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AQUATIC INSECTS DIVERSITY AROUND SOLID WASTE DUMPSITES ALONG RIVER NGADDA BANK, MAIDUGURI, NIGERIA

[*1]Abbator Ahmed, [1]Musa Adamu Ibrahim, [2]Mamoon Asiya

[1]Department of Biological Sciences, University of Maiduguri, Borno State, Nigeria.

[2]Department of Biological Sciences, Federal University of Kashere, Gombe State, Nigeria.

***Corresponding Email Address:** abbatorahmed@gmail.com

ABSTRACT

Aquatic insects are good bioindicators of heath status of water bodies. This study was conducted to evaluate water quality and diversity of insects along the banks of River Ngadda, Maiduguri, Nigeria.Distribution and diversity of aquatic insectswas sampled and evaluated in relation to solid waste disposal sites. Aquatic insects were sampled from three (3) stations (Custom bridge, Lagos Streetbridge and Gwange bridge) using a telescopic net (2mm mesh size). The water quality parameters (pH, temperature, DO, BOD, turbidity, TDS) of each station was also determined. A total of 3,111 aquatic insects of different taxa were collected and identified, the orderHemiptera have the highest distribution (6 genus),while the order Ephemeropterawasthe lowest (1 genus). The water quality analysis indicated that station I (Custom bridge) had the bestquality compared to the other stations. The results indicatea significant influence of water quality on the distribution, abundance and diversity of aquatic insectsalong the bank of River Ngadda.

Keywords: Aquatic Insects; Dumpsite; Invertebrates; River Ngadda; Solid Waste

INTRODUCTION

Water is an environment for ecological growth; it is a universal solvent which forms an essential component of life and survival, a home for several animals including insects [1]. Benthic aquatic insect groups are some of the most directly impacted by changes to surface waterways [2].

Freshwater resources are crucial for human survival as well as those of other organisms and for the maintenance of the natural order [3]. Surface lotic and lentic waters present in nature supply around one-third of the world's fresh water needs [4]. Since freshwater is scarce on Earth, it is crucial to evaluate its quality because human activities have a significant negative impact on many of the world's freshwater resources [5]. According to the Millennium Ecosystem Assessment [6], freshwater habitats are thought to contain the greatest number of species that are thought to be in danger of going extinct due to climate change.

Monitoring water quality enables the detection and control of pollution situations and ensures the benefit of management initiatives [7]. Aquatic macroinvertebrates and physico-chemical traits are frequently used to assess the state of aquatic ecosystems in different parts of the world. Aquatic insects are the most abundant and diverse fresh water macroinvertebrates, and because they spend the most of their lives in the water, if not all of them, they can be used as important markers of the health of aquatic ecosystems [8]. The habitat needs and pollution tolerance of many aquatic insect species vary. Water quality can be determined by looking for tolerant species or absence of sensitive taxonomic group [9]. The use of aquatic insects as bio-monitoring techniques for determining water quality has been explored in a number of studies [10,11,12].

Aquatic insects spend parts of their life cycle in water; they feed similarly to other insects, such as predatory diving beetles, which may seek for food underwater, while land-based insects cannot thrive. Due to the fact that their significance in maintaining and restoring aquatic ecosystems has been challenged and that they provide food for fish, amphibians, and other wildlife while also providing advantages to humans, decision-makers, and the general public. They play a significant role in the processing of energy and nutrients, collecting nutrients, returning them to terrestrial ecosystems, and purifying water [12]. Numerous biotic and abiotic factors influence insect abundance and distribution, and their interactions, survival, and success under extreme physical conditions necessitate special adaptations and responses from abiotic factors. The most significant abiotic factors for aquatic insect abundance and distribution are temperature and humidity. Their abundance, diversity, distribution, and composition are frequently considered when evaluating the ecological health of aquatic environments [13]. Ephemeroptera, Plecoeptera, and Trichoptera (EPT) are often utilized taxa for monitoring aquatic bodies [14,15]. The EPT of aquatic insects are referred to as pollution-sensitive species, whose presence suggests relatively clean, undisturbed, or minimally disturbed waters [16,17,18,19].

