JASEM ISSN 1119-8362

Full-text Available Online at www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage. *March*, 2011
Vol. 15 (1) 105 - 113

Impact of Effluents on Water Quality and Benthic Macroinvertebrate Fauna of Awba Stream and Reservoir

[1]AINA O. ADEOGUN; [2]OYEBAMIJI O. FAFIOYE

[1]Department of Zoology, University of Ibadan, Ibadan.
[2]Department of Plant Science and Applied Zoology, Olabisi Onabanjo University, Ago-Iwoye

ABSTRACT: A study on the impact of effluent discharge on water quality and the benthic macro invertebrate fauna of the Awba stream and reservoir was carried out between April 2007 and May 2008. Benthic macro invertebrate and sediment samples were collected with a Van Veen grab, while physico-chemical parameters were sampled with Hach's Company Fish Farmers' Water Quality Test kit. Four stations were chosen for this study. A total of 4 taxa comprising 10 species of organisms were recorded. The abundance of these species and the physico-chemical parameters at the various stations were significantly different (P<0-05). Dissolved oxygen was considerably lowest at Station 2 ($1.38 \pm 0.19mgl^{-1}$); a region of intense organic pollution during the study period. This was accompanied by high values of dissolved CO_2 ($20.0 \pm 1.51mgl^{-1}$), total hardness (103.0 ± 7.87mg ($CaCO_3$)/l), ammonia-nitrogen ($3.0 \pm 0mgl^{-1}$) and increased pH values (8.5 ± 0.27). Water temperature values was also highest at this station ($30.7 \pm 1.15^{\circ}C$). The values obtained for the physico-chemical parameters and correlation values with the tested organisms indicated that changes in community structure had occurred as a result of changes in prevailing conditions in the habitat. The levels of trace metals (Zn, Mn, Cu, Pb, Ni, and Cr) were analyzed and there was no statistically significant difference in the values recorded between stations. The levels of these metals except zinc and manganese fell within the limits specified by USEPA as values recorded for zinc and manganese were higher than the acceptable limits specified by USEPA.

Humans are adjudged to be the principal driver of change on the earth's surface. Such impact may shape the earth in small subtle ways and sometimes in big catastrophic ways (Karr, 2005). These effects may result in a plethora of consequences felt by plants, animals and even humans alike. One major natural component of the earth is the aquatic environment and is home for a vast array of diverse organisms from those with a planktonic existence through pelagic organisms to benthic species (Adeogun, 2004). Benthic organisms are found in almost all water bodies living on or inside deposits of the bottom substrate and are sedentary with reduced or no mobility (Odum, 1971). They constitute a vital link in the food chain and energy flow, serve as food for other higher organisms such as fish and play a vital role in the circulation of nutrients (Oben *et al*., 2003).
Studies on water quality management have dealt with the use of benthic macroinvertebrates in evaluating the level of environmental degradation and the impact of specific effluents on the aquatic environment due to their importance in the food chain of aquatic biota, (Winner *et al*., 1980; Quinn and Hickey, 1993; Matagi, 1996; Edopkayi and Eikhalo, 2001).

Freshwater bodies contain diverse habitats within and around which support myriads of species of both plants and animals and are important sources of water for human activities. In some instances freshwaters have been dammed to provide potable water for urban settlements and the Awba stream and reservoir is one of such freshwater bodies which are used for domestic purposes by the generality of University of Ibadan populace. Yakub (1998) reported that most surface waters in Nigeria have been used as the most expedient way of disposing wastes especially effluents. This alteration may be due to the introduction of contaminants into the water from both point sources (e.g. sewage and used water) and non-point sources (e.g. erosion and agricultural leaching). The likely impact of human interference on freshwater bodies necessitated this present investigation to appraise the variations in the physico-chemical parameters and likely changes that may have occurred in the macrobenthic invertebrate community of Awba stream and reservoir.

MATERIALS AND METHODS

The Study Area: Awba stream and reservoir is located at the south-western part of the University of Ibadan. It lies between latitudes 7^0 26' to 7^0 28'N and longitudes 3^0 35' to 3^0 54' E at an altitude of 209 metres above sea level and is a tributary of Ona River. The dam is an earthen dam and was constructed in 1964 by damming the stream and impounding the water at a point where it flows through a natural valley. It was further constructed to the present standard in 1971 to increase water supply to the university community. It presently covers an area of about 6 hectares, a total length of 110m, a height of 8.50m, an average width of 12.20m and a maximum depth of 5.50m. The reservoir serves the purpose of water supply, fish production, research amongst others and has a capacity of 227 million litres of water with a treatment rate of about 68,000

*Corresponding author: ainaadeogun@yahoo.com

litres per day. The reservoir also receives effluents from the university community in the form of domestic waste water from halls of residences, sewage, experimental waste water from science laboratories of several departments and non-point sources such as erosion and leaching of chemicals from surrounding farmlands. Four stations chosen for this study were:

Station 1- This is the point of entry of the stream into the University of Ibadan, and is located at the South-eastern part of the university. This portion was clear, clean and was chosen as the control point on the assumption that it was relatively unpolluted. *Station 2* – This is the point located slightly below the sewage and domestic effluent discharge points from all halls of residences. *Station 3*- This is the point just beyond the entry point of the Awba stream into the reservoir. This region also receives effluent discharge from the science laboratories. *Station 4*- This station is a point which lies in the middle of the reservoir.

