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ASSESSMENT OF WATER QUALITY AND MACROINVERTEBRATE ABUNDANCE IN OPA STREAM - RESERVOIR SYSTEM, ILE-IFE

SYLVESTER S. OGBOGU

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ABSTRACT

Water quality and benthic macroinvertebrate abundance at five stations in Opa stream-reservoir system was studied between August and December, 1997. Mean BOD and conductivity showed a narrow range while DO range was wider, among the stations. The total number of individual macroinvertabrates collected was 766 which belonged to 14 taxa. There was no significant difference in neither the total number of individuals ($F = 0.629$, $P > 0.05$) nor the abundance of Ephemeroptera, Copepoda and Hemiptera ($P > 0.05$) among the five stations. However significant difference was observed in the abundance of Odonata, when the upstream (1 and 2) and downstream (4 and 5) stations were compared. Rank correlation coefficients indicated a strong relationship ($r_s = 0.6$) between the number of individuals and mean of two physico-chemical parameters (BOD and DO) among the stations. The mayfly *Caenis* sp. was the only taxon which abundance correlated with all the three parameters. Based on these findings, the water body was considered a stressed ecosystem, and to further investigate this condition, extra data and the use of certain analytical indices are needed.

Keywords: **Water quality, macroinvertebrates, stress ecology**

INTRODUCTION

The practice of using aquatic biota to assess water quality and environmental degradation has gained prominence in recent times. Many studies have correlated degradation with either algae, invertebrates, fish or combinations of these communities (Rosenberg *et al.*, 1986; Ford, 1998; Fausch *et al.*, 1990 and Barbour *et al.*, 1999). Assessments using benthic invertebrates in particular have a long history (e.g. Dills and Rogers, 1974; Winner *et al.*, 1980) and recent studies in water quality management have dealt with the use of macroinvertebrates in evaluating the impacts of specific pollutants in aquatic environments (Scrimgeour, 1989; Quinn and Hickey, 1993; Monda *et al.*, 1995; Ort *et al.*, 1995 and Matagi, 1996).

Many studies on aquatic ecosystem impairment have been reported in Nigeria (e.g. Ogbeibu, 1985; Ogbogu and Hassan, 1996) but the number is far from being adequate. The purpose of this paper is to show how some physico-chemical parameters affect the abundance of macroinvertebrates in Opa stream-reservoir system, Ile-Ife, Nigeria.

The data presented here resulted from part of a detailed long term study on the diversity, distribution and abundance of benthic macroinvertebrates in the water body. The water body consists of a reservoir and a stream flowing through agricultural lands and receive some point source discharge such as an abattoir and a sewage oxidation pond effluents.

MATERIALS AND METHODS

Study Site

The Opa stream is the major source of water supply to the Opa reservoir (Fig. 1). It is located in the northern part of the Obafemi Awolowo University campus. The water body drains a catchment area of 116km² which extends from longtitude 4°31' to 4°34' E and from latitude 7°21' to 7°35' N. The stream continues southward from the reservoir's auxiliary spillway through a channel, crossing the major entrance road to the campus and joined by a stream passing by a sewage oxidation pond. The stream leaves the campus near the southwest end. It crosses Ede road flowing through a farmland beside an abattoir. Benthic macroinvertebrate and water samples were collected from five stations along its stretch (Fig. 1).

Station 1 is located at the upper reaches of the reservoir. It is surrounded by cultivated farmlands and shade trees with the bank vegetation dominated by *Cyclosorus striatus* (Schum), Ching and *Commelina diffusa*. *Pistia stratiotes* virtually covers the surface of the slow-flowing water most times. The substratum is muddy. Station 2 is at the lower reaches of the reservoir beside the dam of the reservoir. The aquatic hydrophytes are dominated by pure stands of *Typha australis* Schum and Thonn with scanty occurrence of *Scirpus cubensis* Poepping and Kunth and *Ludwigia* species.

Station 3 is situated below the dam in the channel just after the spillway. The substratum is made of large stone bed virtually covered by mats of *Fontinalis* sp. (Bryophyta) at the upper portion, and a sandy substratum at the lower portion. The water is lotic most times of the year and records high currents at the peak of rainy season. *Acroceras zizanioides* Dandy, *Pentodon pentandrus* Vatke and *Polygonum senegalense* (Mmeisn) in association with other hydrophytes form the bank vegetation at this station. Station 4 is by the bridge on Ede road. It has a sandy/ gravel substratum and records high flow in the rainy season but little or no water current at extreme dry season. Before this station is adjacent

SYLVESTER S. OGBOGU, Department of Zoology, Obafemi Awolowo University Ile-Ife, Osun State, Nigeria.

