

Effect of physicochemical properties of water on aquatic insect communities of a stream in Nnamdi

Azikiwe University, Awka Nigeria

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Abstract

This study was conducted to evaluate the influence of some water quality parameters on the aquatic insects of a rainforest stream in Nnamdi Azikiwe University, Nigeria. Sampling of the stream and aquatic insects was conducted weekly in the wet season, from May through June, 2013 in three stations. The results showed that the pH of all sampling stations was neutral, dissolved oxygen was highest at station 2 (12.93 ± 0.19) and station 3 recorded the highest conductivity, turbidity and TDS. Analysis of variance showed that there was a significant difference in the physico-chemical properties between sampling stations. The insects' abundance seems to be influenced by substrate, physiological and morphological adaptation, current velocity and turbidity. The physico-chemical properties and Margalef index of water quality shows that the quality of a water body has a role to play in the abundance, diversity and distribution of aquatic insect.

Keywords: aquatic insects, unizik stream, physicochemical water quality

1. Introduction

Contamination occurring in water bodies affects the physicochemical properties such as pH, temperature, conductivity, nutrients and metals, turbidity, dissolved oxygen, velocity, water depth and many others. The degree of contamination differs with different water bodies and thus plays a vital role in determining the diversity of organisms that can live in them (Bellingham, 2013) [6].

Ajogwu (2010) [3] reported that the concentration of nutrients in a river or stream is determined by the interplay of the magnitude, timing and bioavailability of the nutrients, rate of water supply compared with the volume of the stream (flushing) and depth of the stream. Many of the substances dissolved in fresh waters are known to cause disturbances in the population levels of aquatic animal communities (Popoola and Otalekor, 2011) [24]. The presence of low dissolved oxygen indicates presence of high carbon dioxide and leads to low population of aquatic insects (Latimore, 2012) [19]. Water pH is also known to affect population levels of aquatic organisms. For example some insects especially pollution sensitive insects can thrive well in water of pH range 6.5 - 7.5 and thus variation in this water parameter greatly influences the distribution pattern of these aquatic insects (Popoola and Otalekor, 2011) [24].

Studies have also been carried out on the physicochemical properties of some Nigerian waterways (Asonye *et al.*, 2007; Essien-Ibok *et al.*, 2010; Obafemi, 2008; Agbaire and Obi, 2009) [4, 11, 21, 2]. There are few documented data on the impact of anthropogenic activities on the physicochemical properties of the Unizik stream (Obiakor, 2010) [22] and little or no study has been done on the relationship between the physicochemical properties and aquatic insect diversity of the Unizik stream. This study therefore becomes imperative to assess the physicochemical properties of the water body in relation to the aquatic insects' diversity and abundance in the university campus.

2. Materials and Methods

Description of Study Area

The study area is a lotic freshwater body that flows within the Nnamdi Azikiwe University Premises, Awka. Awka is located in the lowland rain forest zone of Southern Nigeria. Awka is located between latitude 5° and $6^{\circ}25'N$ and longitude $007^{\circ}E$ and $008^{\circ}E$ (Obiakor, 2010) [22]. It lies at an altitude between 46m - 48m above sea level. It empties its content into the Amansea River at Amansea village in Awka North L.G.A of Anambra state of Nigeria. Three sampling stations were selected to represent different environments and ecological variation within the stream; Station 1 was located close to the Unizik old gate, adjacent to the Unizik block industry, Station 2 was located close to the laboratory complex at the Science Village, Sampling Station 3 was located close to the old Law Faculty (now the Unizik high school).

Water Samples Collection and Analysis

The sampling period spanned from May through June for a period of 8 weeks. Sampling was carried out between 8:00am and 12:00pm. Water samples were collected weekly from each sampling points with 1000 ml plastic container, thoroughly washed with detergent and rinsed repeatedly (3 times) to ensure it was free from contaminants. 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. Water velocity was estimated at each sampled point using a Fisherman's floater on the water and the time it took to travel 5m distance was recorded using a stopwatch. The average of three determinations was recorded in m/s. Nitrate-nitrogen (NO_3-N) was determined using PD303 UV Spectrophotometer. Dissolved oxygen (D.O) was determined using Winkler's titrimetric method. Turbidity was determined using a Labtech® digital turbidity meter (Model AVI038). Non

conservable parameters temperature, pH and conductivity/TDS were determined and recorded *in situ* with a mercury in glass thermometer, HANNA pHep® pocket-sized pH meter and HANNA DiST conductivity/TDS meters (HI96303, EC-3) respectively.

