PRELIMINARY ASSESSMENT OF AQUATIC INSECTS BIODIVERSITY AND WATER QUALITY PARAMETERS OF ANYA RIVER, UMUDIKE, SOUTH EAST, NIGERIA

ONYENWE, Emmanuel, ANYANWU, Emeka Donald and NNYAMA, Grace Ijeoma
Department of Zoology and Environmental Biology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Corresponding Author: Anyanwu, E. D. Hydrobiology Unit, Department of Zoology and Environmental Biology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. **Email:** ekadon@yahoo.com **Phone:** +234 7036373209

Received: May 27, 2016 **Revised:** July 29, 2016 **Accepted:** August 19, 2018

ABSTRACT

Biodiversity of aquatic insects and physico-chemical water quality parameters of Anya River, Umudike, South East, Nigeria were assessed from June to August 2015. Three sampling stations were established. The samples were collected using standard methods. All the physico-chemical parameters were within acceptable limits except pH in station 2. The physico-chemical parameters also varied significantly in the three stations sampled except for nitrate, phosphate, Biological Oxygen Demand (BOD) and water temperature. A total of 185 individuals of aquatic insects were collected during the study with Hemipterans being the most abundant. Station 2 showed better taxa richness and diversity while Station 3 showed better species evenness. The aquatic insects' biodiversity and physico-chemical parameters showed that this segment of Anya River is not heavily polluted but an expanded study will give a true picture.

Keywords: Aquatic insects, Biodiversity, Water quality, Anya River

INTRODUCTION

The sustaining of biological diversity is a priority of nature conservation in terrestrial, marine and freshwater environments (Brooks *et al*., 2006). Therefore, the assessment of biological diversity and its probably most important element (taxonomic diversity) plays a very significant role as the basis for nature protection (Koperski, 2010). Aquatic insects are a group of arthropods that live or spend part of their life cycle in water bodies (Pennak, 1978). Freshwater aquatic insects inhabit river and stream beds, lakes and reservoirs and are associated with various types of substrates such as mineral sediments, detritus, macrophytes and filamentous algae (Rosenberg and Resh, 1993). They are essential elements in lentic and lotic trophic webs, participating in the energy flow and nutrient cycling (Whiles and Wallace, 1997). They are also important food resources for fish (Wallace and Webster, 1996) and some insectivorous birds (Merritt and Cummin, 1996). The distribution of aquatic organisms is the result of interactions among their ecological role, the physical conditions that characterize the habitat, and food availability (Merritt and Cummin, 1996). Thus, the community structure of aquatic insects depends on a number of factors, such as water quality, type of substrate, particle size of sediment, water flow, sediment organic matter availability, oxygen concentration as well as environmental conditions surrounding the water course (Ward *et al*., 1995; Buss *et al*., 2004). Aquatic insects are often used as bio-indicators because they are affected by changes in environmental factors arising from natural human activity on aquatic ecosystem and thus provide information on habitat and water quality changes (Woodcock and Huryn, 2007; Arimoro

and Ikomi, 2008). The organic enrichment of water caused by both domestic and industrial effluents is a common anthropogenic pollutant of urban watercourses (Payakka and Prommi, 2014). This kind of pollution changes physical and chemical characteristics of aquatic systems, thus affecting the assemblage of aquatic insects (Hynes, 1970; Ward *et al.*, 1995). The use of aquatic insects for assessing water quality provides managerial information to environmentalist that influences his decisions making and management strategies (Arimoro and Ikomi, 2009). Studies on the use of aquatic insects for assessing health and water quality status of streams revealed that such studies are very extensive in tropical Africa (Ugbogu and Akiya, 2001; Dobson *et al.*, 2002; Mafuya *et al.*, 2004; Deliz-Quinones, 2005; Arimoro and Ikomi, 2009). The aim of this study was to investigate the diversity of aquatic insects in relation to some water quality variables of Anya River, Umudike, Abia State, Nigeria.

MATERIALS AND METHODS

Study Area and Stations: The Anya River (Figure 1) in Umudike, Ikwuano LGA of Abia State is located between N5°28′12.0″ to N 5°29′24.0″ and E7°31′48.0″ to E 7°32′24.0″ (Google, 2016).

