HARNESSING AQUATIC PHYSICOCHEMICAL PARAMETERS INFLUENCING MACROINVERTEBRATE FAUNA IN ANAMBRA RIVER BASIN FOR SUSTAINABLE FISH PRODUCTIVITY

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ABSTRACT

The management-oriented background for harnessing aquatic physicochemical parameters influencing macro invertebrate fauna of Anambra River basin for sustainable fish productivity was studied. The intra seasonal variability in the water quality of the river revealed mean transparency of 1.79 cm, Conductivity of 28.81 µscm^{-1}, nitrate-nitrogen of 3.23 mgl^{-1}, total hardness of 6.43 mgcaco$_3$L^{-1}, biological Oxygen Demand (BOD) of 3.62 mgl^{-1}, No$_3$-N/Po$_4$-P 0.54 ratio and Co$_2$/DO of 0.81 were significantly higher in the dry season than all other parameters which were significantly higher in the wet season. A total of 1808 individuals (mostly adults) belonging to 97 species of macro-invertebrate fauna were collected. The overall composition of the fauna in the river basin was dominated by coleopterans and the hemipterans. The estimated annual fish yield of the river basin was 72.91 kg/ha based on a morphoedaphic index. The water quality of the River can be harnessed by controlling and/or prohibiting the discharge of municipal effluents and domestic garbage into the river as well as the continuous use of the riparian zone for agronomy. The maintenance of peripheral 50/60 m of thick riparian vegetation can act as buffer strip to check bank erosion is suggested.

Keywords: Macro invertebrates, Physicochemical Parameters, Harnessing, Fish yield

INTRODUCTION

The invertebrate fauna are important food items for the young and some adult of many freshwater fishes (Ovie, 1993). As such their roles are significant and are extensively used in the rearing of larvae and fry of commercially important fishes. They are also indispensable in the food chain of fishes as animal food which supplies amino-acids, vitamins and mineral salts, (Watanabe, 1978; Alam *et al.,* 1989). The abundance and growth of macro fauna depend upon bacteria, yeast, organic, inorganic nutrients and other small and microscopic organisms and water properties (Hirayama and Watanabe, 1973; Hirata 1977; Ali *et al.,* 1986). Boyd (1982) stated that fish production from aquatic media can be enhanced by adopting rationale management strategies, including the curbing of anthropogenic perturbations of the physicochemical characteristics of water. This is based on the rationale that water quality attributes are prime factors that influence fish survival, reproduction, growth performance and overall biological production (Boyd and Lichtkoppler, 1979). They also affect aquatic biotic integrity by directly causing mortality and/or shifting the equilibrium among species due to subtle influences such as reduced reproductive rates or alterations in competitive ability.

In Nigeria, definitive information on aquaculture based on water quality parameters of lotic and lentic system is useful and many investigations have been conducted to assess the physicochemical and macroinvertebrate (Eyo and Ekwonye, 1995; Odo *et al.,* 2007) status of aquatic ecosystems as guidelines for rational fisheries management and resource conservation.

The present study was designed to provide management-oriented information on the physio-chemical integrity of the Anambra River Basin in Anambra State, Nigeria. This was intended to provide the background data for harnessing the macroinvertebrate fauna that are important food items for the young and some adult of many freshwater fishes. The results are discussed in the light of water quality standards conducive for fish production in tropical aquatic ecosystems. Perspectives in effective water quality improvement, checklist of macroinvertebrate fauna, fisheries potential, management and conservation of the river ecosystem were also provided.

MATERIALS AND METHODS

The Study Area: The Anambra river (Figure 1) is the largest tributary of River Niger below Lokoja, and is often regarded as a component part of the lower Niger lowlands. The source of the river is Ankpa hills where it flows in a southerly direction through a narrow trough that gradually broadens as it courses down. It crosses the Kogi/Anambra State boundary a bit north of Ogurugu, and then meanders through the Ogrugu station to Otuocha and Nsugbe. From there it flows down to its confluence with the Niger river at Ontisha.