Aquatic insects are one of the important components for food web in freshwater ecosystems [21,22]. In the food web of aquatic ecosystem, aquatic insects are the main prey of nekton and have role as decomposer of organic matter and therefore, aquatic insects can be used as a bioindicator of ecosystem stability and water quality [22].

River Ngadda frows from the Mandara mountain and some parts of Biu plateau emptied into Alau dam and Lake Chad basin. It has interfered with the fertile seasonal flood plains in the region of Maiduguri and hence the environmental pollution of river Ngadda affects the distribution and survival of the aquatic insects.

The majority of Nigeria's freshwater bodies, including the River Hadejia, have experienced an increase in human disturbance, which has changed the environmental variables and impacted the structural and functional ecology of the freshwater systems [23,24]. As a result, using a biomonitoring technique that makes use of the structural assemblage of aquatic insects might give us useful insights into how to manage the environment in freshwater environments, enabling us to make informed decisions about the ecological status of these ecosystems [25,26].

According to Garba *et al.* [27], freshwater ecosystems worldwide, including those in Nigeria, are frequently impacted by anthropogenic activities such as home and industrial effluent contamination. Pollution alters the physico-chemical characteristics of water, altering the distribution of aquatic insects in a particular body of water..

By evaluating abiotic or biotic water quality indices, the degree of human waste pollution in an aquatic ecosystem can be found. Temperature, pH, dissolved oxygen (DO), nitrite and nitrate concentration, among other abiotic variables, are typically utilized to identify contamination throughout the sampling period [28]. Due to their prolonged exposure in aquatic ecosystems, biotic variables like macro invertebrates, particularly aquatic insects, can serve as biotic indices for water quality assessments and can indicate the long-term status of aquatic habitats [29].

The increasing population of Maiduguri increased tremendously as of the last census in 2006 (2 million) and is expected to reach more than three million in 2022, accompanied with of solid waste generation [30], and its effects on water pollution, especially along the bank of river Ngadda, with negative effects on aquatic insects, making solid waste disposal a serious issue concerningthe distribution of aquatic insects, and public, when it comes to the problem of water pollution and its effect on aquatic organisms. Several studies were conducted in different rivers on how abiotic factors and pollutions affect the distribution of macro-invertebrates,The primary variables forming lotic communities are hydric stress and the geo-morphology of the stream bed. These factors do not alter predictably, making it difficult to identify patterns in the movement of macro-invertebrates like insects from upstream to downstream [31].

Studies on the variety of benthic macroinvertebrate populations in lotic environments in Brazil have typically concentrated on the composition and geographic distribution on a local scale, i.e., a stretch of river or special microbasins [32]. Takada et al [32] observed that the distribution of aquatic insects in streamsisaffected by the chemical nature of water, which affects the distribution of aquatic organisms in several ways,the concentration of dissolved oxygen (DO), temperature, and surface velocity.Richness and diversity are possibly the most sensitive methods currently available for promptly and correctly detecting alteration in an aquatic ecosystem since geographical and temporal isolation is one of several major elements determining the life cycle pattern of aquatic insects [33]. Conea and Wright [34] state that ideally, ecologists and managers should be aware of the mechanisms underlying the patterns of community structure that are seen in undisturbed flowing water systems. Doing so will give them a solid foundation on which to examine the effects of stresses on community structure and function.

The two most significant elements impacting macro-invertebrates, according to a different study by Newlon and Rabe [35], are substrate and suspended sediment. A substrate, gradient of suspended particles, water temperature, stream order, and width are some of these variables. Mishall [36] supports these findings and provides a literature review of the insect sub-stream relationship. Cornell [37] argues that processes regional (biogeography) and historical (evolutionary) scale are probably more important interactions between species.

The use of the family level for taxonomic identification can also reduce the problem of identifying and sub-sampling, increasing the reliability and robustness of patterns revealed in longitudinal and environment-independent gradients of regions [38]. In studies in Ghana [39] and Congo [40], it was found that the richness of families of aquatic insects is highly correlated with species richness.