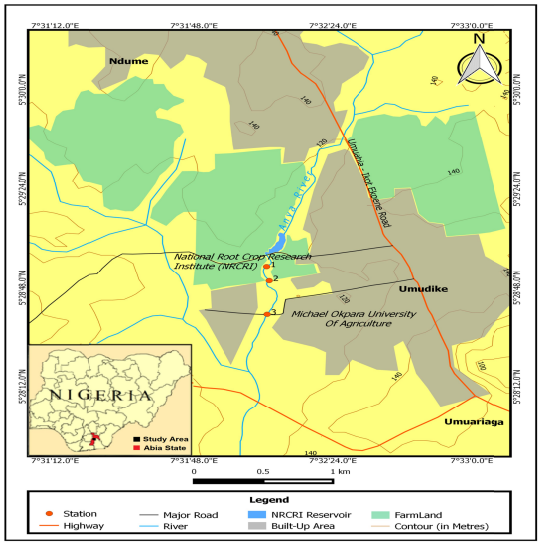

Figure 1: Anya River, Umudike, South East, Nigeria showing the Sampling Stations (Google, 2016).

Umudike is a sub-urban community located 9 – 10 km east of Umuahia, the capital of Abia State, Nigeria. The study was carried out during the wet season in three stations. The station 1 was the control station; located within the National Roots Crop Research Institute, Umudike. Human activities were very minimal around the station (a cocoyam farm). The substratum was sandy and stony. The dominant vegetations were elephant grass (*Pennisetum purpureum*) and water lettuce (*Pistia stratiotes*). The station 2 was located 160 metres downstream of station 1; within the Michael Okpara University of Agriculture, Umudike, close to the University Fish Farm. Stormwater from parts of the University is discharged into the stream at this point. The substratum was muddy and the water was slow-flowing with high transparency. There was luxuriant growth of ferns (*Diplzium sammatii*) and algae around the station. The station 3, 385 metres downstream of station 2, was also located within Michael Okpara University of Agriculture, Umudike close to the Female Hostel. Substratum was muddy and the water was swift- flowing with low transparency. The vegetation included elephant grasses (*Pennisteum purpureum*), water lettuce (*Pistia stratiotes*), palm trees (*Elaeis guineenis*) and fan palm (*Hyphaene petersiana).* Flash flood and wastewater from a greater part of the University environment are discharged at this point. Other human activities observed include washing of cars and motorcycles.

Water: Water samples were collected from Anya River on monthly basis from June to August 2015. The samples were stored in sterilized 1 litre plastic bottles and then taken to the laboratory for analysis. The physicochemical parameters were analysed using standards methods described by APHA (1998). The parameters analysed were air and water temperatures, pH, electrical conductivity, total dissolved solids (TDS), dissolved oxygen, biochemical oxygen demand, salinity, nitrate and phosphate.

Aquatic Insects: At each sampled points, adult insects were collected from water surface

using a dip-net of 500 µm mesh. Adult insects and their nymph were also collected from the vegetation around the stations using a sweep net with a mesh size of 250 µm. The sweep net was passed over the area against the current, for at least two minutes; dislodged insects are washed into the net by the current. 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 microhabitats around the stations. Any non-aquatic insects caught were immediately returned to the water. Insects collected were later preserved in 7 % formalin in plastic containers labelled according to sample point, description and collection date. All samples collected taken to the Entomology Laboratory and identified to species level using relevant aquatic arthropod taxonomic keys (Pennak, 1978; Merritt and Cummins, 1996; Needham *et al.*, 2000; Heckman, 2002).

Statistical Analysis: One-Way Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physicochemical parameters of the three sampling stations. Turkey Pairwise test was also used for multiple comparisons of the means of the physicochemical parameters in order to identify the source of variation. Margalef's Diversity (D) and Shannon-wiener's diversity (H) indices were used to determine species richness and diversity. Evenness index (E) was used to observe the evenness of the species distribution to the maximum.