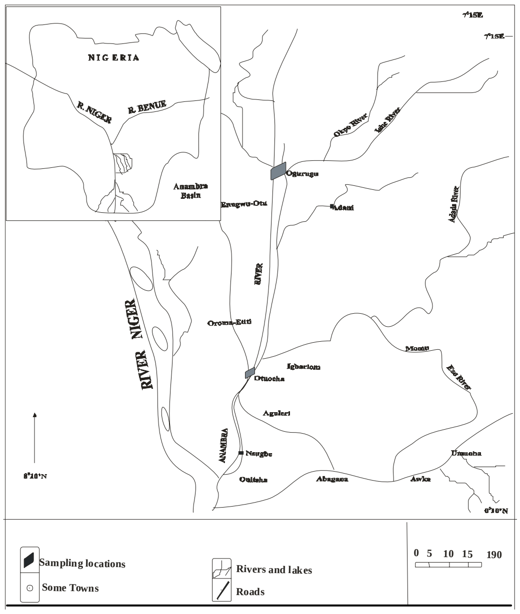

Figure 1: Map of Anambra river showing the sampled stations

The river is about 230 km in length and has an extensive basin which is Ca. 14, 010km^2. The basin lies between latitude 6^o 10" and 7^o 20', longitude 6^o 35' and 7^o 40', east of the Niger river into which the Anambra river empties. The Anambra river system is known to support a rich and thriving fishery (Awachie, 1976). Riparian vegetation, ecology and productivity of the river basin have been extensively studied (Awachie, 1976). Agriculture and fishing thus form the dominant occupations of the local people, and these major economic activities are geared to the two seasons of the year.

Physicochemical Characteristics: Eighteen physicochemical parameters (Table 1), were determined monthly (from January, 1998 to October 1999 inclusive) based on records and samples taken from three stations (Figure 1). All in situ determinations and collection of surface water samples were conducted during mid-morning (10 – 11 am).

Each station water level was determined by means of a graduated wooden pole. Surface temperatures were measured in situ by a 2 minutes immersion of 0 – 50^o C mercury in glass thermometer and transparency, with a 25 cm diameter secchi disc. The concentration of suspended solids (SS) was estimated by filtering (under suction) of 1 litre of water sample through a pre-weighted GF/C What man filter paper and oven-drying at 120^o C for 12 h; it was re-weighed after cooling in a desiccators to obtain the amount of non-filterable residue. The coefficient of coarseness (CC) of suspended solids was estimated by dividing the concentration of suspended solids (SS) by Transparency.

Hydrogen ion concentration (pH) was measured with a glass electrode of a battery powered pH J-250-F Griffin meter. Conductivity (CD) was determined with a Gensway digital meter. Analytical methods for all other parameters are described in (APHA, 1979). Dissolved oxygen was fixed in the field and the concentration estimated in the laboratory by Winkler's method. Water samples for BOD were collected from each station using 250 ml reagent bottles. These bottles were painted black to prevent light penetration. After incubating the sample for five days at 20^o C then it was fixed with Winkler's solutions A and B before adding two drops of concentrated H_2S0_4 to dissolve the precipitate Titration. Titration for DO was then carried out and the difference between the initial and final DO values was the BOD value.

Free $C0_2$ was determined in the field titrimetrically using 0.0027N NaOH and phenolphthalein indicator. Total alkalinity was estimated by titration with 0.02N H_2S0_4 using phenolphthalein and methyl orange indicator.

The No_3-N and Po_4-P were determined calorimetrically using a Gallencamp calorimeter in Analytical Chemistry Laboratory of Soil Science Department, University of Nigeria, Nsukka.

The current (Ms^{-1}) was estimated at the different aforementioned stations by noting the time taken when a piece of lead fixed cork was allowed to drift from one predetermined point to the other.

