pollutional stress from oxygen demanding wastes.

The significant increase ($p<0.05$) in mean pH levels from station 2 to 4 may be partly attributable to the increase in major ions such as carbonate, bicarbonate and hydroxide ions dissolved into the river from underlying rocks or washed by rain and partly as a result of the reduced suspended solids due to deposition in the river at station 4. The significant decrease ($p<0.05$) in the mean levels of dissolved oxygen from station 1 to 3 suggest a significant input of oxygen consuming wastes into the river between these stations. Stations 2 and 3 recorded significant higher mean levels of COD ($p<0.05$) than stations 1 (upstream) and 5 (downstream). This suggests that station 2 and 3 are grossly polluted with organic matter and attests to the self-purifying potential of the river as it moves downstream. This was also the case with mean turbidity levels of the river.

Comparison of the levels of heavy metal data recorded in this study with those recorded by Mombeshora *et. al.*, (1981) on Ibadan surface waters and Fagade *et. al.*, (1993) on Ogunpa river show similarity in the range of Fe and Mn concentrations. The levels of these heavy metals have been associated with high levels of these metals in Ibadan soil (Mombeshora *et. al.*, 1981). The levels of Cu, Pb and Zn recorded were, however, above those recorded by Mombeshora *et. al.*, (1981) and Fagade *et. al.*, (1993). Although the latter authors reported that the levels of these metals had reduced and become less variable when compared with those of the former authors, it appears, from this study, that the levels of these metals in Ogunpa river may be increasing towards dangerous levels.

All the benthic macro-invertebrate organisms recorded in the river are indicative of polluted waters (Haslam, 1990; APHA, AWWA, WEF; 1992 and Odiete, 1999). Variations in the distribution of these organisms could be as a result of differences in local environmental conditions. The absence of *Tubifex spp* and presence of *Bulinus globosus* only at station 2 may be as a result of the nature of the substratum, a concrete channel with a muddy margin and presence of vegetation at one margin of the river. Malek (1958) reported that aquatic vegetation is necessary for the survival of aquatic snails. The presence of *B. globosus* has been reported in freshwaters with high current velocity (Ndifon, 1979). This suggests why the highest mean current velocity recorded at station 2 did not affect the presence of *B. globosus*.

The present state of the river can be improved by establishing water quality criteria, guidelines, specifications or standards to protect the Ogunpa river from further degradation from various discharges into it. The Oyo State Ministry of Environment and Water Resources to be effective should undertake this task. This can be done by monitoring and enforcing the control and treatment of sewage and other wastes before they are being discharged into the river and moreso, by prohibiting solid wastes and faecal discharge into the river.

Acknowledgement

We acknowledge the help of Professor M.K.C Sridhar, of the Division of Environmental Health, College .of Medicine, University of Ibadan, for his guidance in the choice of the project topic. Our sincere appreciation also goes to Dr. A.B. Odaibo for the identification of some snail species.

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