Relevant literature shows that when investigating the effect of solid waste disposal on the distribution of aquatic insects to differentiate the most relevant ones, it is important to take into account that macroinvertebrate ecology is complex and that interaction with their environment is numerous. All of this interaction will have an effect to a certain extent on their survival and distribution.

Most of the studies at River Ngadda were restricted only to the planktons. Studies pertaining to macro-invertebrates diversity in the river were lacking. Therefore, in line with this significant lacuna, the present study is designed to thoroughly investigate the composition of aquatic insects and the physico-chemical properties of river Ngadda. In addition, various biotic indices from aquatic insect diversity and water physico-chemical variables were computed to determine the distribution of aquatic insects along the bank of river Ngadda.

MATERIALS AND METHODS

Study Area

RiverNgadda flows into the Lake Chad basin, and the construction of the Alau dam on the river has interfered with the fertile seasonal flood plains in the region of Maiduguri. Maiduguri, northeast, Nigeria (latitude of 14951.95N longitude of 1393.48E or 11.831098 and 13.150967).

Sampling Sites

Sampling of Aquatic Insect

Aquatic insects were sampled (January 2021 to March 2021) using a telescopic net, a D-frame aquatic net, and handpicking [41]. The nets were moved through the water column or rapidly pushed into macrophytes beds and into the substrate to collect the samples. Each sample was collected to provide some standardization of sampling effort. The specimens collected in the field were preserved in 10% formalin before being taken to the laboratory for identification and enumeration. In the laboratory, samples were placed in a slide and viewed using a binocular microscope for proper identification, following [42] pictorial guide. After which, voucher samples of the aquatic insects were preserved in 40% formalin for future referenceInsect identification was done using standard keys for the identification of the aquatic insect.

Table 1: Description of the sampling stations

Station	Coordinates		Description
	Longitude	Latitude	
Station I: Custom bridge	13.1722	11.8492	Custom Bridge has low transparency and was highly polluted with sewage water dumped into the area. It was filled with dense solid waste
Station II: Lagos bridge	13.1797	11.8202	The two-station area is Lagos Bridge,which was the least polluted due to less human interference, sewage disposal, and Solid Waste dump.
Station III: Gwange bridge	13.1832	11.7248	Gwange Bridge area which has medium transparency is polluted to some extent, due to population and human activities around the bridge

Samples were usually done between 7:00am to 10:00am. The water samples were collected using standard operation procedure (SOP) and then taken to the laboratory and analysed immediately. [27]. The surface water temperature was recorded with mercury in a glass thermometer.pH was measured with apH meter (Model PYE 79). Dissolved oxygen (DO) dissolve oxygen present in the water samples was measured at the site with a dissolve oxygen meter. Biochemical oxygen demand (BOD_5) biochemical oxygen demand using methods of Odiete [43].

Statistical Analysis

Data were analyzed using SPSS (version 24), and presented using descriptive statistics. Multivarite analysis (CCA and dedrogram) were plotted with PAST software (Ver. 1.4).

RESULTS AND DISCUSSION

The aquatic insects in three sampling sites of river Ngadda, the total number recorded for three months. The result showed that therewas a significant difference in the total number of individuals collected from the different stations of the river. The highest number of aquatic insects of 1439 was found at the first sampling station because there were several types of microhabitats with aquatic plants, gravel and sand. The lowest number was found from station III of 706, which might be the result of human interference which is not suitable for aquatic insects' distribution. A total number 3111 aquatic insects belonging to the order Ephemeroptera, Hemiptera and Coleoptera were collected from January to March in three sampling stations of the river Ngadda. The analysis was based on three sampling stations and a total of aquatic insectscollected in the river with the highest number of aquatic insectscollected from the river are fromthe order Hemiptera, followed by Coleoptera and Ephemeroptera. There was a variation in the total number of individual insects collected from the different stations of the river (Table 1)

This variation in the total number of individuals insects collected agreed with Leska [44], who said the variety of aquatic insects likely to be found in different stationsare types of aquatic insects such as stoneflies, Mayflies, and Caddie flies. This corresponds with Ephemeroptera, Coleoptera and Hemiptera.