Macroinvertebrates: Three stations, Ogurugu, Otuocha and Nsugbe were chosen as sampling points because of accessibility as well as their strategic locations on the various stretches of the Anambra river and fishery activities. Samples were taken during the last week of each month from each of the three stations for 22 months. Samples were equally taken at Iyi-Eri, Ozele and Ojo ponds as well as in Adada and Igbariam occasionally. Macroinvertebrates were collected from each station monthly using Ekman grap which was normally lowered into the water body with a graduated rope which also measures the dept of the water. The samples collected were later emptied into wide mouthed plastic container for sorting.

The plankton net made of bolt silk number 10 meshes (154 cm) with a plastic bottle at the end was used to collect drifting organism along water current and other limnitic (pelagial) regions. The plankton samples were collected by sinking the plankton net beneath the surface of water and towering with a silk along the opposite direction of the flowing river.

Hand scoop net of mesh size 74 cm was used to collect macroinvertebrates at biotopes and littoral regions. Benthic samples were collected from the bank root biotope of the three sampling stations by kick sampling techniques. This technique has earlier been described (Hynes, 1970; Peterson and Fernado, 1970; Towns, 1979; and Berton, 1980).

An area of 0.3 m^2 was carefully marked out each sampling station. On every sampling occasion the substratum and emergent vegetation were vigorously disturbed for about five to ten minutes so as to dislodge the organisms. A benthic hand net made of bolting silk No. 10 mesh (154 $^u/_m$) with a plastic bottle at the end of it was used to sweep organisms along water current. This was later emptied into a wide-mouthed plastic container. This technique was repeated three times at each sampling station.

On some sampling occasions samples were taken to the laboratory without fixing. The aim of this exercise was to see the moving organisms. This was useful for identification purpose, and a better method of recovering very small macro benthic invertebrates.

Macro invertebrate samples collected from the different stations were sieved through a 0.25 mm mesh sieve before sorting was done. Sorting was done both with the unaided eyes and under the Olympus, binocular dissecting microscope (model 570, 0.7 to 4-2x). Organisms were sorted into taxa, each taxon representing distinct morphological entity. The number of individuals was counted and recorded.

Representative specimens were photographed while temporary slides of representative specimens were prepared by mounting in polyvinyl lacto phenol, tented with lignin pink between slides and cover slips and then sealed with nail vanish for examination.

Large specimens were mounted directly without slide preparations. Specimens were identified using only the external taxonomic features. Specimens were preserved in vial bottles with 70 % alcohol mixed few drops of glycerin to keep them from dehydration.

Identification of species was by use of a wild MLL binocular microscope and relevant texts used to aid identification included Needham and Needham (1962), Mellamby, (1963), and Smith (1984). Also some notable aquatic Entomologists and Limnologists including Prof. Madubinyi of Entomology Unit, Faculty of Veterinary Medicine and Prof. M .C .Eluwa both of University of Nigeria, Nsukka and Prof Landis Hare of University of Waterloo, Ontario Canada were consulted for the identification of the macroinvertebrates.

Temporal Variability and Potential Fish Yield: Temporal variabilities in each water quality parameter were evaluated on annual and seasonal scales by the coefficient of variation (% CV = standard deviation x 100 / mean) (Lowentin, 1966) with the expectation that the amplitude of variation would be high under "poor" water quality condition and vice-versa under "better" condition (Karr *et al*., 1981). Potential fish yield from the river was estimated from the morphoedaphic index (Welcome and Henderson, 1976) using the formula: Y = 14.3136 (MEI); where Y = Potential fish yield (kg yr $^{-1}$); MEI = morphoedaphic index (i.e. annual mean conductivity/mean depth of river in metres).

Anthropogenic Perturbations: Non-quantitative field observations were conducted on the major forms of anthropogenic perturbations of the river basin that are likely to influence its suitability for aquatic organisms and fish productions.