Sampling Procedure and Macrobenthos analysis: Benthic sediment samples were collected between the hours of 8.00a.m and 9.00a.m by means of boat cruises in sample stations within the reservoir while stations outside the reservoir did not require the use of a boat. Sampling was carried out weekly and spanned between April 2007 and May, 2008. Samples were collected using a Van Veen grab sampler, emptied into pre-labelled polythene bags and taken to the laboratory for sorting and analysis. At the laboratory, small portions of sediment samples were washed in a 0.5mm sieve to remove debris. Benthic macro-invertebrates were sorted out and were transferred into sample bottles containing 4% formalin. Analysis was carried out on the organisms while identification and classification were done using standard methods (Odum, 1971; Pennak, 1978). Thereafter, the orgainisms were grouped into different taxa in each sample.

Analysis of Physico-Chemical Parameters: Tests for water quality parameters were carried out with "Hach Sach's fish farmer's water quality test kit" (HACH company U.S.A). Water samples were analyzed for temperature, dissolved oxygen (DO), dissolved carbon dioxide (DCO_2), Alkalinity, Total Hardness, Ammonium-Nitrogen (NH_3: N), Nitrite-Nitrogen (NO_2: N) and Chloride at each station following standard procedures as outlined in the kit's manual.

Table 1: Variations in physico-chemical parameters of Awba stream and reservoir.

Stations	pH	Ammonia nitrogen (mgl^{-1})	Nitrite (mgl^{-1})	Alkalinity (mgl^{-1})	DCO_2 (mgl^{-1})	Chloride (mgl^{-1})	DO (mgl^{-1})	Hardness (mgl^{-1})	Water temp (^0C)	Air temp (^0C)
1	6.78± 0.25^{bc}	0.28± 0.08^b	0.11± 0.04^b	89.40± 8.63^b	7.84± 1.29^b	19.40± 1.35^b	5.38± 0.87^a	103.00± 17.0^a	27.20± 1.54^b	26.40± 1.48^a
2	8.50± 0.27^a	3.00± 0.00^a	0.45± 0.09^a	145.00± 22.4^a	20.0± 1.51^a	37.30± 2.96^c	1.38± 0.19^c	103.00± 7.87^a	30.70± 1.15^a	26.50± 1.77^a
3	6.63± 0.23^c	0.26± 0.12^b	0.11^b± 0.04^b	96.40± 6.82^b	8.0^b± 1.41^b	20.10± 1.89^b	4.63± 0.44^b	95.40± 8.86^a	28.40± 1.90^b	26.90± 1.64^a
4	7.00± 0.27^b	0.29± 0.11^b	0.11± 0.05^b	86.40± 11.10^b	7.25^b ±1.1^b	19.20± 1.73^b	5.54± 0.36^a	94.10± 4.66^a	28.40± 1.90^b	26.60± 1.94^a

*Means with the same superscript are not significantly different along the columns ($p<0.05$)

Analysis of Trace Metal Elements in the Sediments: Sediment samples were collected using the Van Veen grab sampler. At the laboratory, sediment samples were air dried and then sieved using a 0.5mm sieve to extract fine particles as described by (Salomons and Forstner 1980; Herr and Gray 1997a). The fine sediments were packed into sealable nylon bags, labelled and stored. One gram of sediment was weighted into a beaker which was then digested with 10ml of a mixture of nitric (HNO_3) and perchloric acids ($HCIO_4$) [in the ratio 2:1]. The beaker was covered with a watch glass and set aside during which the reaction would have subsided. The beaker and contents were heated to not above 160 ^0C on an Aluminium Tetator digestion block for 2 hours until the volume in the beaker was about 2-5ml. The digest was allowed to cool and then transferred into a volumetric flask and subsequently diluted to a volume of 25ml using distilled water in a volumetric flask. The resultant solution was then analysed for lead, chromium, copper, cadmium, nickel and manganese with a flame Atomic Absorption Spectrophotometer according to the methods of APHA (1992).