The physico-chemical parameter analysed for the three-sampling station comprised temperature, turbidity, pH TDS, DO and BOD. Water temperature was found to vary and ranged from 19.5 to 28.3, with the station recording the highest of 28.3 which affects the assemblage of insects to the total of 1036, which agrees with Wood *et al.* [45] that reported temperature has a direct impact on aquatic organisms. The pH analysis of all three stationsrevealed the nature of the water from slightly acidic to neutral status the water body, with values ranging from 6.1(slightly acidic) to 7.1 (neutral), an indication of oligotrophic status and hence insignificant to the assemblage of insects from all stations that ranged from 706-1436 across all orders, families, and genus of insects identified which agrees with Steeman-Nilsson [46] that decay of allochthonous and autochthonous organic materials in water bodies would decrease the pH to below 7.0, the nature of the basement granite-biotic must be important in the buffering of the pH to above 7.8, which means the pH cannot be linked to the distribution of the insects (Table 3).

Most aquatic insects belonging to the order Hemiptera and Coleoptera are only slightly affected by the pH of water whereas other Ephemeroptera, Trichoptera and Odonata were found in alkaline water ecosystems. The lowest turbidity value of 44.2 was recorded for the station I and the highest turbidity valueof 63.9 was recorded for station II. Dissolve oxygen did not go with the predictive pattern of water ecosystem is an essential bio-indication of the water ecosystem that agrees with Thirmulai [47] that said is an essential bio- indication of water ecosystem that supports insect distribution.

Biochemical oxygen demand represents the degree to which the sample consumes oxygen in water characterized by the low BOD, less oxygen is consumed by decomposition and respiratory process, and low BOD concentration in the fresh water aquatic system indicates higher,pollution causing a drastic negative consequence on the aquatic ecosystem. The BOD values recorded indicate less pollution status of the water which agrees with Yakub [48].

The lowest DO value of 3.3 was recorded at the station I which might be caused by contamination from community waste dumped at the stations. The low value of DO concentration recorded during this study is a warning of the decline of the water, quality in the station due to various human interference.It can be observed that the diversity of aquatic insects is greatly determined by environmental variables. Station III in our study has shown the presence of the least diversity and the assemblage of aquatic insects in the community due to the high sedimentation that leads to the decline of primary productivity on the banks of the river.

Aquatic insects were adversely affected and there was a significant reduction in insect diversity at the polluted station; thus,the destruction of aquatic habitats can lead to a reduction in the biodiversity of aquatic invertebrates such as insects.

Table 2: Physicochemical parameters of River Ngadda Maiduguri, Nigeria between January and March 2021.

	Station I			Station II			Station III		
Parameters	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.
Temperature (℃)	19.8	21.8	21	19.5	21.0	28.3	20.0	21.3	24.7
Turbidity (NTU)	44.2	45.1	60.8	43.8	45.7	63.9	44.5	46.2	60.1
pH	6.1	6.1	6.1	6.82	6.93	6.85	7.06	7.11	7.2
TDS (Mg/l)	1233	1220	1219	1278	1231	1332	1285	1215	1305
DO (Mg/l)	3.3	3.6	6.1	4.30	3.56	4.3	8.83	9.43	9.55
BOD (Mg/l)	3.20	1.30	1.50	1.80	1.54	1.40	1.25	1.6	1.35

