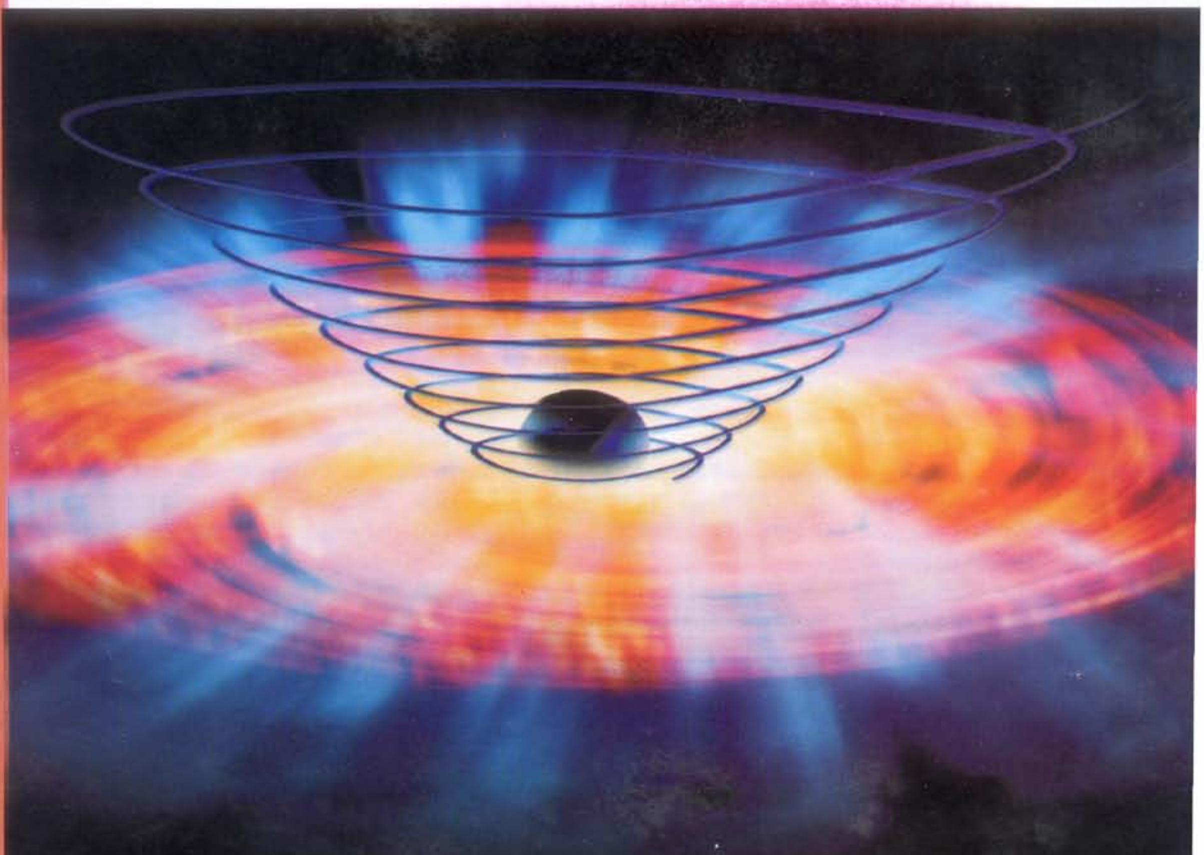
Research Journal of Environmental & Earth Sciences



Volume 3
Number 4
ISSN: 2041-0484

Maxwell Science Publication
Maxwell Scientific Organization
www.maxwellsci.com

Research Journal of Environmental and Earth Sciences 3(4): 422-428, 2011
ISSN: 2041-0492

Received: March 02, 2011 Accepted: April 07, 2011 Published: June 05, 2011

Analysis of Aquatic Insects' Communities of Awba Reservoir and its Physico-Chemical Properties

K.O.K. Popoola and A. Otalekor
Department of Zoology, University of Ibadan, Oyo State, Nigeria

Abstract: This study was conducted to assess the Awba reservoir insects' communities and the health status through the determination of insects' abundance, composition, distribution and water qualities parameters. Water samples and insects were collected bi-weekly from August through December, 2009. Insects were sampled using standard entomological methods, while water samples was analyzed using standard Winkler's titrimetric and APHA methods to determine the chemical properties. Water analyses and insects' identifications were conducted in the laboratory in Department of Zoology, University of Ibadan, Oyo State. The results show that only DO and phosphate-phosphorus had significant difference ($p<0.05$). A total of 1,154 insects were recorded, Chironomidae and Culicidae were most abundance. The chemical properties and the distinct taxa found in the water suggest that the water body is polluted and may be dangerous to the health of people around the reservoir.