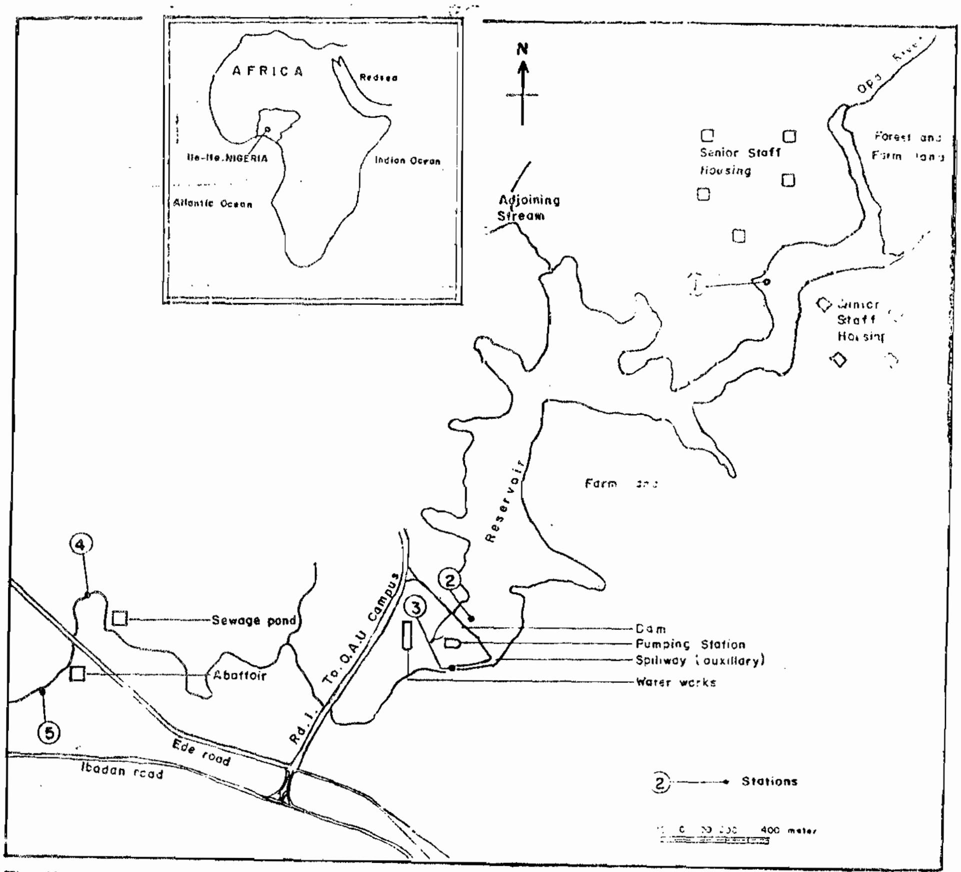

Fig. 1: Opa stream-reservoir system, Obafemi Awolowo University showing sampling sites numbered 1-5.

farm land in which is situated a sewage treatment pond. The pond effluents are usually discharged into the stream through an adjoining stream.

Station 5 is situated 300 meters down stream of station 4, after an abattoir and its animal yard at the eastern bank. An average of 20 cattle are slaughtered daily and consequently, tons of organic load (blood, cow dung and associated materials) are discharged into the stream from the abattoir. The substratum and bank vegetation is similar to that of station 4.

Sampling

Benthic macroinvertebrate were sampled fortnightly between August and December 1997 using Surber sampler in substrata devoid of submerged and rooted hydrophytes. Kick samples using a standard pond net (Mason, 1991) were also taken from areas with aquatic plants. The samples were then washed into plastic bowls for sorting in the laboratory. Samples were stored in 4% formalin whenever it was not possible to sort them immediately. Water was collected in 2 litre plastic cans, biochemical oxygen demand (BOD) and dissolved oxygen (DO) bottles for the measurement of conductivity, BOD and DO respectively, using standard methods (APHA, 1985).

In the laboratory macroinvertebrates, were identified with a binocular microscope using the keys in Pennak (1978) and counted. Percentage composition was used to determine the most abundant taxa in each station. The differences in macroinvertebrate abundance between the stations were compared using analysis of variance (ANOVA) (Zar, 1984). The Spearman's rank correlation test was employed in investigating the relatioships between the total number of individuals at the five stations and the physico-chemical parameters. The correlation test was also used to show the nature of the relationship between the abundance of macroinvertebrates and the physico-chemical parameters.