RESULTS

Water: The summary of the physico-chemical parameters is recorded in Table 1. The air temperature value ranged between 27.0^{o}C and 28.5^{o}C. The lowest air temperature value was recorded in Station 1 in August 2015, while the highest air temperature value was recorded in station 2 in June 2015. ANOVA test showed that Station 1 was significantly different ($F = 6.51$, $p < 0.05$) from the other stations. The water temperature value ranged between 26.0^{o}C and 27.8^{o}C. The lowest water temperature value was recorded in station 2 in June 2015 while the highest water temperature value was recorded in station 1 in July 2015. ANOVA test showed that there was no significant difference in water temperature ($F = 0.11$, $p > 0.05$) in all the stations.

The pH value recorded during the study period ranged between 5.28 and 7.13. The lowest pH value (5.28) was recorded in station 2 in August 2015 throughout the sampling period while the highest pH (7.13) was recorded in station 1 in June 2015. ANOVA test showed that Station 2 was significantly different ($F=9.87$, $p<0.05$) from the other stations.

The electrical conductivity value ranged between 13.5 and 28.1 µS/cm. The lowest conductivity value was recorded in Station 1 in August 2015, while the highest conductivity was recorded in Station 2 in June 2015, throughout the study period. ANOVA test showed that Station 1 was significant different ($F=292.6$, $p<0.05$) from the other stations.

The total dissolved solids (TDS) value ranged between 8.0mg/l and 18.5mg/l. The lowest TDS value was recorded in station 1 in June 2015 while the highest TDS value was recorded in station 3 in July 2015. ANOVA test showed that station 1 was significantly different ($F = 2500.8$, $p<0.05$) from the other stations.

The dissolved oxygen (DO) value ranged between 6.2 and 7.2 mg/l. The lowest DO value was recorded station 2 in August 2015, while the highest DO was recorded in station 1 in June 2015 throughout the study period. ANOVA test showed that Station 1 was significantly different ($F=20.8$, $p<0.05$) from the other stations.

The biochemical oxygen demand (BOD) value ranged between 1.8 mg/l and 2.3 mg/l. The lowest BOD values were recorded station 1 (July 2015) and station 2 (June and August 2015), while the highest BOD values were recorded in station 2 (July 2015) and station 3 (June 2015) throughout the study period. ANOVA test showed that there was no statistical difference ($F=0.64$, $p>0.05$) in all the stations. The salinity value ranged between 5.3 and 13.8 mg/l. The lowest salinity value was recorded station 1 in August 2015, while the highest salinity was recorded in station 3 in July 2015 throughout the sampling period.

Table 1: Summary of preliminary survey of physico-chemical characteristics of Anya River, Umudike, Abia State, Nigeria

Parameters	Station 1	Station 2	Station 3	F-value	FME
Air temperature (°C)	27.4±0.37[a] (27.0-28.2)	28.4±0.03[b] (28.4-28.5)	28.4±0.67[b] (28.3-28.5)	6.51*	<35
Water temperature (°C)	27±0.49 (26.1-27.8)	26.7±0.35 (26.0-27.1)	26.7±0.55 (25.7-27.5)	0.11	<35
pH	7.08±0.04[b] (7.0-7.13)	5.81±0.27[a] (5.28-6.18)	6.45±0.21[b] (6.03-6.73)	9.87*	6.5-8.5
Conductivity (µS/cm)	13.7±0.16[a] (13.5-13.9)	27.3±0.66[b] (26.0-28.1)	20.1±0.18[b] (19.9-20.5)	292.6*	1000
Total Dissolved Solid(mg/l)	8.1±0.1[a] (8.0-8.3)	14.9±0.08[b] (14.8-15.1)	18.2±0.12[b] (18.1-18.5)	2500.8*	250
DO (mg/l)	7.1±0.06[a] (7.0-7.2)	6.3±0.09[b] (6.2-6.5)	6.7±0.1[b] (6.5-6.8)	20.8*	>4.0
BOD (mg/l)	1.97±0.09 (1.8-2.1)	1.97±0.17 (1.8-2.3)	2.13±0.09 (2.0-2.3)	0.64	40
Salinity (mg/l)	5.5±0.15[a] (5.3-5.8)	12.4±0.09[b] (12.3-12.6)	13.5±0.18[b] (13.2-13.8)	917.7*	NS
Nitrate (mg/l)	0.27±0.02 (0.23-0.30)	0.46±0.11 (0.25.0.58)	0.51±0.07 (0.37-0.6)	2.93	40
Phosphate (mg/l)	0.42±0.3 (0.11-1.01)	0.28±0.04 (0.19-0.33)	0.60±0.34 (0.23-1.28)	0.39	5