Key words: Aquatic insects, Awba reservoir, bioindicators, water quality

INTRODUCTION

Aquatic insects are a group of arthropods that live or spend part of their life cycle in water bodies (Pennak, 1978). They are of great importance to water bodies where they are found and their presence in water serve various purposes; some serve as food for fishes and other invertebrates, others acts as vectors through which disease pathogens are transmitted to both humans and animals (Foil, 1998; Chae *et al*., 2000). Most importantly, aquatic insects are very good indicators of water qualities since they have various environmental disturbances tolerant levels (Arimoro and Ikomi, 2008).

Some are very vulnerable and sensitive to pollution, while others can live and proliferate in disturbed and extremely polluted waters (Merritt and Cummins, 1996). Anthropogenic activities of humans encourage discharge of untreated animal waste, such as releases from sewage and septic tanks, run - off from agricultural lands, laundering into streams and rivers. Most water bodies have been subjected to increasing pollution loads consequently, affecting greatly their quality and health status. This result in changes in the physico-chemical properties of water e.g., Temperature, Dissolved oxygen, Alkalinity, Phosphates, Nitrates and metal concentrations. Variations in these water properties greatly influence the distribution patterns of aquatic insects in the water, since some of them are highly sensitive to pollution while others are somewhat tolerant or completely tolerant to pollution and environmental disturbances (Bauernfeind and Moog, 2000).

The use of Aquatic insects for assessing water quality provides information to environmental managers and decisions makers to take accurate and justifiable actions in regards to the state and quality of water bodies (Arimoro and Ikomi, 2008). Published works on the use of Aquatic insects for assessing health and water quality status of streams revealed that studied in tropical Africa is not extensive (Ugbogu and Akiya, 2001; Dobson *et al*., 2002; Mafuya *et al*., 2004; Deliz-Quinones, 2005; Arimoro and Ikomi, 2008).

Awba reservoir has a surface area of 6 hectare with a height of 8.3 and 110 m long. The crest is 12.2 m high. It has a maximum depth of 5.5 m and a maximum length of 700 m. It holds about 230 million liters of water. The reservoir is marked by two seasons, the wet and the dry seasons. Rainy season occurs between April and October while the dry season is between November and March. The reservoir was created in April 1964 to serve the purpose of water storage for domestic consumption, laboratory use, table fish culture (Hassan, 1974).

The water has a moderate multi directional current due to effect of wind. The physico-chemical parameter of the reservoir showed that the reservoir has a pH (hydrogen ion concentration) range between 6.2 and 8.4, Oxygen ranged between 7.13 to 8.92 ppm, temperature ranged from 28.5 to 34.0ºC and the transparency ranged between 0.48 to 0.70 m.

Much of the vegetation of the stream and the reservoir has been described to be evergreen with grass interspersed by fair trees. Some of the hydrophytes include *Camellias gambia*, *Pistia stratiole*, *Marsilea*

Corresponding Author: K.O.K. Popoola, Department of Zoology, University of Ibadan, Oyo State, Nigeria. Tel: +234 802 325 8029