RESULTS

The overall macroinvertebrates collected from the water body totalled 766 individuals which constitute 14 taxa (Table 2). The total number of individuals collected from stations 1 to 5 throughout the study period were 112, 233, 141, 116 and 164, representing 8, 13, 7, 8 and 7 taxa respectively. Ephemeroptera was the most abundant order represented by two genera, *Caenis* sp. and *Cloeon* sp. with 269 and 72 individuals respectively. This was followed by Copepoda with 126 individuals.

Copepoda, Odonata, Hemiptera, Diptera, Trichoptera, Coleoptera and Acarina were restricted to the first three stations. Ephemeroptera however, was well represented in all stations and generally dominated by *Caenis* sp. with the highest percentage composition in station 1, 4 and 5 (58.04, 47.41 and 79.88% respectively). It represents 35.12% of the total catch. Acarina and Copepoda were the most

Table 1: Mean BOD, DO and conductivity of water at five stations in Opa stream-reservoir system, August to December, 1997

Station	BOD (mgl^{-1})	DO (mgl^{-1})	Conductivity (:mhos) x 10^{-4} " 10^{-5}
1	3.1 ± 2.5	6.0 ± 0.93	1.95 ± 1.26
2	3.88 ± 2.55	4.96 ± 1.36	1.71 ± 1.15
3	4.18 ± 1.44	6.28± 1.87	1.69 ± 1.29
4	3.05 ± 2.38	5.0 ± 0.81	1.68 ± 1.31
5	3.28± 2.57	4.88 ± 2.11	1.72 ± 1.23

Table 2: Composition, distribution and abundance of benthic macroinvertebrates in Opa stream-reservoir system, August to December, 1997. Values in parenthesis represent percentage composition (%).

Taxon	Total number of individuals collected at stations					Total
	(1)	(2)	(3)	(4)	(5)	
EPHEMEROPTERA						
Caenis sp.	65(58.04)	16(6.87)	2(1.42)	55(47.41)	13(79.88)	269(35.12)
Cloeon sp.	13(11.6)	20(8.58)	14(9.92)	18(15.52)	7(4.27)	72(9.0)
COPEPODA						
Copepods	12(10.7)	11(4.72)	78(55.32)	21(18.10)	4(2.44)	126(16.45)
ODONATA						
Dragonfly	14(12.5)	32(13.73)	0	6(5.17)	3(1.83)	55(7.18)
Damselfly	2(1.79)	14(6.0)	8(5.67)	11(9.48)	1(6.71)	46(6.01)
HEMIPTERA						
Notonecta	1(0.89)	4(1.72)	0	0	0	5(0.65)
Pondskater	4(3.57)	12(5.15)	4(2.84)	2(1.72)	2(1.22)	24(3.13)
Belostoma sp.	0	4(1.72)	1(0.71)	0	6(3.66)	11(1.44)
DEPTERA						
Mosquito larvae	1(0.89)	4(1.72)	0	1(0.86)	0	6(0.78)
TRICHOPTERA						
Hydropsychidae	0	0	34(20.1)	0	0	34(4.44)
COLEOPTERA						
Beetle larvae	0	7(3.0)	0	0	0	7(0.91)
ACARINA						
Water mites	0	107(45.92)	0	0	0	107(13.97)
UNIDENTIFIED						
Species 1	0	1(0.43)	0	2 (1.72)	0	3(0.39)
Species 2	0	1(0.43)	0	0	0	1(0.13)
Total no. of taxa	8	13	7	8	7	14
Total no. of individuals	112	233	141	116	164	766

abundant taxa in station 2 and 3 with 45.92 and 55.32% respectively. Acarina seem to prefer deep pools with much hydrophytes and without water current, hence they are restricted to station 2. Trichoptera larvae were only found attached to the *Fontinalis* sp. in station 3 where water current was high most times.

ANOVA test did not indicated any significant difference (F = 0.629, P>0.05) in the total number of individuals collected from all the stations on each sampling day. There was no significant difference in the abundance of Ephemeroptera, Copepoda and Hemiptera (P>0.05) in the five stations. For Odonata however, the abundance of dragonfly was significantly different in the five stations (F = 2.926, P<0.05) while that of damselfly was not (P>0.05). No dragonfly was caught in station 3. Using the least significant difference (L.S.D.) in comparing mean abundance of dragonfly, differences were observed between stations 2 and 4. and between stations 2 and 5. There was no difference between stations 1 and 2, and between stations 4 and 5. This shows that stations 4 and 5 are not conducive for the Odonata.