Means with different superscript in a row shows significant difference (p<0.05) indicated by Turkey Pairwise test, with range in parenthesis

Table 2: Aquatic insects composition and distribution of Anya River, Umudike, Abia State, Nigeria

Aquatic Insects	Stations			Total
	1	2	3	
Coleoptera				
Dicranopselaphus variegatus	35	-	-	35
***Hydrophilus* sp**	-	-	30	30
Hemiptera				
Lethocerus americanus	12	-	-	12
Aquarius remigis	-	18	35	53
Odonata				
***Anax* sp**	-	19	-	19
***Enallagma* sp**	-	8	-	8
Diptera				
***Chironomus* sp.**	-	28	-	28
Total	47	73	65	185

Table 3: Diversity and other indices of aquatic insects in the study stations of Anya River, Umudike, Abia State, Nigeria

Ecological Indices	Stations		
	1	2	3
Number of Individuals	47	73	65
Number of Species	2	4	2
Margalef's Index (d)	0.259	0.699	0.239
Shannon-Wiener Index (H)	0.568	1.305	0.690
Evenness Index (E)	0.883	0.922	0.997

ANOVA test showed that station 1 there was significantly different (F=917.7, p<0.05) from the other stations. The nitrate value ranged between 0.23 and 0.60 mg/l. The lowest nitrate value was recorded in station 1 in August 2015 while the highest nitrate value was recorded in station 3 in June 2015. ANOVA test showed that there was no significant difference (F = 2.93, p>0.05) in all the stations.

The phosphate value ranged between 0.11 mg/l and 1.28 mg/l. the lowest phosphate value was recorded in station 1 in June 2015 while the highest phosphate value was recorded in station 3 in August 2015. ANOVA test showed that there was no significant difference (F = 0.39, p>0.05) in all the stations.

Aquatic Insects: The overall insect composition, abundance, and distribution were presented in Table 2. Seven (7) taxa were identified from the sampled stations. A total of 185 individuals were collected during the sampling period. Insect's percentage composition of 25.4, 39.5 and 35.1 %, were recorded for Stations 1, 2 and 3, respectively. Diversity, taxa richness and evenness indices of various insects collected during period of sampling were shown in Table 3.

DISCUSSION

The water quality status of the Anya River was significantly different in the three stations sampled except for Nitrate, phosphate, BOD and Water temperature. All the physico-chemical parameters are within acceptable limits except pH in Station 2. The physico-chemical qualities of water and food availability are important factors affecting the abundance of aquatic insects (Rueda *et al*., 2002; Nelson and Roline, 2003; Zabbey and Hart, 2006). The increased human activities in Station 3 and wastewater discharges probably led to increase in BOD, TDS, phosphate, nitrate, salinity and decrease in DO at that site. Human activities and discharges in Station 2 also probably led to increase in electrical conductivity and decrease in pH and dissolved oxygen. The low values of DO concentration recorded in Stations 2 and 3, is an indication of deterioration of the water quality as a result of various anthropogenic activities in the stations (Oku *et al*., 2014). Previous studies has shown that intense human activities resulting from discharge of organic pollutants into streams lead to increase in nutrients levels and in biochemical oxygen demand which in turn affects the distribution and abundance of aquatic insects (Atobatele *et al*., 2005; Zabbey and Hart, 2006; Arimoro *et al*., 2007 a,b).

The 7 taxa of aquatic insects recorded in this study was poor compared with 13 taxa reported by Popoola and Otalekor (2011) in Awba Reserviour, 18 taxa reported by Oku *et al.* (2014) in Great Kwa River and 19 taxa reported by Edegbene *et al.* (2015) in River Chanchaga, Niger State, Nigeria. Hemipterans were the most abundant group in this study. This was in line with the works of Huang *et al.* (2010) in the Du river Basin in Northern Vietnam, Takhelmayum *et al.* (2013) in the Lower Reach of River Moirang, Manipur, North East India, Oku *et al.* (2014) in Great Kwa River, Southern Nigeria and Barman and Gupta (2015) in Bakuamari Stream, Chakras Hila Wildlife Sanctuary, Assam, North East India.