RESULTS AND DISCUSSION

Physico-Chemical Quality Of The Sample Stations: The results of the physico-chemical parameters of Awba stream and reservoir are presented in Table 1. Correlation coefficients between physico-chemical parameters are presented in Table 2. pH values were highest at station 2 with a mean value of 8.5, while other stations ranged within 6.78 and 7.00. Ammonium-nitrogen level was also highest at station 2 (3.00mgl^{-1}). Stations 1, 2 and 3 had lower values of 0.26mgl^{-1}, 0.26mgl^{-1} and 0.31mgl^{-1} respectively. The highest alkalinity level was also recorded in station 2, while the lowest value was in station 4.

The pH of the stream and reservoir had a range of between 6.78 and 8.50. The higher values of pH recorded in Station 2 shows that this region is alkaline and may be due to the presence of organic sediments which produce ammonia as they are decomposed. This shows that pH has strong positive correlation with ammonia. Ammonia is a known alkaline chemical and increasing concentrations may be the cause of the increased pH in Station 2. Increased Ammonium-nitrogen values is probably due to the decomposition of proteinous and nitrogen-rich compounds present in the organic waste discharge. Monda *et al* (1995) stated that the decomposition of protein and nitrogen containing organic compounds results in the formation of ammonia. The alkaline nature of station 2 may inhibit the establishment of species not tolerant to alkaline conditions. Ionic concentration (pH) also has strong positive correlation with alkalinity, hardness, dissolved CO_2, water temperature and nitrites. Increased pH at this station was also recorded by Oben (2000) and Tyokumbur *et al,* (2002) in their study of the Awba stream and reservoir. The decomposition of organic materials is carried out by the anaerobic respiration of the resident bacteria (Rosenberg and Resh, 1993; Clark, 1997). Organic sediments were transported by water flow into stations 3 and 4 and this probably had effects on the temperature of the stations downstream. Similar observations were recorded by Oben (2000).

Table 2: Pearson's Correlation (r) Values Between The Physiochemical Parameters At The Four Stations

Physio-chemical parameters	pH	Ammonia	Alkalinity	DCO_2	Chloride	Dissolved Oxygen	Hardness	Water temperature	Air temperature	Nitrite
pH	1.00	0.94*	0.77*	0.89*	0.89*	-0.86*	0.13	0.58*	-0.04	0.87*
Ammonia	0.94*	1.00	0.85*	0.97*	0.97*	-0.97*	0.21	0.60*	-0.04	0.93*
Alkalinity	0.77*	0.85*	1.00	0.83*	0.89*	-0.82*	0.22	0.46*	0.04	0.82*
DCO_2	0.89*	0.97*	0.83*	1.00	0.93*	-0.94*	0.30	0.54*	-0.06	0.89*
Chloride	0.89*	0.97*	0.89*	0.93*	1.00	0.91*	0.26	0.57*	-0.02	0.94*
DO	0.86*	-0.94*	-0.82*	-0.94*	-0.91*	1.00	-0.32	-0.51*	0.07	-0.88*
Hardness	0.13	0.21	0.22	0.30	0.26	-0.32	1.00	-0.06	0.09	0.17
Water temp	0.59*	0.60*	0.46*	0.54*	0.57*	-0.51*	-0.06	1.00	0.61	0.56*
Air temp	-0.04	-0.04	0.04	-0.06	-0.02	0.07	0.09	0.61	1.00	-0.04
Nitrite	0.87*	0.93*	0.82*	0.89*	0.94	-0.88	0.17	0.17	-0.04	1.00

Note: *indicates significant correlation between parameters ($p<0.05$)

Station 2 showed the lowest concentration levels for dissolved oxygen with a mean value of 1.38mgl^{-1}, while all other stations had higher dissolved oxygen concentrations. Dissolved oxygen level at station 3 was 4.63mgl^{-1}, while the values at Station 1 and station 4 had mean values of 5.37mgl^{-1} and 5.54mgl^{-1} respectively. The mean concentration of dissolved oxygen recorded at Station 1 falls within the normal range for dissolved oxygen. However, the marked reduction recorded at Station 2 was due to the depletion of the dissolved oxygen owing to the enormous amount of organic materials discharged into this station requiring high levels of oxygen for chemical oxidation, decomposition or break down by microbial organisms (Mason, 1992; Yakub 1998). The breakdown requires the use of oxygen and its effect is evident as a sharp decline in dissolved oxygen values also known as the oxygen sag curve. This reduction is still noticeable as one move upstream to station 3 where the dissolved oxygen concentration is still lower than that recorded at station 1 and station 4. This could be because of the breakdown of remaining organic matter transported to this station. The results obtained are similar to those of Yakub (1998) and Soares *et al* (1999) who concluded that point organic effluent discharged into water bodies may result in a marked decline in dissolved oxygen concentrations at that region. Fakayode (2005) in his study of Alaro stream also recorded a sharp decline in dissolved oxygen level at the point of effluent discharge into the stream.