Data Analysis: Ninety-seven macro invertebrate species were collected during the survey. The numeric and biomass data matrices consisted of eight sampling cruises covering three sampling stations each with five replicate. Numeric density was expressed as individuals/1000 m^2 and biomass in grams (wet weight). Species richness, biomass, individual numeric abundance, and species diversity (Shannon-Wiener H) were computed for each station using pooled data. Temporal variability of each water quality parameter were evaluated on annual and seasonal scales by the coefficient of variation (% CV = standard deviation x 100/mean; Lowentin, 1966) with the expectation that the amplitude of variation would be high under "poor" water quality condition and vice versa under "better" condition (Karr *et al.,* 1981). Potential fish yield from the river basin was estimated from the morphoedaphic index (Welcomme and Hendson, 1976). Non-quantitative field observations were conducted on the major forms of anthropogenic perturbations of the river basin that are likely to influence its suitability for fish production.

RESULTS

Physicochemical Characteristics: The annual means and ranges of the physicochemical parameters of the river are presented in Table 1. Means of the river basin were calculated for 22 months. The minimum and maximum records of water level showed that the amplitude of annual fluctuation was moderate and represented only 2.95 fold variation. The river has a relatively stable thermal regime with a surface water temperature difference of 6.4^o C between the extreme values. Water transparency displayed a 2.4 fold annual variation in the concentration of suspended solids. This lowest water transparency and highest concentration of suspended solids registered indicate that there were periods of very low light penetration.

Although average water pH was approximately neutral, the minimum and maximum estimates respectively depicted slight acidity and alkalinity. Annual fluctuation was minimal and moderate for fish production with a difference of 1.01 between the extreme ends (Table 1). The Anambra river was well oxygenated, with mean DO of less than 6 mg1^{-1}.

The average concentration of Co_2 was relative and the range corresponded to a 1.96-fold annual variation The Co_2/DO_2 ratios revealed that the levels of Co_2 exceeded those of DO_2 except in their minimal values in the month of (Jun and July) which were slightly less than a half unity. Total alkalinity was mainly of the bicarbonate type, with high values recorded during the wet season. The ranges in the concentrations of nitrate-nitrogen and phosphate-phosphorus revealed relatively moderate magnitudes of fluctuations (2.94 fold for No_3-N and 4.4 fold for PO_4-P).The nitrate- nitrogen exceeded those of phosphate-phosphorus during the months of the study

The mean conductivity of the River Basin revealed a relatively moderate dissolved electrolyte content.

Table 1: Physicochemical attributes of Anambra river basin and optima levels for fish production in tropical aquatic ecosystems

		Levels in Anambra River Basin			Optima levels for fish production		
		Means	Mini.	Maxi.	Mini.	Maxi.	Ref.
1	Dept. (m)	5.97	3.76	11.1			
2	Temperature (^{i}C)	28.89	25.7	32.1	25.0	32.0	1
3	Transparency (cm)	1.79	1.1	2.6	30.0	60.0	1
4	Coefficient of Coarseness of SS	3.01	1.1	6.0			
5	Suspended Solids Mgl^{-1}	3.03	1.3	5.6	25	80	2
6	Conductivity μscm^{-1}	29.81	16.9	40.5	40.7	61.8	4
7	PH	6.68	6.19	7.2	6.5	9.0	1
8	Nitrate-Nitrogen Mgl^{-1}	3.23	1.8	5.3			
9	Phosphate-phosphorus Mgl^{-1}	7.53	3.0	13.2	12.5	60.0	4
10	Free Carbon dioxide $MgCaCo_2l^{-1}$	3.33	2.3	4.5		5.0	1
11	Total Hardness $MgCaCo_3l^{-1}$	6.43	4.1	11.01		5.0	
12	Dissolved o_2 Mgl^{-1}	5.18	3.85	7.13		5.0	
13	Biological o_2 demand Mgl^{-1}	3.62	2.20	5.9			
14	Total alkalinity $MgCaCo_3l^{-1}$	33.28	25.34	48.36	20	300	1
15	Current ms^{-1}	2.02	1.6	2.6			
16	$No_3^-N/P04$- Ratio	0.54	0.19	1.77		4.0	3
17	Co_2/o_2 Ratio	0.81	0.42	1.31			
18	Chemical o_2 demand Mgl^{-1}	4.17	1.81	6.8			