This is because most hemipterans are tolerant of pollution (Voshell, 2009). Station 2 had better taxa richness and diversity indices than stations 1 and 3. The plausible reason for this is that there are no human activities except stormwater discharge there. Furthermore, the general water conditions of station 2 (good dissolved oxygen, low BOD and moderate amount of nutrients) may have translated to high biodiversity indices at that station. Station 3 had better species evenness (0.997) than Stations 1 and 2. Anya River recorded a low abundance of aquatic insects. This study therefore addresses the need for more intensive study on the entire length of the river to fully comprehend the general fauna assemblages of the river.

ACKNOWLEDGMENTS

The second and third authors thanked the Department of Zoology and Environmental Biology for the provision of research facilities used for the study, but regrets the death of the first author in a ghastly motor accident in 2016.

REFERENCES

APHA (1998). *Standard Methods for Exanimation of Water and Waste Water*. 20th Ed. American Public Health Association, Washington, D.C.

ARIMORO, F. O. and IKOMI, R. B. (2009). Ecological integrity of upper Warri River, Niger Delta using aquatic insects as bioindicators. *Ecological Indicators*, 9: 455 – 461.

ARIMORO, F. O., IKOMI, R. B. and EREBE, E. (2007a). Macroinvertebrate community diversity in relation to water quality status of River Ase, Niger Delta, Nigeria. *Journal of Fisheries and Aquatic Science,* 2(5): 337 – 344.

ARIMORO, F. O., IKOMI, R. B. and IWEGBUE, C. M. A. (2007b). Water quality changes in relation to Diptera community patterns and diversity measured at an organic effluent impacted stream in the Niger Delta, Nigeria. *Ecological Indicators,* 7: 541 – 552.

ATOBATELE, O. E., MORENIKEJI, O. A. and UGWUMBA, O. A. (2005). Spatial

variation in physical and chemical parameters of benthic macroinvertebrate fauna of River Ogunpa, Ibadan. *The Zoologist,* 3: 58 – 67.

BARMAN, B. and GUPTA, S. (2015). Aquatic insects as bio-indicator of water quality: A study on Bakuamari stream, Chakras hila Wildlife Sanctuary, Assam, North East India. *Journal of Entomology and Zoology Studies,* 3(3): 178 – 186.

BROOKS, T. M., MITTERMEIER, R. A., DA FONSECA, G. A. B., GERLACH, J., HOFFMANN, M., LAMOREUX, J. F., MITTERMEIER, C. G., PILGRIM, J. D. and RODRIGUES, A. S. L. (2006). Global biodiversity conservation priorities. *Science*, 313(5783): 58.

BUSS, D. F., BAPTISTA, D. F., NESSIMAIN, J. L. and EGLER, M. (2004). Substrate specificity, environmental degradation and disturbance structuring macroinvertebrate assemblages in neotropical streams. *Hydrobiologia,* 518(1- 3): 179 – 188.

DELIZ-QUINONES, 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,* Suan Juan.

DOBSON, M., MAGANA, A., MATHOOKO, J. M. and NDEGWA, F. K. (2002). Detitivores in Kenyan highland streams: more evidence for the paucity of shredders in the tropics? *Freshwater Biology*, 47: 909 – 919.

EDEGBENE, A. O., ARIMORO, F. O., ODOH, O. and OGIDIAKA, E. (2015). Effect of anthropogenicity on the composition and diversity of aquatic insects of a municipal river in North Central Nigeria. *Biosciences Research in Today's World,* 1(1): 55 – 66.

GOOGLE (2016). Map of River Anya, Umudike, Abia, State, Nigeria. https://www.google.com.ng/ maps/@5.5140395,7.2359965,11.75z Accessed June 23, 2016.

HECKMAN, C.W. (2002). *Encyclopaedia of the South American aquatic insects: Ephemeroptera*. Kluwer Academic Publishers, Norwell, MA 02061, USA.

HUANG, T. H., LOCK, K., CHI DANG, K., DE PAUW, N. and GOETHALS, P. L. M. (2010). Spatial and temporal patterns of macroinvertebrate communities in the Du river Basin in Northern Vietnam. *Journal of Freshwater Ecology*, 25: 637 – 647.