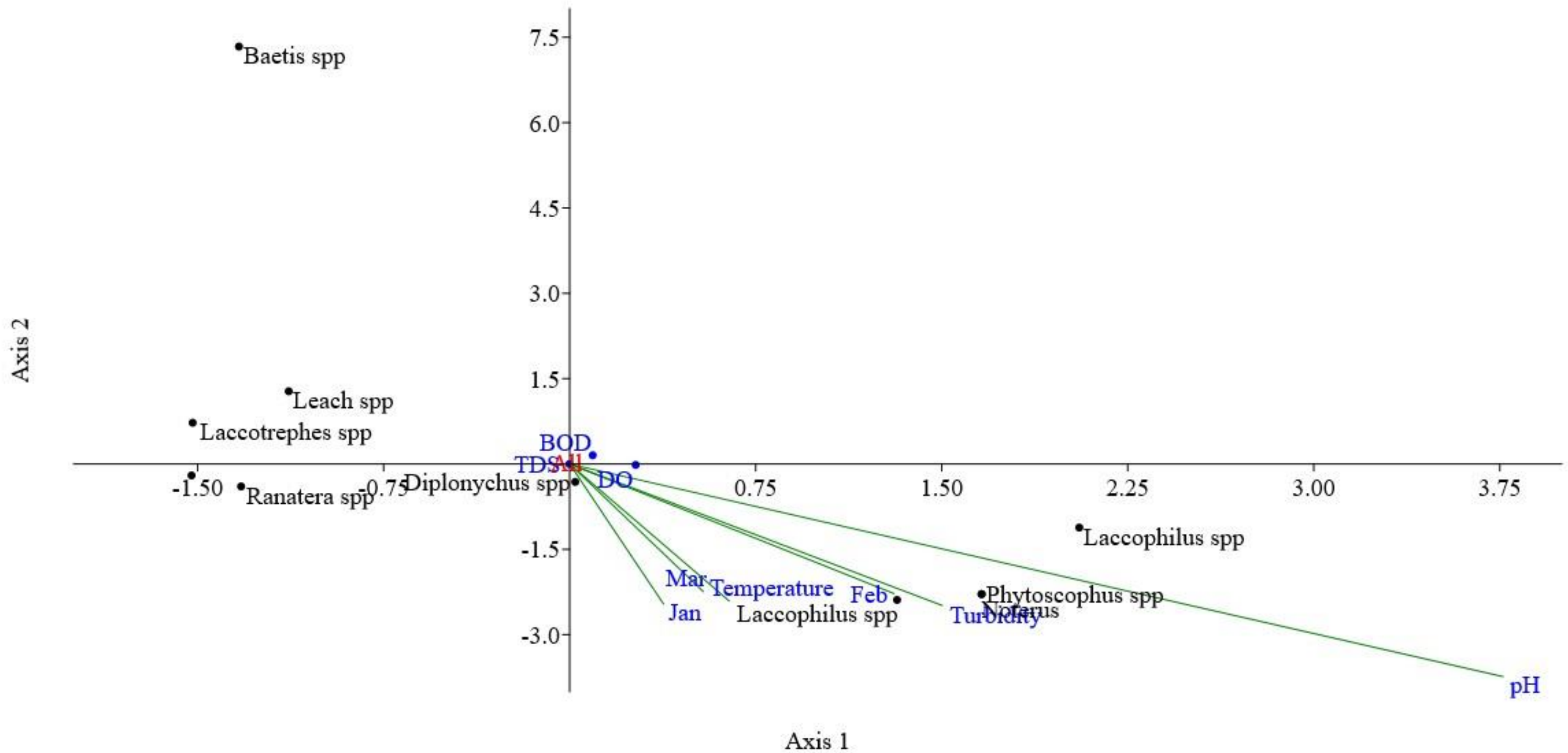

Figure 1: CCA of physicochemical parameters and aquatic insects collected between January-March, 2021 from river Ngadda, Maiduguri, Nigeria