1 = Boyd and Lichkropler (1979), 2. = FWPCA (1968) 3. = Kutty (1987), 4. = King (1998)

Table 2: Conductivity (μscm^{-1}) and pH of some Africa river systems (Welcomme, 1985)

S/N	Rivers	Conductivity	pH	Reference
1	Ubangui	19.4-56	6.2-6.7	Micha, 1974
2	Oshun	57.96		Egborge, 1971
3	Niger	31-7-	6.7-7.2	Daget, 1957
4	Sokoto		6.9-8.1	Welcomme and Henderson, 1976
5	Chari	22-73	6.9-7.7	Welcomme, 1972
6	Black Volta	41-124	6.5	Welcomme, 1972
7	Idodo	27.9-54.1	6.04-7.39	Anibeze 1995
8	Anambra	16.9-40.5	6.19-7.2	This Study

Potential fish yield of the Anambra River = Y = 14.3136 (MEI)$^{0.4681}$ MEI = Conductivity/Dept MEI = Morphoedaphic index (i.e. annual mean conductivity/mean depth of the River. Annual mean conductivity = 29.44, Annual mean depth = 5.78, Y = 14.3136 (2944/72.91 kg ha^{-1} based on a morphoedaphic index.) 0.4681 = 72.905257$^{0.4681}$

The range of conductivity (Table 2) was moderate represented only a 2.4 fold changes during the period of study

Macroinvertebrate: A total of 1808 individuals (mostly adults) belonging to 97 species of macro invertebrate fauna were collected. The composition of the river basin strongly dominated by Coleopteran, and Hemiptera. The coleopteran group consisted of Hydrophiledae, Dytiscidae, Gyrinidae**,** and Chrysomelidae (Table 3).

Among the species Gyrinidae ranked highest in abundance, followed by Decapods and the least were the species of the Simuliidae (Table 3). In the fauna is the monthly variation was A total of 1808 individuals (mostly adults) belonging to 97 species of macro-invertebrate fauna were collected. The overall composition of the river basin is strongly dominated by coleopteran and Hemiptera. The coleopteran groups consisted of Hydrohilidae, Dytiscidae, Gyrinidae and Chrysomelidae. Among the species Gyrinidae ranked highest in abundance, followed by Decapods and the least were the species of the Simuliidae (Table 3). The monthly variation of fauna was highest in the dry season months of November to January and low in September and October, wet season months.

Temporal variability and Potential Fish Yield: The estimated annual fish yield of the river basin was 72.91 kg ha^{-1} based on a morphoedaphic index. Temporal dynamics in the physicochemical parameters of Anambra river basin as indexed by coefficients of variation are presented in Table 4.

Amplitudes of annual variability were generally low for the lotic media (CV 30 %). The most variable parameters (CV 30 %) were suspended solids, Nitrate-Nitrogen, phosphate-phosphorus, total hardness, No_2-N/PO_4-P ratio, and Co_2/DO_2.Table 5.

Intra seasonal variability in the water quality of the River revealed that Transparency, conductivity, Nitrate-Nitrogen, Total hardness, biological oxygen demand, No_2-N/PO_4 ratio and Co_2/DO_2 were more variable in the dry season while all other attributes were more variable during the rains. Overall river quality was more stable in the dry season than in the wet season. Biological oxygen demand displayed a 2.7 fold annual variation and this indicated that the river was slightly polluted.

Anthropogenic Perturbations: About 50 – 60 % of the primary riparian vegetation of the River Basin has been cut to make way for predominantly subsistence crop agriculture.