Aquatic Insects Sampling and Identification

At each sampling station, aquatic insects were collected using a dip-net with a mesh size of 200mm. The contents collected were put in a sorting bucket and the net was properly checked for insects clinging on the mesh. Insects collected were preserved in 70% ethanol in specimen bottles labeled according to the sample stations, description and collection date. Sediments were collected and emptied into labeled polythene bags and taken to laboratory for washing. The washed samples were sieved separately through a sieve with mesh size of 0.5mm 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 2cm×4cm vials containing 10% formalin solution for keeps in the laboratory. Aquatic arthropods taxonomic keys (Hickman *et al.*, 2008; Kentucky, 2013; Hadley, 2013; Kellogg and Kellogg, 1994; Edelman, 1993; Abowei and Ukoroije, 2012) [13, 16, 12, 15, 8, 1] were used to identify the collected specimens to family level.

Statistical Analysis

The total number of aquatic insect species was calculated for each sampling station and Margalef’s Diversity Index (D) was used to determine species richness. The species abundance and diversity was calculated using Shannon-Wiener’s diversity index. Shannon’s equitability (E) was used to measure the evenness of the community. Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physicochemical parameters of the three sampling stations.

3. Results

Water Sample Physicochemical Parameters

The results showed that the pH of all the three sampling stations ranged from 6.95 to 7.39; an indication of neutrality. The water temperature ranged from 26.57 ±0.83 in station 1 to 27.25 in station 2 and 3. There was a wide range of data in the conductivity of water as station 3 (123.75±7.44) >stations 2(80.00±13.09) > station 1(23.75±5.18). Turbidity was highest at station3 (140.25±7.6) and least at station 2(128.88±1.73). Dissolved oxygen was highest at station 2(12.93±0.19) and least at station 3 (6.71±2.07). Nitrates was least at station 1(11.38±0.72) and highest at station 3(12.55±0.68). Velocity was highest at station 2(0.25±0.03) and lowest at station 3(0.21±0.03). As with conductivity, there was also a wide range of data in the TDS of the water as station 3 (79.20±4.76) > stations 2 (51.20±8.38) > stations 1(15.20±3.31).

Table 1: Mean values of the physico-chemical parameters at the three sampling stations in Unizik stream, Awka Nigeria.

	Stream Sampling stations		
	Station 1 (Old Gate)	Station2 (Science Village)	Station3 (Law Faculty)
Physiochemical Properties	Mean ± Std	Mean ± Std	Mean ± Std
pH	7.04±0.42	6.95±0.33	7.39±0.16
Temperature (°C)	26.57±0.83	27.25±1.41	27.25±0.90
Conductivity(µS/cm)	23.75±5.18	80.00±13.09	123.75±7.44
Turbidity (NTU)	129.75±2.25	128.88±1.73	140.25±7.36
Dissolved Oxygen (mg/l)	10.08±1.17	12.93±0.19	6.71±2.07
Nitrates (mg/l)	11.38±0.72	12.09±0.33	12.55±0.68
Velocity (m/sec)	0.24±0.03	0.25±0.03	0.210±0.03
TDS (mg/l)	15.20±3.31	51.20±8.38	79.20±4.76

Table 2: Analysis of variance of the physicochemical properties of Unizik stream sampled at three sampling stations for eight weeks.

	Sum of Squares	df	Mean Square	F-cal value	F-Critical @ 5%
Between Streams	15081.339	2	7540.670	3.620	3.00
Within Streams	393736.306	189	2083.261		
Total	408817.645	191			

Aquatic Insects Sampling and Identification

The overall insect composition, abundance, and distribution from the sampled points are summarized in Table 3. Twelve (12) insect taxa were identified from a total of 177 individuals collected during the sampling period. The percentage composition of 49.7, 19.2 and 31.1%, were recorded for station1, station 2 and station 3, respectively. Diversity, taxa richness and dominance indices of various insects collected during period of sampling are shown in Table 4.

Table 3: Aquatic Insects Sampled in the Study Site and their Relative Abundance

Aquatic Insects	Number of individuals			
	Station 1	Station 2	Station 3	Total
Coleoptera				
Gyrinidae (whirlgig beetle)	7	2	5	14
Hydrophilidae (water scavenger beetle)	2	1	1	4
Elmidae (riffle beetle)	4	2	5	11
Diptera				
Chironomidae (bloodworms)	30	10	12	52
Culicidae (mosquito larva)	2	4	4	10