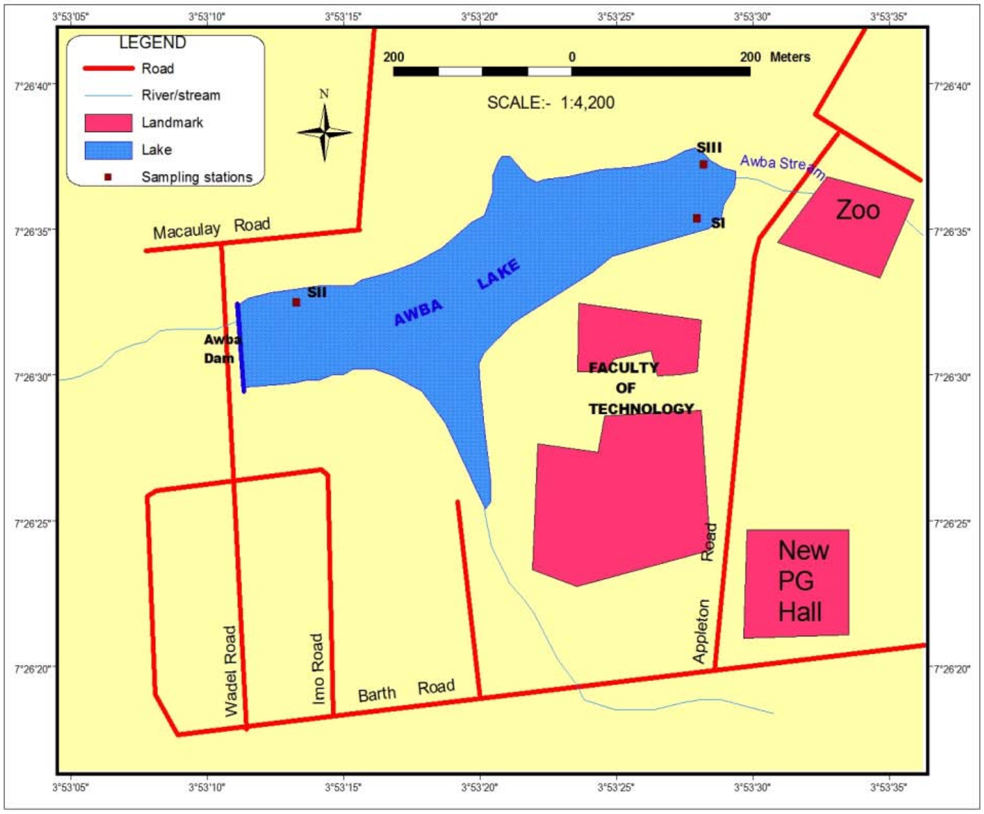


Fig. 1: Map of University of Ibadan showing study area with sampling points in Awba reservoir

quadrifolia, *Cyprus* sp. The shallow water surfaces along the northern and southern banks are covered with *Salvinia* sp., *Eichhornia crassipes* (water hyacinth). Submerged plants in the lake include *Ceratophylum* species and *Utricularia* sp.

This present study was conducted to investigate the composition, diversity, and distribution of aquatic insects in relation to the physico-chemical properties of Awba stream and reservoir water in University of Ibadan, to be able to evaluate aquatic insects abundance and the health status of the water.

MATERIALS AND METHODS

Description of study area: The study area lies within Awba reservoir, located in the University of Ibadan, Oyo state, Nigeria. Geographically, the reservoir is located in the southwest area of the campus at an altitude of 185 m above sea level. It lies between latitude 7º26′ to 7º28′ North and longitude 3º53′ to 3º54′ East (Fig. 1) (Tyokumbur *et al*., 2002; Akin-Oriola, 2003).
The research was done in 2009.

Water samples collection and analysis: Water samples were collected fortnightly from each sampled points with 200 mL plastic containers washed with nitric acid to remove any form of contaminants. The sampling period spanned from August through December. Sampling was usually carried out between the hours of 8:00 am and 12:00 noon. The water samples collected were then taken to the laboratory and analyzed immediately to ensure that the physical and chemical properties of the water were maintained. Surface water temperature was recorded with a mercury- in-glass thermometer, Water velocity was determined at each sampled point using a fisherman's floater on the water and the time it took to travel 50 m distance was recorded using a stopwatch. The average of three determinations was recorded in m/s.

Nitrate-nitrogen (NO_3-N) and Phosphate-phosphorus (PO_4-P) were determined spectrophotometrically after reduction with appropriate solutions (APHA). Dissolved oxygen (D.O) was determined using Winkler's titrimetric method. Other parameters were determined according to APHA methods.

Aquatic insects sampling and identification: At each sampled points, adult insects were collected from water surface using a dip-net with Nytex® netting of 500 µm mesh. Adult insects and their nymph were also collected from the vegetations around the reservoir using a sweep

Table 1: Mean variations and F-values of the physico-chemical parameters measured at the three sampling points along Awba Reservoir

Parameters	Point 1	Point 2	Point 3	F-value
Temperature(ºC)	26.75± 0.89 (26.00-28.00)	26.63±1.50 (25.00-29.00)	25.75±1.16 (24.00-27.00)	1.62
pH	6.69±0.26 (6.5-7.0)	6.81±0.26 (6.5-7.0)	6.75±0.35 (6.0-7.0)	0.34
Dissolved Oxygen(mg/L)	1.68±0.79 (0.89 - 3.36)	1.21±0.92 (0.20-1.96)	3.10±1.18 (1.72-4.80)	8.08 *
Alkalinity (mg/L)	88.5±9.97 (78.0-102.0)	85.63±12.80 (70.0-104.0)	81.75±9.97 (70.0-91.0)	0.77
Nitrate (mg/L)	0.03±0.01 (0.02-0.04)	0.02±0.01 (0.01-0.03)	0.03±0.01 (0.01-0.04)	0.74
Phosphate (mg/L)	0.05±0.03 (0.03 - 0.08)	0.02±0.01 (0.01 - 0.04)	0.03±0.01 (0.01 - 0.05)	7.66*
Velocity (ms^{-1})	0.03±0.01 (0.02-0.04)	0.02±0.01 (0.01-0.03)	0.02±0.03 (0.01-0.06)	1.17
Zinc (ppm)	1.53±0.55 (0.96-2.56)	1.57±0.48 (1.04-2.35)	1.51±0.49 (0.87-2.13)	0.03
Copper (ppm)	0.51±0.19 (0.20-0.74)	0.55±0.24 (0.14-0.88)	0.56±0.23 (0.19-0.896)	0.09
Lead (ppm)	0.009±0.009 (0.002-0.029)	0.010±0.012 (0.002-0.037)	0.010±0.013 (0.001-0.041)	0.04
Cadmium (ppm)	0.004±0.002 (0.001-0.008)	0.004±0.008 (0.000-0.009)	0.003±0.003 (0.000-0.007)	0.15

*: Indicates significant difference (p<0.05) ANOVA; Values are Mean±Standard Deviation (Range in Parenthesis)

net with a mesh size of 250 µm. The sweep net was passed over the area for at least two minutes. The contents collected were put in a sorting bucket and the net was properly checked for insects clinging to the mesh. Other several insects' were handpicked from specific micro-habitats throughout the reservoir. Insects collected were later preserved in 7% formalin in jars labeled according to sample point, description, and collection date. All samples collected taken to the Entomology laboratory for identification.