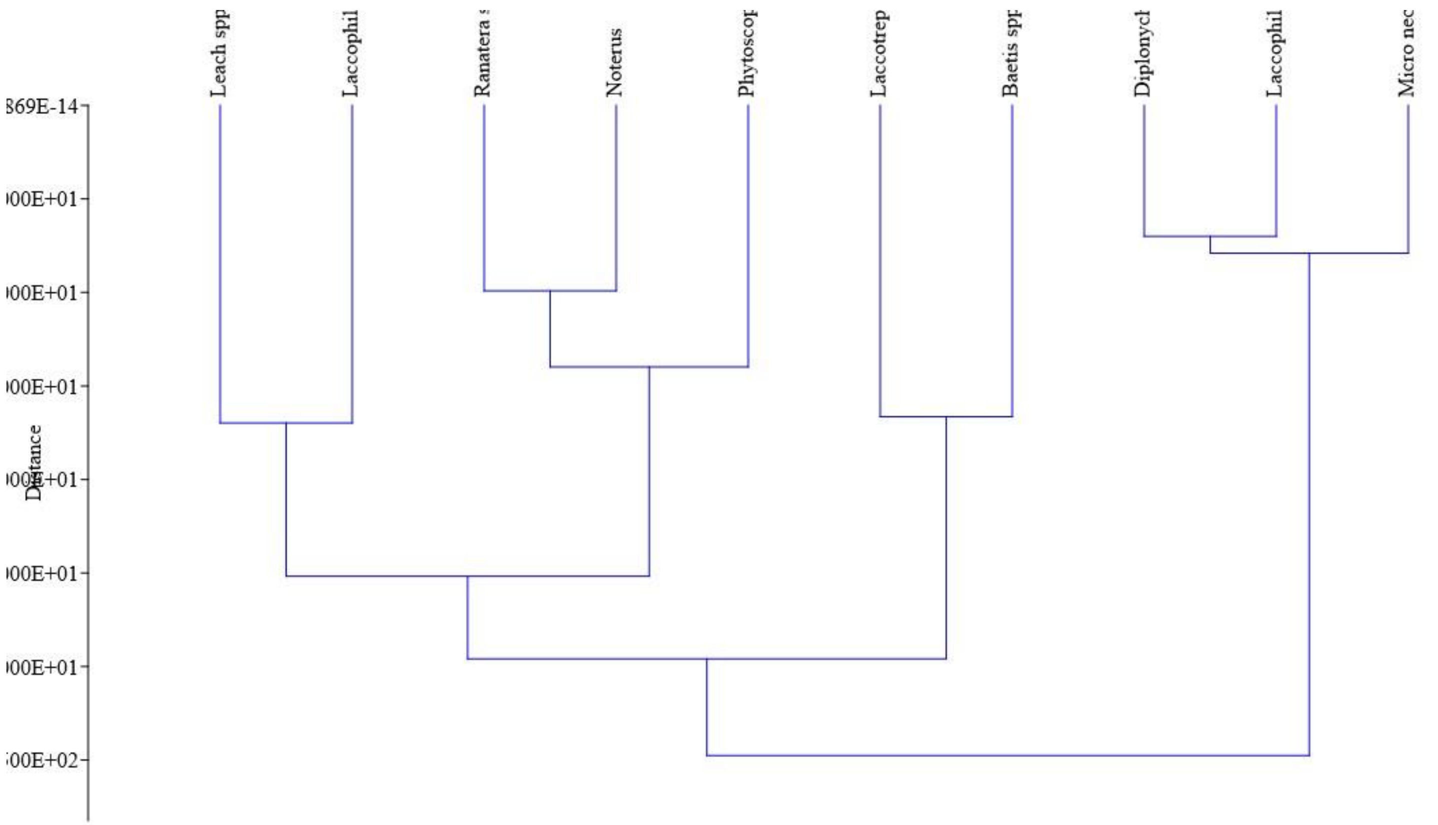

Figure 2: Dendrogram of aquatic insects collected between January-March, 2021from river Ngadda, Maiduguri, Nigeria