Table 3a: Composition, distribution and abundance of macro – invertebrates in Awba stream and reservoir from April 2007 to May 2008. (The values in parentheses represent percentage abundance)

Organism	Station 1	Station 2	Station 3	Station 4
Mollusca *Melanoides tuberculata*	52 (37.68)	- -	16 (9.46)	2 (9.09)
Physa sp	8 (5.79)	- -	5 (2.95)	- -
Bulinus (bulinus)forskalli	42 (30.4)	7 (1.02)	13 (7.69)	1 (13.63)
Biomphalaria sp	13 (9.42)	- -	13 (7.69)	3 (13.63)
Lymnea sp	1 (0.7)	- -	- -	- -
Dipteran larvae *Chironomus* sp.	55 (39.85)	645 (94.29)	84 (49.70)	8 (36.36)
Chaoborus sp.	- -	20 (2.92)	5 (2.95)	6 (27.27)
Tubifera sp.	- -	12 (1.75)	- -	- -
Annelida *Glycera dibranchiate*	15 (10.87)	- -	2 (1.18)	- -
Odonata *Macromia magnifica*	- -	- -	1 (0.59)	2 (9.09)
Total number of species	7	4	8	6
Number of individuals	138	684	169	22
Margalef's Index	1.2	0.46	1.42	1.94
Shannon-Weiner's Index	0.70	0.12	0.58	0.68

In contrast to dissolved oxygen values at the four stations, the mean highest value of dissolved carbon (iv) oxide for the period of study was also recorded at station 2 ($20mgl^{-1}$), while the lowest value was at station 4 ($7.25mgl^{-1}$). Water temperature showed a progressive increase from stations 1 to 4 but the highest value was recorded at station 2 (30.7^0C). Water temperature recorded through-out the duration of the study ranged between 27.2^0C – 30.7^0C and this was within the range for tropical freshwaters (APHA, 1992). Ayodele and Ajani, (1999) reported that tropical freshwaters had temperature values ranging from 21.0^0C to 32.0^0C. Station 2 recorded the highest values for water temperature and this can be attributed to the heat produced due to the decomposition of organic waste discharged into this station. Total hardness progressively decreased from stations 1 to 4. However, the values outside the dam were almost the same while the values in the dam were close ranged.

Conversely, the highest dissolved carbon (IV) oxide concentrations were recorded at station 2. This is expected because respiration by microbial population produce excess CO_2. Similar results were recorded by Oben, (2000) and Tyokumbur *et al,* (2002). Alkalinity and total hardness values were also highest at station 2. This might be as a result of the high pH values observed in this station. It is the position of Fakayode, (2005) that pH could determine such water characteristics as metal solubility, the alkalinity and hardness of the water.

Table 4: Pearson's correlation co-efficient (r) values between the benthic macro-invertebrates and physiochemical parameters. Note: * indicates significant correlation (p<0.05)

	Organisms									
Parameters	*M.tuberculata*	*B. forskalli*	*Lymnaea* sp	*Biomphalaria* sp	*Physa* sp	*Chironomus* sp	*Chaoborus* sp	*Tubifera* sp	*Glycera* sp	*Macromia* sp
pH	-0.05*	-0.18	-0.11	-0.41*	-0.25	0.72*	0.32	0.52*	-0.24	-0.17
Ammonia	-0.45*	-0.14	-0.10	-0.04	-0.21	0.77*	0.33	0.54*	-0.23	-0.16
Alkalinity	-0.34	-0.06	-0.14	-0.21	-0.15	0.58*	0.42*	0.55*	-0.21	-0.04
DCO_2	-0.41*	-0.03	-0.11	-0.33	-0.21	0.73*	0.37*	0.58*	-0.22	-0.19
Chloride	-0.45*	-0.15	-0.06	-0.27	-0.24	0.75*	0.35*	0.53*	-0.22	-0.10
DO	0.42*	0.04	0.16	0.24	0.17	-0.76*	-0.30	-0.49*	0.33	0.17
Hardness	0.12	0.35*	0.15	-0.12	-0.06	0.07	0.22	0.35*	0.005	-0.05
H_2O temp	-0.55*	-0.31	0.03	-0.43*	-0.20	0.51*	0.18	0.35*	-0.18	-0.17
Air temp	-0.16	-0.14	0.04	-0.35*	-0.08	-0.07	0.04	0.09	-0.08	-0.09
Nitrite	-0.43*	-0.13	-0.10	-0.27	-0.23	0.82*	0.31	0.47*	-0.19	-0.03