Benthic macro-fauna collection: A Van Veen Grab with a surface area of 66.6 m^2 was used to collect sediments. The sediments collected were emptied into labeled polythene bags and taken to laboratory for washing. The washed samples were sieved separately through a sieve with mesh size of 0.5 mm to eliminate the excess sediments. Organisms contained were sorted from the detritus and stored in 10% formalin solution. Subsequently, the collected benthic macro-fauna were identified with the aid of a compound microscope, and stored in separate 2 cm × 4cm vials containing 10% formalin Solution for keeps in the laboratory.

Aquatic arthropod taxonomic keys (Heckman, 2002; Needham *et al.*, 2000; Merritt and Cummins, 1996; Pennak, 1978) were used to identify the collected specimens to species, or at least genus level, except chironomids that were identified to family level.

Statistical analysis: Each sampled points total number of species was calculated and Margalef's Diversity Index (D) was used to determine species richness. The family and species abundance and diversity was calculated for each sampling data and for the overall samplings using Shannon-wiener's diversity index. Evenness index (E) was used to observe the evenness of the species distribution to the maximum.

Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physico-chemical parameters of the three sampling stations.

Duncan's Multiple Range Test (DMRT) was also used for multiple comparison of the means of the physico-chemical parameters in order to measure similarities of the sampling points. Pearson Correlation coefficient (r) was used to determine the interdependence of the parameters where physico-chemical parameters were correlated with the themselves and the abundance of insects species.

RESULTS

Water sample physic-chemical parameters: The result of the physico-chemical parameters of Awba reservoir water is presented in Table 1. The spatial trend in the pattern of each physical, chemical and heavy metal characteristic was similar along the stream. Temperature, pH, nitrate, velocity, zinc, copper, lead and cadmium were not significant during the period of study, (Table 1).

DO and phosphate-phosphorus concentrations among the three points sampled varied significantly ($p<0.05$), using ANOVA (Table 2). All other chemical parameters were not significantly different and the recorded values are presented on Table 2.

Pearson's correlation coefficient (r) shows the relationship between the physic-chemical parameters recorded in Awba reservoir (Vide Table 3). The analysis shows that pH and temperature correlated negatively, r = -0.052. Dissolved oxygen (DO) had an inverse correlation with pH and temperature, while nitrate-nitrogen, phosphate-phosphorus, alkalinity, and velocity had a direct correlation with DO, Table 3.

Aquatic Insects sampling and identification: The overall insect composition, abundance, and distribution

Table 2: Summary of the Analysis of Variance (ANOVA) of physico-chemical parameter of water samples from Awba reservoir

Parameters	Point 1	Point 2	Point 3
Temperature (ºC)	26.80^{a}	26.60^{a}	25.75a
pH	6.69^{a}	6.81^{a}	6.75a
Dissolved Oxygen (mg/L)	1.68^{b}	1.21^{b}	3.10a
Alkalinity	88.50^{a}	85.63^{a}	81.75^{a}
Nitrate	0.03^{a}	0.02^{a}	0.02a
Phosphate	0.04^{a}	0.02^{b}	0.02b
Velocity (m/s)	0.03^{a}	0.01^{a}	0.02a
Zinc	1.52^{a}	1.56^{a}	1.50a
Copper	0.51^{a}	0.54a	0.55a
Lead	0.01^{a}	0.01^{a}	0.01a
Cadmium	0.004^{a}	0.004^{a}	0.003^{a}

Means with different superscript in a row shows significant difference ($p<0.05$) indicated by Duncan Multiple Range Test

Table 3: Pearson's Correlation (r) values between the physico-chemical parameters at the three points sampled

Parameters	Temp	pH	D.O	Alkalinity	NO_3-N	PO_3-P	Velocity	Zinc	Copper	Lead	Cadmium
Temperature (^{0}C)	1										
pH	- 0.052	1									
D.O (mg/L)	- 0.404	- 0.697	1								
Alkalinity (mg/L. $CaCO_3$)	- 0.696	- 0.567	0.270	1							
NO_3-N(mg/L)	- 0.882	0.704	0.423	0.327	1						
PO_3-P (mg/L)	- 0.158	0.162	0.976	0.149	0.846	1					
Velocity (m/s)	0.706	- 0.219	0.085	0.630	0.293	- 0.185	1				
Zinc (ppm)	0.210	- 0.572	- 0.812	0.264	0.113	0.664	- 0.185	1			
Copper (ppm)	- 0.673	0.905	0.235	- 0.994	0.210	- 0.469	0.538	0.639	1		
Lead (ppm)	- 0.846	0.461	0.746	- 0.332	0.514	- 0.737	- 0.740	- 0.876	0.081	1	
Cadmium (ppm)	0.611	0.974	0.759	- 0.573	-0.499	0.298	0.992	0.679	0.043*	0.013*	1