Table 3: The composition, distribution, density (No/1000m^2) and diversity of macroinvertebrate fauna in the study stations of Anambra river basin for 22 months

Taxonomic	Ogurugu Station 1		Otuocha Station 2		Nsugbe Station 3		Total	
	No. of Taxa	No. of Indiv.	No. of Taxa	No. of Indiv.	No. of Taxa	No. of Indiv.	No. of Taxa	No. of Indiv.
1.*Coleoptera:*								
Hydrophilidae	3	67	10	80	1	9	14	156
Dytiscidae	4	89	7	101	2	14	13	204
Gyrindiae	6	184	8	270	3	91	17	545
Chrysomelidae	4	19	1	10			5	29
2. Decapods	2	110	4	215	1	40	7	365
3. Nematodes			1	2	1	1	2	3
4.*Hemiptera:*								
Nepidae	3	90	15	171	2	58	10	319
Velidae	1	5	3	87	2		6	126
5. Lepidoptera	2	5	3	6		3	5	11
6.*Mollusca*:								
Lymnaeidae			2	8	1	6	3	11
7. *Oligochaeta:*								
Lumbriculidae			3	10	2		5	16
8. *Dipterans:*								
Chironomidae	2	4	2	7			4	11
Simuliidae			1	2			1	2
9. *Ephemeroptera:*								
Baetidae			2	5			2	5
Caenidae			2	3	1	2	3	5
Total:	28	625	55	983	14	166	97	1808
Taxa richness		9.66		18.04		5.86		
Shannon div (H)		0.86		3.15		0.21		
Equitability.		0.09		0.32		0.03		
Faunal Similarity		0.69		0.64		0.64		
Community dominance		47.04		49.69		53.1		

Table 4: Temporal variability in the physicochemical attributes of Anambra river basin

S/N	Physicochemical Attributes	Coefficient of Variation %		
		Means	DS	WS
1	**Dept**	5.78	29.58	37.34
2	**Temperature**	28.91	4.98	6.30
3	**Transparency**	1.75	30.86	24.57
4	**Coefficient of Coarseness of suspended solids**	2.85	36.53	48.07
5	**Suspended Solids**	3.13	34.50	40.26
6	**Conductivity**	29.44	28.63	26.56
7	**Hydrogen ion Concentration**	6.69	5.38	6.28
8	**Nitrate-Nitrogen**	3.7	31.08	26.76
9	**Phosphate-phosphorus**	7.72	35.49	39.12
10	**Free Carbon dioxide**	3.68	19.57	21.20
11	**Total Hardness**	7.23	33.20	27.80
12	**Chemical oxygen demand**	4.27	15.69	20.80
13	**Dissolved oxygen demand**	5.14	12.54	16.28
14	**Biological O_2 demand**	4.06	11.69	10.98
15	**Total alkalinity $MgCaCo_3l^{-1}$**	3.60	22.51	39.62
16	**Current ms^{-1}**	2.07	25.60	25.76
17	**$No_3^-N/P04$- Ratio**	0.66	83.33	53.77
18	**Co_2/o_2**	1.00	54.00	34.64

Values for calculation were used as from January-Dec. Dry season values were from Jan.-March and Nov.-Dec.
Wet season = April—Oct.

This riparian land use has exposed the basin to non-point source input of surface run-off which peaks during the wet season. This has resulted in the silting up of the River banks and the concomitant destruction of fish micro-habitats, spawning areas and benthic food items.

Additionally, there are many discharge points of untreated municipal effluents into the river basin. The effluents enter the basin throughout the year with peaks in the wet season.