Macro-Invertebrate Abundance: The composition, distribution and abundance of macro-invertebrate fauna in Awba stream and reservoir were presented in Table 3a, while the mean benthic species diversity is as shown in Table 3b. A total of 1013 individuals distributed among 4 taxa were observed. Station 1 had the highest number of species followed by station 3 while station 4 recorded the lowest in terms of species diversity. Wide fluctuations were observed in the abundance of taxa from station to station. Four taxa viz- Mollusca, Diptera, Annelida and Odonata recorded during the period of study showed a substantial reduction compared to the number observed by Tyokumbur *et al* (2002). The absence of Ephemeroptera, Plecoptera and Trichoptera especially at Station 1 can be traced to increase in farming activities around that region. The use of fertilizers increases the amount of nutrients entering the water and this may lead to a corresponding increase in ammonia, nitrate-nitrogen levels and a reduction in dissolved oxygen (Mason, 1992; Yakub, 1998). The presence of gastropods can be traced to their tolerance to some levels of pollution. This explains why only *Bulinus (bulinus) forskalii* was found at Station 2. The correlation between the benthic macro-invertebrate organisms observed and the physico-chemical parameters operating where they are found also confirmed this assertion. The occurrence of *Chironomus* species in all the stations observed is perceived to be normal as they are usually present in water bodies (Samson, 1982; Emere and Narisu, 2007).

TABLE 3b: Mean Benthic Macro-Invertebrates Diversity In Awba Stream And Reservoir

Station	*M. tuberculata*	*B. bulinus forskalli*	*Biomphalaria* species	*Lymnea* species	*Physa* species	*Chironomus* species	*Chaoburus* species	*Tubifera* species	*Glycera dibranchata*	*Macromia* species
1	6.75±1.49[a]	3.31±3.13[a]	1.64±1.13[ab]	0.35±0.13[a]	1.41±0.63[b]	3.88±3.09[a]	0.00±0.00[a]	0.00±0.00[a]	2.13±2.10[b]	0.00±0.00[a]
2	0.00±0.00[c]	1.80±0.88[ab]	0.00±0.00[a]	0.00±0.00[b]	0.00±0.00[a]	80.00±55.00[b]	2.50±1.85[b]	2.14±1.50[b]	0.00±0.00[a]	0.00±0.00[a]
3	2.00±1.60[b]	2.00±1.63[ab]	0.00±0.00[a]	1.92±1.63[a]	1.06±0.63[b]	13.80±10.50[b]	1.19±0.63[b]	0.00±0.00[a]	0.00±0.00[a]	0.35±0.13[b]
4	0.46±0.25[c]	0.35±0.13[b]	0.00±0.00[a]	0.74±0.38[ab]	0.00±0.00[a]	1.93±1.00[b]	1.39±0.73[b]	0.00±0.00[a]	0.00±0.00[a]	0.74±0.25[b]

Means with the same letter are not significantly different along the columns (p<0.05)

However, their abundance at Station 2 may be linked to their high tolerance to anoxic conditions. Strong negative correlation values between this species and dissolved oxygen indicated an affinity for anoxic conditions and this may probably be because of their possession of haemoglobin, a pigment that transports dissolved oxygen (Tyokumbur *et al*, 2002). This property is advantageous to their proliferation and colonization of this station effectively out-competing other taxa. Victor and Onomivbori (1996) documented some species as opportunistic fauna with high reproductive rates, short life span, high dispensability and reduced long-term competitive abilities occupying disturbed habitats. This was especially true for *Tubifera* (rat-tailed larvae) which was only found in Station 2. Studies by Oben, (2000), Tyokumbur *et al,* (2002) and Oben *et al* (2003) did not record this organism. It is possible that the *Tubifera* species was transported by water current from their original source and being tolerant to the alkaline and anoxic condition of the sample site, may proliferate at the expense of resident taxa. Correlation coefficients (r) values between the benthic macro-invertebrates and with physico-chemical parameters are presented in Tables 4 and 5. Correlation (r) values show significant positive correlation of *Tubifera* species with pH, ammonia, alkalinity, nitrites, dissolved oxygen showing that this organism probably only exists at the extremes of organic pollution. The blood worm, *Glycera dibranchiata,* was the only Annelid observed. Its presence has been linked with an affinity for copper concentrations and the organism is known to bio-accumulate high copper concentrations without signs of poisoning. It may have been transported by water currents to the station. Its population is reduced, and the fact that it was not recorded by previous works carried out on this water body, may be an indication of the beginning of its proliferation. This and the fact that the organism prefer sandy or silty substrata may probably be the reason for their presence in Stations 1 and 3.

TABLE 5: Pearson's Correlation Co-Efficient (R) Values Between The Different Benthic Macro-Invertebrates In The Four Stations.