Significant relationship is asterisked

Table 4: The overall composition and distribution of aquatic insects encountered during sampling of Awba Reservoir

	No. of Individual insects from			
	Point 1	Point 2	Point 3	Total
Coloeptera				
Hydrophilidae	2	3	-	5
Gyrinidae	7	4	12	23
Diptera (Larvae)				
Chironomidae	418	254	34	706
Tabanidae	12	-	2	14
Culicidae	35	52	7	94
Water flea	12	15	31	58
Odonata (Nymphs)				
Lesticidae	-	1	1	2
Libellulidae	5	4	37	46
Aeschnidae	3	-	13	16
Hemiptera				
Belostomatidae	6	9	20	35
Gerridae	94	10	39	143
Neopla sp	2	-	5	7
Tricoptera				
Hydrosychidae	-	-	5	5
Total	596	352	206	1154

Table 5: Diversity and other indices of Aquatic Insects in the study stations of Awba Reservoir

	Sampling points		
	1	2	3
No. of Taxa	11	9	12
No. of individuals	596	352	206
Taxa richness (d) Margalef's index	1.56	1.27	2.06
Shannon Weiner index (H)	0.46	0.44	0.92
Evenness (E)	0.44	0.457	0.852
Simpson Dominance index (D)	0.52	0.54	0.42

from the sampled points were summarized in Table 4. Thirteen (13) taxa were identified from a total of 1154 individuals collected during the sampling period. Insect's percentage composition of 45.0, 29.5 and 18.3%, were recorded for point 1, point 2 and point 3, respectively.

Diversity, taxa richness and dominance indices of various insects collected during period of sampling are shown in Table 5.

Pearson's correlation coefficient (r) relationship between species and physico-chemical parameters are shown on Table 6. *Chironomus* sp., *Culex* sp., *Libellula* sp. had an inverse relationship with dissolved oxygen, the relationship of Chironomus was significant at ($p = 0.05$).

DISCUSSION

Temperature values recorded during the sampling period ranged from 24 to 29ºC. This value falls within the optimal range for tropical fresh waters. This was also corroborated by Ayodele and Ajani (1999), but that tropical freshwaters had temperature values ranging from 21 to 32ºC.

Table 6: Pearson correlation coefficient values (r) between the means of the physico-chemical parameters of water and aquatic insects encountered during the sampling period at Awba reservoir

Parameter Aquatic insect	Temp	pH	DO	Alkalinity	Nitrate	Phosphate	Velocity	Zinc	Cupper	Lead	Cadmium
Hydrophilus sp.	-	- 1.00000**	0.25207	- 0.65887	- 0.17408	- 0.52223	1.0000*	- 0.49818	0. 58066	0.71241	0.47458
Gyrinus sp.	- 0.35878	0.43685	0.59255*	0.01274	0.49424	0.20727	0.013582	- 0.02514	0.00215	- 0.03629	- 0.13343
Chironomus sp.	0.32821	- 0.22245	0.40191*	- 0.0081	0.09501	0.02723	0.48286*	- 0.17696	- 0.06000	0.01507	0.10568
Tabanus sp.	- 0.45455	- 0.30151	-0.32933	- 0.32706	0.21320	0.69631	0.24940	- 0.26453	0.58195	0.55379	0.43774
Culex sp.	- 0.02600	- 0.22519	0.56092*	- 0.06728	0.06428	0.14627	- 0.17136	0.17311	0.01514	- 0.06513	- 0.10971
Water flea	- 0.15854	- 0.24725	0.44585*	0.08751	0.20583	0.13872	0.09661	0.09097	0.06604	- 0.18751	- 0.25003
Lestes sp.	-	-	-	-	-	-	-	-	-	-	-
Libellula sp.	- 0.13617	- 0.03341	0.57203*	- 0.06058	0.48305	- 0.33383	0.13193	0.37792	- 0.24578	- 0.03203	- 0.40327
Aeschna sp.	0.16941	0.51148	0.05543	0.36080	0.69310*	0.27285	- 0.50776	0.08664	0.09627	0.00335	0.03752
Belostoma sp.	- 0.44234	- 0.05325	0.20086	- 0.46062	- 0.20514	- 0.32331	0.37222	- 0.09269	- 0.30157	0.03913	- 0.16675
Geris sp.	- 0.020175	0.01608	0.05820	0.14178	0.15347	0.68735**	0.19219	- 0.3829	- 0.23763	0.12398	- 0.05537
Neoperla sp.	- 0.40825	0.1667	0.06379	- 0.21078	- 0.40825	0.61237	- 0.05748	0.46801	- 0.21196	- 0.37272	- 0.43994
Hydrosyche sp.	0.33333	0.52223	0.04537	0.57682	1.00000**	0.81650	0.48064	0.07483	- 0.28823	- 0.6366	- 0.47140