Moreover some of the river banks serve as dumpsites for city garbage which are constantly washed into the river via surface run-off. The rice mills are typical illustration of this effluent discharge into the river and anthropogenic perturbations

DISCUSSION

The potential impacts of the observed anthropogenic water shed perturbations include inter alias, water

Table 5: Monthly variations in Co_2/Do_2 and No_3-N/Po_4-P ratio in the river

S/N	Months	Co_2/Do_2	No_3-N/Po_4-P
1	January	1.30	1.77
2	February	1.05	1.07
3	March	1.28	0.78
4	April	0.80	0.57
5	May	0.64	0.43
6	June	0.58	0.33
7	July	0.59	0.27
8	August	0.58	0.23
9	September	0.64	0.40
10	October	0.89	0.25
11	November	0.91	0.48
12	December	1.19	0.67
13	January	1.21	0.98
14	February	1.31	0.83
15	March	0.97	0.74
16	April	0.67	0.57
17	May	0.61	0.46
18	June	0.46	0.35
19	July	0.42	0.30
20	August	0.50	0.26
21	September	0.54	0.22
22	October	0.70	0.19

quality degradation and/or high temporal plasticity in the physicochemical parameters (Karr *et al.*, 1981). These can adversely influence the survival, growth and reproduction of aquatic biota including fish. The optima levels of physicochemical parameters for fish production in the tropics are presented in (Table 1).
Surface temperature readings were well within the limits conducive for aquatic biota as well as for fish growth and production (Boyd and Lichkroppler, 1979). Mean transparency was lower than the optimum for lotic fish production; this low light penetration is probably responsible for the poor growth of aquatic macrophytes of the Anambra river which can enhance the growth of phytoplankton, an important food for aquatic biota and fish.

The levels of suspended solids in the Anambra river fall short of the FWPCA (1968) ranges for the maintenance of good or moderate fisheries. Since the suspended solids of the river comprise mainly silt/clay particles, its low concentration may not be a limiting factor based on the premise that it is only when suspended solids are composed of largely plankton that the low levels are limiting to aquatic biota and fish production (Boyd and Lictkoppler, 1979). However, this does not rule out the ecophysiological impacts of very high concentrations of suspended silt/clay on aquatic biota and fishes (Karr and Schlosser, 1981).

Mean river pH and DO_2 were within desirable ranges for fish production (Boyd and Lichkroppler, 1979). The low Co_2 content of the River Basin is suitable for aquatic biota and fish production as it may not be lethal to fish or culminate in the exhibition of a variety of distresses (Kutty 1987).

The river alkalinity indicates that the "soft water" is unlikely to support appreciable phytoplankton productivity (Boyd and Lichkroppler, 1979). The low primary productivity of Anambra River is corroborated by the low conductivity, concentrations of nitrate-nitrogen, and phosphate-phosphorus, all of which are nutrient determinants of phytoplankton productivity and hence fish production (Wetzel and Likens, 1979). Moreover, the mean No_3-N/Po_4-P ratio in the river is below that suggested by Kutty (1987) for the maintenance of a healthy aquatic ecosystem.

The high variability in the river volume indicates that the inputs of the composite of precipitation, surface run-off and municipal effluents, are in volumes that have an impact on the overall water levels of river throughout the year. The absence of marked variability in surface temperature is in consonance with the reports of Armitage (1984) for tropical streams and Abohweyer (1990) for the Kigera Reservoir, Nigeria since fishes have poor tolerance for sudden short-term temperature fluctuations (Boyd and Lichtkoppler, 1979), the stability in the ambient temperature of the river basin is thus an asset for fish production.

The stability of the Anambra river pH is attributable to the fact that most of the hydrogen ions are autochthonous; thus the river pH is unresponsive to cycles in the input of precipitation, surface run-off, municipal effluents and garbage's. This low variability in pH which is comparable to that of Kigera (Abohweyere, 1990) is an index of good biotic integrity. The low variability in conductivity contradicts the high variability recorded in the Kigera (Abohweyere, 1990) and connotes regular mineralization of nutrients and allochthonous loadings.