Benthic organisms	*M.tuberculata*	*B.bulinus forskalli*	*Lymnaea* sp	*Biomphalaria* sp	*Physa* sp	*Chironomus* sp	*Chaoborus* sp	*Tubifera* sp	*Glycera* sp	*Macromia* sp
M.tuberculata	1.0	0.49*	0.10	0.36*	0.29	-0.30	-0.25	-0.24	0.57*	-0.13
B. bulinus forskalli	0.49*	1.00	0.2	0.12	-0.04	-0.24	-0.18	0.14	0.39*	80.15
Lymnaea sp	0.11	0.20	1.00	-0.10	0.14	-0.08	-0.06	-0.05	0.73*	-0.04
Biomphalaria sp	0.36*	0.12	-0.10	1.00	-0.09	-0.23	-0.09	-0.17	0.19	0.09
Physa sp	0.29	-0.04	0.14	-0.09	1.00	-0.07	-0.08	-0.11	0.02	-0.08
Chironomous sp	-0.30	-0.24	-0.08	-0.22	-0.08	1.00	-0.04	0.34*	-0.17	-0.10
Chaoborus sp	-0.25	0.18	-0.06	-0.09	-0.09	-0.04	1.00	0.74*	-0.14	-0.08
Tubifera sp	-0.24	0.14	-0.05	-0.18	-0.11	0.34	0.74*	1.00	-0.12	-0.08
Glycera sp	0.56*	0.39*	0.73*	0.19	0.02	-0.17	-0.14	-0.12	1.00	-0.09
Macromia sp	-0.13	0.15	0.04	0.09	-0.09	-0.1	-0.08	-0.08	-0.09	1.00

Note:* indicates significant correlation ($p<0.05$)

Table 6 compares the Margalef's and Shannon-Weiner indices reported by Adeogun (1991), Tyokumbur *et al* (2002) and the present study in a bid to explain the changes in the community structure over time. Stations 1* and 2* for Tyokumbur *et al*, (2002) are compared with Stations 1 and 2 for this study while station B for Adeogun (1991) is compared with Station 3 and 4 for this study . It is evident that the Margalef's and Shannon-Weiner values in 1998 were higher than those encountered in 2008 for station 1 owing to increased farming activities at this hitherto undisturbed region. Comparison of station 2 gives almost the same result because it is the same type of pollutants (primarily sewage and domestic waste water) that is still encountered there. There is however marked disparity between the Margalef's index values in 1991 for Station B and that observed now (Station 3 and 4). This could be as a result of changes in the benthic community due to sustained pollution. Nouvelle environmental conditions cause the resident species to either die, reduce in number or may have afforded some opportunistic ones conditions necessary for their proliferation.

Trace Metal Analysis: Trace metals detected in the sediments of Awba stream and reservoir were quite evenly distributed among the stations (Table 7). Zinc was recorded with mean values of 0.32 mgl^{-1} at Station 1; 0.24mgl^{-1} at Station 2; 0.28mgl^{-1} at Station 3 and 0.29mgl^{-1} at Station 4. Manganese, copper, lead, nickel and chromium had values within the range of 0.48- 0.52mgl^{-1}, 0.037- 0.041mgl^{-1}, 0.0016-0.002mgl^{-1}, 0.006 - 0.007mgl^{-1} and 0.005-0.005mgl^{-1} respectively for the stations sampled. The occurrence of heavy metals in the bottom sediments of the reservoir may be due to the discharge of experimental waste water from the laboratories of the Departments of Physics and Chemistry via a gutter. The values recorded were not significantly different between the stations for all the heavy metals analysed. However, the levels recorded for zinc and manganese were significantly higher ($P<0.05$) than the APHA (1992) permissible limits for trace metals in sediments.

The levels of copper and lead were much lower than were previously encountered by other workers (Oben, 2000; Tyokumbur *et al*, 2002). It is suggested that the freshwater organisms may have bio-accumulated some of these metals in their tissues. The organisms produce digestive juices that solubilize trace metals making them more available than in the sedimentary form. There is also some evidence to suggest that the level at which they do this is related to the amount of the metals in the surrounding environment. This conforms to earlier work done by Oben *et al* (2003) and they posit that the freshwater bivalve *Aspartharia sinuate* (not recorded during this study) had bio-accumulated these metals evident from the bioaccumulation factors obtained. The high value of zinc and manganese is expected due to the geochemical nature of the catchment. The basement complex of Ibadan, where the study site is located, is composed mainly of Precambrian rocks (pegmatite, amphibolites, and quartz) rich in Zinc, Iron and Manganese ores (D'Hoore, 1964).

Conclusion: The quality and quantity of benthic macro-invertebrates recorded during the period of study are quite low. Comparisons with previous work done at Awba stream and reservoir showed a reduction in the number of organisms recorded. The physico-chemical conditions, species diversity and the number of taxa encountered during the period of this study point clearly to degradation of Awba stream and reservoir largely as a result of the discharge of untreated sewage effluents into the course of the stream. The discharge of sewage effluents is associated with a shift in the pH of the region towards alkalinity and this effectively bars the proliferation of species adapted to acidic conditions. The presence and occurrence of *Tubifera* species *and Chironomus* species larvae at the sewage discharge point is indicative of an opportunistic occurrence. *Tubifera* species has not been recorded by previous workers and may be a new entrant into the stream habitat. Its presence at Station 2 may be due to its tolerance and preference for the alkaline and anoxic conditions prevalent there. *Chironomus* species larvae are known to possess the oxygen transport pigment – haemoglobin, conferring a more efficient mode to absorb dissolved oxygen. This effectively puts it ahead of other competing species. The occurrence of *Glycera dibranchiata* may also be opportunistic proliferation as no previous work done has reported its presence. It may have been brought to the stream from the Ona River which is the source of the Awba stream.