Correlation is significant at the 0.05 level; **: Correlation is significant at the 0.01 level; Significant correlations are asterisk

The variation in temperature observed was as a result of low solar heat radiation across the stations. Inundation by run-off water into the stream also causes a reduction in temperature. This temperature reading indicates a great impact on the abundance and distribution of aquatic insects as more species were collected at relatively high temperature than when there was a drop in temperature. Ajao (1990) and Oben (2000), recorded similar observation during their studies. Pearson's correlation coefficient (r) analysis between insect abundance and water temperature showed that most of the species correlated positively with water temperature. Possibly because some insect species are temperature dependent, this favours their rate of feeding and metabolism. Some other species like *Gyrinus* sp., *Tabanus* sp., *Culex* sp., *water flea*, *Gerris*, *Neopla* sp. and *Libellula* sp. had positive correlation with temperature. These groups of insects increase in abundance with decreasing temperature because they prefer cooler waters for their feeding rate, metabolism and reproduction (Pennak, 1978).

Water flow velocity is directly and indirectly important as it influence the river-bed and amount of silt deposition which in turn affects the distribution of benthic organisms (Imoobe and Oboh, 2003; Ikomi *et al*., 2005). Point 1 and 2 of Awba dam, had relatively low flow velocity; hence, it was dominated by pollution tolerant species like *Chironomus* midge and *Culex* larva.

Pearson's correlation coefficient analysis between insects abundance and physico- chemical parameters confirmed an inverse relationship between *Chironomus* sp abundance and flow velocity (r = -0.48286*), other species like *Culex*, *Neopla*, showed a negative correlation with flow velocity from this study, this will amount to abundance of pollution tolerant species. This is corroborated by Doisy and Rabeni (2001) and Arimoro *et al*. (2007a) observations. This may be due to the fact that the detritus material that they feed on does not accumulate in areas of high velocity.

Dissolved oxygen (DO), concentration in Awba reservoir was inversely related to changes in temperature. Pearson's correlation coefficient (r) analysis confirmed an inverse relationship between DO and water temperature. This observation agreed with Arimoro and Ikomi (2008) findings, who reported that increase in water temperature brings about a decrease in DO. This is because as water temperature increases, dissolved oxygen decreases, also it may be due to respiration and other processes such as breakdown of organic matters. Species diversity was highest in point 3 where the DO was high. Pearson correlation coefficient analysis showed a positive relationship of the insects and dissolved oxygen; species like *Gyrinus* sp., *water flea*, *Libellula* sp., showed statistical significance at $p<0.05$ value . Other species like *Chironomus* sp., *Tabanus* sp., *Culex* sp., correlated inversely with dissolved oxygen from the study. This observation is in accordance with Emere and Nasiru (2007), from their study carried out in an urbanized stream in Kaduna, Nigeria.

The low values of DO concentration recorded in point 1 and 2, is an indication of deterioration of the water quality as a result of various anthropogenic activities in these sites as observed. Yakub (2004) also attributed the low level of DO in these points to human activities. The plausible reason for high dissolved oxygen in point 3 could be attributed to the large surface area of the sampling point and the less impact of organic waste in that point as compared to that of points 1 and 2 which receives organic waste discharge from the Zoological garden and the laboratories around.

Nutrients (Nitrate and Phosphates) correlated positively with insect species. It is likely that input of nutrients in the reservoir enhanced secondary production. Point 1 recorded higher values in nutrients (nitrates and phosphates) indicating significant input of organic discharges in this area. Zabbey and Hart (2006) recorded similar trend in Woji creek in the Niger Delta where organic wastes are discharged constantly into the stream. Arimoro *et al*. (2007a) also recorded similar result in Ethiope River in Niger delta. Nutrient is also an important factor in the distribution and abundance of *Chironomus* sp. Ali *et al*. (2003) reported a positive correlation in his study carried out in Malaysia. Low varieties of species was observed in points 1 and 2, this finding was consistent with Ndaruga *et al*. (2004) who observed that heavily organic impacted areas, have low varieties of species and most of the species dominating such zones are tolerant to pollution. Dipterans (*Chironomus*, *Culex* sp.) are the most dominant in these sites.