The annual variability in DO was probably occasioned by regimes in the levels of CO_2 and inputs of municipal effluents and organic garbage's. High variability in D0 concentration reduced the growth rate of fishes (Tsadik, 1984), but the level of DO is conducive for fishes in Anambra river, its variability appears to be favourable to fish growth. The broad variation in the level of suspended solids is in accordance with the findings of Karr and Dubley (1981) in modified headwater streams in Eastern North America and Abohweyere (1990) in the Kigera reservoir, Nigeria. The variations in the concentrations of nitrate-nitrogen and phosphate-phosphorus contradict the latter author.

The higher dry season variability (vis-à-vis the wet season) in nitrate-nitrogen, phosphate-phosphorus and CO_2/DO ratio are considered to reflect the effects of subtle intrinsic factors predominating in the dry season. Conversely, the higher variability of all other parameters in the wet season is perhaps related to the impacts of extrinsic factors e.g. precipitation, influx of surface run-off from riparian agro ecosystem and municipal effluents which were more predominant during the wet than dry season. Stochastic (CV = 30 % annually and/or per season) in most of the water quality parameters (Table 2) can adversely influence the well-known tropical seasonality regimes in the reproductive and feeding strategies of fishes (Lowe-McConnell, 1978).

The distribution and abundance of specific taxa could be of use in assessing the levels of impact in the study stations. Nematodes although considered as meiobenthos were used here because of their role as indicators of siltation. Their abundance was however low in stations 2 and 3. The oligochaeters respond to organic pollution by increase in abundance (Egborge, 1995; Eyo and Ekwonye, 1995; Odo *et al.,* 2007). Their presence in stations 2 and 3 could be attributed to organic enrichment and growth of macrophytes. Decapods are common taxa in this river. Their presence in all the station 3 indicates that they are tolerant to the anthropogenic perturbations. Victor (1996) reported that coleopterans are useful indicators of organic pollution. They were the most abundant of the invertebrate fauna of the river.

This means that the aquatic ecosystem is favourable to them. The dipterans, notably the family chronomidae, have been found to dominate aquatic invertebrates communities (Hynes, 1970; Eyo and Ekwonye, 1995) and show no habitat restriction but was absent in station 3. The importance of water current in the distribution of the dipterans was further reinforced by their disappearance from station 3. The Hemiptera was second most abundant fauna of the River. They were recorded in all the 3 stations but was more abundant in Otuocha, the station 3. The high abundance could be as a result of its tolerance to municipal effluent, levels of physiochemical parameters, agro ecosystem perturbations and organic pollution.

The density and diversity indices vary both spatially and temporally. The pattern of temporal dynamics in the density of fauna was affected by the variability of the physicochemical parameters of the river. The overall diversity is the product of all spatial and temporal changes affecting the community. The higher variability in diversity indices that were observed in stations 2 and 1 are reflection of community instability in these stations. This is a further proof of the documented change in species composition, community structure, density and measures caused by agro ecosystem perturbations, municipal effluents, anthropogenic influences as well as physicochemical parameters, of lotic environments.

The potential fish yield from the Anambra River is high when viewed vis-à-vis the average estimates from other waters bodies e.g. the Cross river, Nigeria, Y = 57.44kg ha^{-1}, (Moses, 1987) and Kigera reservoir, Y = 19.5kg ha^{-1}, (Abohweyere, 1990). The high potential fish yield from the River is attribution to some of the aquatic physicochemical that are favourable to aquatic biota and macro invertebrates that serve as food for fishes.

From the foregoing, some of the water quality parameters are unsuitable for aquatic biota and fish production. The various methods of adjusting water quality parameters (Boyd and Lichtkoppler, 1979; Boyd, 1982; Kutty, 1987) can be employed prior to harnessing Anambra river for intensive fish production. The water quality of the river can be improved further by controlling and/or prohibiting the discharge of municipal effluents and domestic garbage into the river as well as the use of the riparian zone for crop agriculture. The maintenance of a 50 – 60 m of thick riparian vegetation can act as buffer strip to check erosion by acting as sediment break/filter.

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