Mean BOD showed a narrow range, between 3.05 ± 2.38mgl^{-1} in station 4 and 4.18±1.44mgl^{-1} in station 3 while that of DO was wider, between 4.88 ± 2.11mgl^{-1} in station 5 and 6.28 ± 1.87mgl^{-1} in station 3 (Table 1). There was gradual but continuous decrease in DO downstream along the channel. Mean conductivity did not show marked difference among the stations. It ranged from 1.68 X 10^{-4} to 1.95 X 10^{-4}:mhos. The differences in the pattern of fluctuation of these parameters among the five stations were not statistically significant (P>0.05).

The correlation coefficients indicated a strong relationship (r_s = 0.6) between the total number of individuals and mean BOD as well as mean DO. Table 3 shows the correlation between some common taxa and the physico-chemical parameters. *Caenis* sp. correlated with all three parameters while *Cloeon* sp. correlated with only conductivity. Pondskater correlated with BOD while Copepoda correlated with DO and conductivity.

DISCUSSION

The total number of taxa observed in the present study is low compared to higher numbers recorded for related tropical streams (Amakye, 1980; Bishop, 1983; Victor and Ogbeibu, 1985 and Ogbeibu and Victor. 1989). This suggests that the water body is a stressed ecosystem. This could be attributed to the influx of contaminants through runoff as well as sewage and abattoir effluents which are discharged into it. However, it can be regarded as fairly clean if the BOD is compared with Hynes (1963) data. This may explain the abundance of certain taxa despite the stress.

Many species of Ephemeroptera are absent in polluted waters (Goel *et al.* 1983) but some tolerate such conditions as observed by Lenat and Crawford (1994). *Caenis* was more abundant in downstream than upstream stations, the contrary being the case with *Cloeon*. Since the downstream stations receive more effluent discharge it could be inferred that *Caenis* can tolerate stressed conditions more than *Cloeon*. This differences in response to stress is not restricted to Ephemeroptera alone. For example Kondratieff *et al* (1984) observed diverse macroinvertebrate communities above, and a community dominated by chironomids, psychodid flies and oligochaetes below a sewage out fall. The tendency of macroinvertebrates towards upstream sites is in keeping with many previous findings (Birge, *et al.*, 1989; Monda *et al.*, 1995 and Matagi, 1996) in which low number of invertebrates taxa were found downstream below point and non-point sources of discharge. Such areas are noted for having lower DO compared to upstream areas as observed in the present study. The lack of significant difference in patterns of fluctuations in BOD, DO and conductivity can be attributed to the dilution of water through runoff. Such event can reduce the differences in the physico-chemical parameters between two locations in a water body. This effect of runoff can also explain the observed lack of significant difference in total number of macroinvertebrates and the abundance of the commonest taxa among the five stations.

The large numbers of Trichoptera and Copepoda found in station 3 suggests that these taxa prefer areas with high water current. The hydropsychid net-spinning Trichoptera in particular inhabit many types of running water (Clifford, 1991). This explains the restriction of Trichoptera to station 3 where they were attached to the *Fontinalis* sp. which provides the foundation for larval nets. On the other hand, water mites were found mainly in the pool above the dam, to avoid being washed away by spates of water current.

The significant difference observed for abundance of dragonfly among the five stations suggests species-specific nature of responses to pollutants in aquatic invertebrates. This is further demonstrated when differences in its abundance between upstream (stations 1 and 2) and downstream (stations 4 and 5) stations were considered.

The correlation of total number of individual macroinvertebrates with BOD and DO suggests that although the water is fairly clean, some of its physico-chemical properties can act in assorted combinations to influence macroinvertebrate abundance and distribution as noted by Rabeni and Minshall (1977) and Ogbogu and Hassan (1996). This phenomenon was corroborated by the significant correlation of *Caenis* sp. with BOD, DO and conductivity.

To conclude, it has been established that the water body is stressed, because of the lower number of taxa in its invertebrate fauna. However, it is important to note that it does not appear to be heavily stressed since the number of taxa did not vary so much among the stations. For further investigation of this condition, more data collection and the use of analytical techniques such as taxa richness, evenness and general diversity indices are imperative. This therefore forms the next approach in the on-going study of the effects of pollution on benthic macroinvertebrates in the water body.

Table 3: Spearman's rank correlation coefficients for the relationships between macroinvertebrate taxa and physico-chemical parameters

Taxon	Parameter		
	BOD	DO	Conductivity
Caenis sp.	-0.6*	-0.6*	0.6*
Cloeon sp.	0.1	0.1	-0.6*
Dragonfly	-0.3	-0.3	-0.3
Damselfly	-0.38	-0.18	-0.68*
Pondskater	0.6*	0.3	0.25
Copepod	0.1	0.9*	-0.6*

* Significant correlation

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