The multiple comparison tests showed that Odonatans were greatest in point 3, where macrophytes dominated. Odonata nymphs are usually associated with macrophyte Carchini *et al*. (2004, 2000), Ravera (2001), Ruggiero *et al*. (2003) and Arimoro *et al*. (2007b), have reviewed that Diptera abundance are attributed to considerable load of organic particles from untreated sewage and livestock effluents. Less sensitive species like the *Ephemeropterans*, *Tricoptera*, *Plecoptera* only occur sporadically, limited in most cases by high concentration of organic pollutants. Points *2* and 3 recorded more Diptera taxa precisely *Chironomus* sp. and these are characteristic species showing some degree of change in the quality of their trophic resources

Awba reservoir water pH during the study ranged from 6.0-7.0. Pearson's correlation coefficient showed that most of the pollution tolerant species had inverse relationship with pH. The pH value obtained from this study ranged from slightly acidic to neutral. Most insects species such as *Chironomus* sp., water boatmen, and damselflies are only slightly affected by acidification hence their abundance in points 1 and 2; whereas others like mayflies, stoneflies are acid-sensitive and they are mostly found in clean waters that are alkaline in nature. Hence they were absent throughout the points sampled.

Alkalinity values recorded during the months of sampling varied from 70-104 mg/L. $CaCO_3$. Pearson's correlation relationship between alkalinity and other physico-chemical parameters showed inverse relationship. In addition, the correlation with insects showed inverse relationship with pollution tolerant species like *Chironomus* (r = - 0.0081), *Culex* sp. (r = - 0.06728).

The high mean metal (Lead, zinc, copper and cadmium) concentration observed at Point 2 may be attributed to the discharge of laboratory waste through a gutter into the reservoir at this point. These wastes emanates from the Chemistry and Physics laboratories.

The physico-chemical parameters variation from the study greatly influenced the aquatic insects' species composition, distribution, and abundance in Awba reservoir.

The results showed that dissolved oxygen had the strongest influence on the community structure at Awba reservoir. At concentrations below 1 mg/L, pollution tolerant species dominated the stream, while concentrations above 2.0 mg/L promote high abundance and diversity of sensitive aquatic insects in the reservoir. Representatives of aquatic insect families like *Chironomidae* (*Diptera*), *Lesticidae* and *Libellulidae*, *Aeschnidae* (*Odonata*), *Gyrrinidae*, (*Coleoptera*), *Gerridae* and *Belostomatidae*, (*Hemiptera*) were considered as index of pollution for different levels of perturbation in the stream.

CONCLUSION

In conclusion, water quality plays a vital role in the distribution, abundance and diversity of aquatic insects. The high abundance and distribution of pollution tolerant orders of aquatic insects in points 1 and 2 indicates the relative pollution of the reservoir. With special reference to Margalef's water quality index, values greater than 3 indicate clean conditions, values less than one (1) indicates heavy pollution of a stream, while values between one to three (1-3) indicates moderately polluted conditions (Lenat *et al*., 1980). Margalef index for point 1 was 1.56, point 2 was 1.27 while that of point 3 was 2.06 thereby corroborating the evidence of the relative polluted nature of the reservoir and this showed that the various activities around the reservoir has brought about pollution.

It is imperative that there should be strict adherence to adequate conservation measures like sewage and inorganic waste treatment before they are discharged into the Awba stream and reservoir to improve the quality and health status of the reservoir.

REFERENCES

Ajao, E.A., 1990. The influence of domestic and industrial effluents on the population of sessile and benthic organisms in Lagos lagoon. Ph.D. Thesis, University of Ibadan, Ibadan, pp: 411.

Akin-Oriola, G.A., 2003. On the phytoplankton of Awba reservoir, Ibadan, Nigeria. Revista biol. Trop., 51(1): 99-106.

Ali, A., R. Lobinske, J. Frouz and R.J. Leckel, 2003. Spatial and temporal influence of environmental conditions on benthic macroinvertebrates in Northeast Lake Jessup; Central Florida. Florida Sci., 66(2): 69-83.

Arimoro, F.O., R.B. Ikomi and E. Erebe, 2007a. Macroinvertebrate community diversity in relation to water quality status of River Ase, Niger Delta. Nigeria. J. Fish. Aquat. Sci., 2(5): 337-344.

Arimoro, F.O., R.B. Ikomi and C.M.A. Iwegbue, 2007b. Water quality changes in relation Diptera community patterns and diversity measured at an organic effluent impacted stream in the Niger Delta, Nigeria. Ecol. Indicators, 7: 541-552.

Arimoro, F.O. and R.B. Ikomi, 2008. Ecological Integrity of upper Warri River, Niger Delta using Aquatic insects as bioindicators. Ecol. Indic., 395: 1-7.

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

Bauernfeind, E. and O. Moog, 2000. Mayflies (Insecta: Ephemeroptera) and the assessment of ecological integrity: A methodological approach. Hydrobiology, 135: 155-165.

Carchini, G., T. Pacione, C.I. Tanzilli, M. Di Domenico and A. Solimini, 2004. Temporal variation of an Odonata species assemblage (Rome, Italy). Odonatologica, 33: 157-168.