Furthermore, sewage discharge into Awba stream should be treated and the entry of raw sewage into streams should also be strictly regulated just as in the advanced countries. The stringent measures of sewage treatment follow many stages that lead to the eventual release of harmless or near harmless effluents into the environment.

The presence of *Bulinus, Lymnaea and Biomphalaria* species which are known intermediate hosts for pathogenic roundworms suggests the presence of pre-adult stages of these pathogens. The occurrence of diseases of low hygiene such as Schistosomiasis, hookworm infections, amoebic dysentery is linked to the contamination of food and drink with human faeces. Effective and sanitary discharge of sewage as one of the measures responsible for the decrease in the occurrence of septic diseases in the advanced nations is hereby recommended.

TABLE 6: variations in the distribution and abundance of macro-invertebrate fauna of awba stream and reservoir. (1991-2008)

Composition	Total number of individuals/station						
Taxon	Station 1 (2008)	Station 1* (1998)	Station 2 (2008)	Station 2* (1998)	Station 3 (2008)	Station 4 (2008)	Station B (1991)
PLECOPTERA *Isogenus* species	0	3	0	0	0	9	0
Isoperia species	0	3	0	5	0	0	0
EPHEMEROPTERA *Iron* species	0	3	0	0	0	4	0
Caenis species	0	1	0	0	0	0	0
Cloeon species	0	4	0	0	0	0	0
Trichoptera *Trianodes tarda*	0	2	0	0	0	0	0
DIPTERA *Chironomus* species	55	0	645	19	84	8	0
Chaoborus species	0	0	20	0	5	6	71*
Tubifera species	0	0	12	0	0	0	0
ODONATA *Herlocordulia* species	0	4	0	0	0	0	0
Progomphus species	0	4	0	0	0	0	0
HYDRACARINA *Mideopsis* species	0	2	0	1	0	0	0
OLIGOCHAETA *Tubifex* species	0	0	0	390	0	0	0
GASTROPODA *Lymnaea* species	1	7	0	0	0	0	0
Biomphalaria species	13	7	0	0	13	3	0
Melanoides tuberculata	52	9	0	0	16	2	0
Physa species	8	2	7	0	5	0	98*
B. bulinus fosrkalli	42	0	0	0	13	1	
Bivalvia: *Asparthria simata*	0	0	0	0	0	0	0
TOTAL NUMBER OF TAXA	7	13	04	03	08	06	17
TOTAL NUMBER OF INDIVIDUALS	138	51	684	410	169	22	169
MARGALEF'S INDEX	1.2	3.05	0.46	0.33	1.42	1.94	2.14
SHANNON-WEINER INDEX	0.7	1.05	0.12	0.12	0.58	0.68	0.70

Notes :Station 1and 2 = Station 1* and 2* ,Tyokumbur *et al,* (2002); Station 3 and 4 = Station B, Adeogun (1991)

.

TABLE 7: MEAN AND STANDARD DEVIATION OF TRACE METALS AT THE VARIOUS STATIONS

Heavy metals (mgl^{-1})	Permissible limits (USEPA)	Station 1	Station 2	Station 3	Station 4
Zinc	0.1	$0.32±0.05^a$	$0.25±0.07^a$	$0.28±0.03^a$	$0.29±0.06^a$
Manganese	0.01	$0.51±0.06^a$	$0.48±0.06^a$	$0.48±0.05^a$	$0.52±0.06^a$
Copper	0.01	$0.039±0.001^a$	$0.037±0.006^a$	$0.041±0.004^a$	$0.041±0.004^a$
Lead	0.01	$0.0016±0.0005^a$	$0.0017±0.0006^a$	$0.0019±0.0003^a$	$0.002±0.0007^a$
Nickel	0.02	$0.006±0.001^a$	$0.007±0.002^a$	$0.007±0.001^a$	$0.007±0.002^a$
Chromium	0.10	$0.05±0.007^a$	$0.05±0.007^a$	$0.05±0.004^a$	$0.05±0.05^a$

Note: Means with the same letter are not significantly different along the stations

REFERENCES

Adeogun, A.O. (1991) – Zooplankton and benthic fauna of Awba reservoir; An illustrated guide. B.Sc dissertation in the Department of Zoology, University of Ibadan.