The CCA (Figure1) revealed the relationship between physicochemical parameters, and the temporal distribution of the aquatic insects collected from January 2021 to March, 2021. The eigen values for axes 1 and 2 is 91.9 and 8.1, respectively. The first axis explained most of the variation in the insect diversity and the monthly physicochemical parameters. *Baetis*spp, *Leach*s pp, *Laccotrephes*s pp, *Diplonynchus*spp and *Ranateria*s pp are associated with axis 2, with *Baetis*spp at a distal locaton. *Laccophilus*s pp, *phytoscopus*s pp, *Laccophilus*s pp are associated with axis 1, and with the exception of *Laccophilus*s pp. All species were uniformly associated with BOD,DO,TDS. Temperature, turbidity and pH are highly associated with the distribution of *Laccophilus*spp, *Phytoscophus* spp. The month of January shows a uniform impact of BOD, TDS, DO on the distribution and diversity of the insect with the exception of *Phytoscophus*s pp and *Laccophilus*s pp.

The dendogram (Figure 2) shows that all the aquatic insects taxa are related,but differ with distance. *Leach* spp, *Laccophilus* spp, *Laccotrephes* spp. and *Baetis* spp. are on the same level of relationship. *Ranatera*spp and *Noterus*spp,leachspp and *Laccophilus* and *Laccotrephes* and *Baetis*spp on the same level, while *Phytoscopus* appeared at the most distal position. However, Diplonyct and Laccophil were the most related.

Table 3: Diversity of aquatic insects in river Ngadda Maiduguri, Nigeria between January and March 2021.

			Station I			Total	Station II			Total	Station III			Total	EX	%
Order	Family	Genus	Jan	Feb.	Mar		Jan	Feb.	Mar		Jan	Feb.	Mar			
Ephemoroptera	Baetidae	Baetisspp.	16	10	-	26	7	3	0	10	2	0	55	57	93	2.9
Hemiptera	Corixidae	*Micronectar* sp.	68	55	95	218	62	42	70	174	43	35	30	108	500	16.0
	Belostomatidae	*Diplonychus* sp.	82	62	85	229	65	52	65	182	42	40	55	137	548	17.6
	Notonectidae	*Leach*spp	75	45	35	215	61	31	75	167	35	20	15	70	452	14.5
	Nepidae	*Laccotrephes*spp	50	20	35	105	30	12	29	71	12	2	10	24	200	6.4
	Nepidae	*Ranatera* sp.	45	25	25	95	29	10	16	55	11	0	55	66	216	6.9
	Gerridae	*Limnogomus* sp.	70	45	85	200	60	16	72	148	30	14	45	89	437	14.0
Celoeptera	Dytiscidae	*Laccophilus*spp.	72	62	75	209	50	45	61	156	35	25	0	60	425	13.6
	Curculionidae	*Phytoscophus*sp.	25	12	0	37	9	3	0	12	0	0	9	9	58	1.9
	Noteridae	Noterus	45	35	25	105	25	21	15	61	16	0	0	16	182	5
Total	10	10	548	371	520		398	235	403		226	136	274		3111	
						1439				1036				706		

CONCLUSION

Aquatic insects are an assemblage of arthropods that survive on water quality due to their varying tolerant levels in the environment, and hence to study the effect of solid waste disposal on the distribution of aquatic insects along the river Ngadda. Threestations of the river Ngadda were found to be affected by environmental variables, with the highest number of aquatic insects found at the first sampling station because there were several types of micro-habitat with aquatic plants, gravel, and sand, the lowest number was found at station 3 which could be the result of human interference, which is not suitable for aquatic insect survival and distribution.

The present investigation has concluded that there is an important association between the composition of aquatic insectsand environmental conditions. A close study of these aquatic insects has shown that the oligotrophic statusofthe river Ngadda has some minimum level of pollution, as the water quality of the river plays a crucial role in the maintenance of the biodiversity of aquatic insects in the river. It is highly essential to keep a check on the increasing anthropogenic disturbance which adversely affects the freshwater ecosystem and causes a severe threat to the aquatic insect. It is necessary to ensure their safety before they are discharged into the river to improve the quality of the river water and hence;the resident of Maiduguri needs to be advised of the effect of the distribution of solid waste of aquatic insects along the Ngadda river, which is an important component of biodiversity and the importance of aquatic insects in assessing the environment and water quality.

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