Chae, S.J., N. Purstela, E. Johnson, E. Derock, S.P. Lawler and J.E. Madigan, 2000. Infection of aquatic insects with trematode metacercariae carrying *Ehrilichia risticii*, the case of the Potomac house fever. J. Med. Entomol., 37: 619-625.

Deliz-Quiñones, K.Y., 2005. Water quality assessment of a tropical Freshwater marsh using Aquatic insects. M.Sc. Project Research in the Department of Biology University of Puerto Rico, pp: 148.

Dobson, M., A. Magana, J.M. Mathooko and F.K. Ndegwa, 2002. Detitivores in Kenyan highland streams: more evidence for the paucity of shredders in the tropics? Freshwater Biol., 47: 909-919.

Doisy, K.E. and C.F. Rabeni, 2001. Flow conditions, Benthic Food resources, and invertebrate community composition in a low-gradient stream in Missouri. J. N. Am. Benthol. Soc., 20(1): 17-32.

Foil, L.D., 1998. Tabanids as vectors of disease agents. Parasitol. Today, 5: 88-96.

Emere, M.C. and C.E. Nasiru, 2007. Macroinvertebrates as indicators of the water quality of an urbanized stream in Kaduna Nigeria. J. Fisher. Int., 2(2): 152-157.

Hassan, A.T., 1974. Studies on the Ecology, Behaviour and Life History of Libelluline Dragonflies. Ph.D. Thesis, Zoology Department, University of Ibadan, pp: 51-58.

Heckman, C.W., 2002. Encyclopedia of the South American aquatic insects: Ephemeroptera. Kluwer Academic Publishers, Norwell, MA, pp: 419.

Ikomi, R.B., F.O. Arimoro and O.K. Odihirin, 2005. Composition, distribution, and abundance of macroinvertebrates of the upper reaches of River Ethiope, Delta State, Nigeria. The Zoologist, 3: 68-81.

Imoobe, T.O.T. and I.P. Oboh, 2003. Physical and chemical hydrology of River Jamieson, Niger Delta, Nigeria. Benin Sci. Digest, 1: 105-119.

Lenat, D.R., L.A. Smock and D.L. Penrose, 1980. Use of Benthic Macroinvertebrates as Indicators of Environmental Quality. Biological Monitoring for Environmental Effects, Lexinton Books, Toronto, Canada, pp: 7-114.

Mafuyai, H.B., J.W. Wade, A.K. Agoom and B.S. Audu, 2004. Aquatic insect composition at a *Simulium* breeding site on the River Assop, Plateau State, Nigeria. J. Aquat. Sci., 19(1): 9-15.

Merritt, R.W. and K.W. Cummins, 1996. An introduction to the aquatic insects of North America. 3rd Edn., Dubuque, IOWA: Kendall-Hunt, pp: 862.

Ndaruga, A.M., G.G. Ndiritu, N.M. Gichuki and W.N. Wamicha, 2004. Impact of water quality on the macroinvertebrate assemblages along a tropical stream in Kenya. Afr. J. Ecol., 42(3): 208.

Needham, J.G., M.J. Westfall and M.L. May, 2000. Dragonflies of North America. Revised Edn., Scientific Publishers, Inc., Gainesville, FL, pp: 940.

Oben, B.O., 2000. Limnological assessment of the impact of agricultural and domestic effluents of three man-made lakes in Ibadan, Nigeria. Ph.D. Thesis, University of Ibadan, Nigeria, pp: 344.

Ugbogu, S.S. and T.O. Akinya, 2001. Distribution and abundance of insect orders in relation to habitat types in opa stream-reservoir system, Nigeria. J. Aquat. Sci., 16(1): 7-12.

Pennak, R.W., 1978. Freshwater invertebrates of the United States. 2nd Edn., John Wiley and Sons, New York, pp: 810.

Ravera, O., 2001. A comparison between diversity, Similarity, and biotic indices applied to the macroinvertebrate community of a small stream: The Ravella River (Como Province, N. Italy). Aquat. Ecol., 35: 97-107.

Ruggiero, A., A.G. Solimini and G. Carchini, 2003. Nutrient and chlorophyll a temporal patterns in eutrophic maintain ponds with contrasting macrophyte coverage. Hydrobiologia, pp: 506-509, 657-663.

Tyokumbur, E.T., E.T. Okorie and O.A. Ugwumba, 2002. Limnological assessment of the effects of effluents on macroinvertebrate fauna in Awba stream and Reservoir, Ibadan, Nigeria. The Zoologist, 1(2): 59-62.

Yakub, A.S., 2004. Assessment of water Quality and Plankton of Effluent receiving lower Awba stream and Reservoir, Ibadan. Afr. J. Appl. Zool. Environ. Biol., 6: 107-110.

Zabbey, N. and A.Z. Hart, 2006. Influence of some physicochemical parameters on the composition and distribution of benthic fauna in Woji Creek, Niger Delta, Nigeria. Global J. Pure Appl. Sci., 12(1): 1-5.