Adeogun, A.O. (2004) - Effects of Methanolic Extracts of *Raphia hookeri* (Mann and Wendl, 1804) on Life Stages of *Clarias gariepinus* (Burchell, 1862). Ph.D thesis, University of Ibadan. 337p.

Ayodele, I.A. and E.K. Ajani (1999) – Essentials of fish farming (Aquaculture). Odufuwa Press, Ibadan, 46p.

APHA (1992) -Standard methods for the examination of water and wastewater, 18th edn. Washington D.C. Joint publication of American Public Health Association, American Water Works Association and Water Pollution Control Federation

Clark, R.B. (1997) -Marine Pollution. Caredom Press, Oxford pg 9-62.

D'Hoore. (1964)- The soil map of Africa, CCTA, Lagos.

Edopkayi, C.A and Eikhalo, C.O (2001)- Hydrological studies on the Ibiekuma River at Ekpoma, Southern Nigeria after impoundment: the faunal characteristics *AJST* Vol 2, no.1pp 72-78.

Emere, M.C and Narisu, C.E (2007) - macro-invertebrates as indicators of water quality of an urbanized stream in Kaduna, Nigeria. Journal of Fisheries International 2(2):152-157.

Fakayode, S.O (2005) - Impact assessment of the effect of industrial effluents on the receiving Alaro stream, Ibadan, Nigeria.

Herr, C. and Gray, N.F. (1997a) - Sampling riverine sediments impacted by acid mine drainage: problems and solutions. Environmental Geology 29, 37- 45.

Karr, J.R (2005)-Measuring biological condition, protecting biological integrity. Principles of conservation biology essay. Natural Academy Press, Washington, D.C. 110-121.

Mason, C.F (1992)-Biological aspects of freshwater pollution: cause, effects and control 2nd edition. The Royal Society of Chemistry Cambridge CB4, 4WF, *pp 99 125*.

Matagi, S.V (1996)-The effects of pollution on the benthic macro-invertebrates in a Ugandan stream. Archives of Hydrobiology 137(4):537-549

Monda, D.P; Galat, D.L; and Finger, S.E (1995)-Evaluating ammonia toxicity in sewage effluents to stream macro-invertebrates. 1A multilevel approach, Archives of Environmental Contamination and Toxicology 28:378-384

Oben, B.O (2000)-Limnological assessment of the impact of agricultural and domestic effluents in three man-made lakes in Ibadan, Nigeria. PhD thesis, University of Ibadan.

Oben, B.O; Oben, P.M; Ugwumba, A.O; Okorie, T.G; Pleysier J (2003) - Trace metal dynamics in Water, Sediments and Shellfish of a Constructed Freshwater Wetland.

Odum, E.P. (1971) - Fundamentals of Ecology. 3rd ed. London, W.B. Sanders. 546p.

Pennak, R.W. (1978) – Freshwater Invertebrates of the United Stastes. John Wiley and Sons Inc. 803p.

Quinn, J.M and Hickey, C.W (1993)-Effects of sewage waste stabilization lagoon effluents on stream invertebrates – Journal of Aquatic Ecosystem Health 2:205-219.

Rosenberg, D.M and Resh, V.H (eds) (1993) - Fresh water biomonitoring and benthic macro-invertebrates. Chapman and Hall, New York.

Salomons, W. and Forstner, U. (1980) Trace metal analysis in polluted sediments: II. Evaluation of environmental impact. Environmental Technology Letters 1, 506_/17.

Samson (1982) - Physico-chemical parameters of Awba Lake, University of Ibadan. M.Sc research project, University of Ibadan, Ibadan, Nigeria.

Soares, H.M.V.M., Bonaventura, R.A.R., Machado, A.A.S.C. and Estevez da Silva, J.C.G. (1999) Sediments as monitors of heavy metal contamination in the Ave river basin (Portugal): multivariate analysis of data. Environmental Pollution 105, 311-323.

Tyokumbur, E.T; Okorie, T.G; and Ugwumba, A.O (2002) - Limnological assessment of the effects of effluents on the macro-invertebrate fauna of the Awba stream and reservoir, Ibadan, Nigeria. The Zoologist, 1 (2), p59-69.

Victor, R and Onomivbori, O (1996) - The effects of urban perturbations on the benthic macro-invertebrates of a southern Nigerian stream. In: Scheimer, F; Boland, K.T, editors. Perspectives in tropical limnology. Amsterdam, Netherlands SPB academic publishing 1996, pp223-238.

Winner, R.W.; Boesel, M.W.; Farrell, M.P. (1980)-Insect community structure as an index of heavy metal pollution in lotic ecosystems. Canadian Journal of Fisheries and Aquatic Science.

Yakub, A.S (1998)-Effects of effluents on the water quality, plankton, and macro-invertebrates of the shore sediments and shore foliage of the Awba stream and reservoir, Ibadan, Nigeria. M.Sc. Thesis, University of Ibadan.