HYNES, H. B. N. (1970). *The Ecology of Running Waters.* University of Toronto Press, Toronto, Canada.

KOPERSKI, P. (2010). Diversity of macrobenthos in lowland streams: Ecological determinants and taxonomic specificity. *Journal of Limnology,* 69(1): 88 – 101.

MAFUYAI, H. B., WADE, J. W., AGOOM, A. K. and AUDU, B. S. (2004). Aquatic insect composition at a *Simulium* breeding site on the River Assop, Plateau State, Nigeria. *Journal of Aquatic Science*, 19(1): 9 – 15.

MERRITT, R. W. and CUMMINS, K. W. (1996). *An Introduction to the Aquatic Insects of North America*. 3rd Edition, Kendall-Hunt, Dubuque, Iowa, USA.

NEEDHAM, J. G., WESTFALL, M. J. and MAY, M. L. (2000). *Dragonflies of North America*. Revised Edition, Scientific Publishers Incorporated, Gainesville, Florida, USA.

NELSON, S. M. and ROLINE, R. A. (2003). Effects of multiple stressors on the hyporheic invertebrates in a lotic system. *Ecological Indicators,* 3: 65 – 79.

OKU, E. E., ANDEM, A. B., ARONG, G. A. and ODJADJARE, E. (2014). Effect of water quality on the distribution of aquatic entomofauna of Great Kwa River, Southern Nigeria. *American Journal of Engineering Research,* 3(4): 265 – 270.

PAYAKKA, A. and PROMMI, T. (2014). Aquatic insects biodiversity and water quality parameters of receiving water body. *Current World Environment,* 9(1): 53 – 58.

PENNAK, R. W. (1978). *Freshwater Invertebrates of the United States*. 2nd

Edition, John Wiley and Sons, New York, USA.

POPOOLA, K. O. AND OTALEKOR, A. (2011). Analysis of aquatic insects' communities of Awba Reservoir and its physico-chemical properties*. Research Journal of Environmental and Earth Sciences,* 3(4): 422 – 428.

ROSENBERG, D. M. and RESH, V. H. (1993). *Freshwater Bio-monitoring and Benthic Macroinvertebrates*. Chapman and Hall, New York.

RUEDA, J., CAMACHO, A., MEZQUITA, F., HERNANADEZ R. and ROCA, J. R. (2002). Effect of episodic and regular sewage discharge on water chemistry and macroinvertebrate fauna of a Mediterranean stream. *Water, Air and Soil Pollution*, 140: 425 – 444.

TAKHELMAYUM, K., GUPTA, S. and SINGH, N. R. (2013). Diversity and density of aquatic insects in the lower reach of River Moirang, Manipur, North East India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences,* 83(4): 575 – 584.

UGBOGU, S. S. and AKINYA, T. O. (2001). Distribution and abundance of insect orders in relation to habitat types in Opa stream-reservoir system, Nigeria. *Journal of Aquatic Science*, 16(1): 7 – 12.

VOSHELL, J. R., Jr. (2009). *Aquatic Insect Biodiversity and Conservation.* Virginia Cooperative Extension, Publication 420-531. *www.ext.vt.edu*. 1 – 8.

WALLACE, J. B. and WEBSTER, J. R. (1996).The role of macroinvertebrates in stream ecosystem function. *Annual Review of Entomology*, 41: 115 – 139.

WARD, D., HOLMES, N. and JOSÉ, P. (1995). *The New Rivers and Wildlife Handbook*. RSPB, NRA. The Wildlife Trusts, Bedfordshire.

WHILES, M. R. and WALLACE J. B. (1997). Leaf litter decomposition and macroinvertebrate communities in headwater streams draining pine and hardwood catchments. *Hydrobiologia,* 353(1-3): 107 – 119.

WOODCOCK, T. S. and HURYN, A. (2007). The response of macroinvertebrate production to a pollution gradient in a headwater stream. *Freshwater Biology,* 52(1): 77 – 196.

ZABBEY, N. and HART, A. Z. (2006). Influence of some physicochemical parameters on the composition and distribution of benthic fauna in Woji Creek, Niger Delta, Nigeria. *Global Journal of Pure Applied Science*, 12(1): 1 – 5.