Tabanidae (horsefly larva)	4	3	2	9
Odonata				
Lestidae (spread-winged damselfly)	3	1	2	6
Libellulidae (skimmer-dragonfly)	5	2	6	13
Hemiptera				
Gerridae (pond skater)	15	4	10	29
Veliidae (riffle bugs)	6	2	2	10
Ephemeroptera				
Beatisidae (armoured mayfly larva)	7	2	3	12
Plecoptera				
Perlidae (stonefly)	3	1	3	7
Total	88	34	55	177
% Composition	49.7%	19.2%	31.1%	100%

Table 4: Diversity and Other Indices of Aquatic Insects in the Sampling Station of Unizik Stream

Sampling Stations			
	1	2	3
No. of Taxa	12	12	12
No. of individuals	88	34	55
Magalef's index	2.46	3.01	2.74
Shannon Weiner index (H)	2.10	2.22	2.26
Shannon Weiner equitability (E)	0.8453	0.8943	0.9103

4. Discussion

Physicochemical Parameters

Water depth depended on the amount of rainfall, the degree of heterogeneity of stream bed and silt deposition. Sampling stations 1 and 3 had average depths of 47.5cm and 55cm but station 2 was shallow with a depth of 20 cm. It was observed that depth tends to increase downstream.

Variation in flow is responsible for temporary reduction in macroinvertebrates abundance and diversity. Increasing current velocity results in more turbulence thus high oxygen diffusion, allowing cold stenothermic taxa to survive in warm water. Water flow velocity of the Unizik stream ranged between an average of 0.21- 0.25m/sec with the strongest flow (0.25m/sec) at station 2 and weakest flow (0.21m/sec) at station 3; this agrees with the studies carried out by Essien-Ibok *et al.*, (2010) ^[11], that high flow velocity are usually more prominent during the rainy season. Popoola and Otalekor (2011) ^[24] pointed out that water flow velocity is directly and indirectly important as it influences the river-bed and the amount of silt deposition which in-turn affects the distribution of benthic organisms.

Average water temperature showed similar values at station 2 and station 3 and lower temperature at station 1. These values fall within the optimal range for tropical fresh waters temperature values ranging from 21 to 32°C as reported by Popoola and Otalekor (2011) ^[24] and Edema *et al.*, (2002) ^[9]. The recorded temperature range was as a result of low solar radiation due to the shade provided by the vegetation surrounding the stations. Inflow of run-off water into the stream also causes a reduction in temperature. Studies carried out by Thani and Phalaraksh (2008) ^[26], show that differences in water temperature in a stream may depend on the climate and environment near the stream as well as sampling time, wind, water mixing and the amount of sunlight; they also pointed out that water temperature affects the number of aquatic insects since each species requires specific temperature range to survive because of their different respiratory rate and metabolism.

Average conductivity was generally low at station 1, moderate at station 2 and station 3 had distinctively high value. High conductivity at station 3 may be attributed to the drainage system which empties into the stream and this agrees with the studies carried out by Thani and Phalaraksh (2008) ^[26] at the Mekong River; as high conductivity recorded were attributed to high rate of soil erosion, high ions dissolved in water and discharge of wastewater into the stream. Similarly, average TDS was generally low at station 1, moderate at station 2 and station 3 had a distinctively high value of 79.20mg/l.

Unizik stream water average pH during the study ranged from 6.95 – 7.4. These pH values obtained ranged from relatively neutral to slightly alkaline. This agrees with the findings of Essien-Ibok *et al* (2010) ^[11] on a project carried out at Mbo River Nigeria; where pH values ranged from 6.6 – 7.3 and was considered normal for unpolluted freshwater. Likewise, the pH was known to increase during the rains as a result of dilution of chemical substances by increased base flow. This agrees with the findings of Li and Jackson (2003) ^[20] and Essien-Ibok *et al* (2010) ^[11].

Dissolved oxygen (DO) concentrations ranged from an average value of 6.7 mg/l – 12.9 mg/l, with station 3 having the lowest DO value and station 2 having the highest value. Dissolved oxygen concentration in the Unizik stream was inversely related to temperature change. This observation agrees with the findings of Li and Jackson (2003) ^[20], Edema *et al* (2002) ^[9] and Popoola and Otalekor (2011) ^[24]; they reported that temperature increase brings about a decrease in DO concentrations which may be due to respiration and other processes such as breakdown organic matters. The low value of DO recorded in station 3 may be attributed to contamination from waste water, poor aeration and low flow velocity; and this observation is in agreement with the findings of Thani and Phalaraksh (2008) ^[26]. Essien-Ibok *et al.*, (2010) ^[11], points out that dissolved oxygen are usually higher in wet season due to increased current flow and this agrees with the observation at the Unizik stream. On the other hand, Critical values of less than 3ppm were not observed during the observation period.

Average nitrates levels ranged from 11.38 – 12.55 mg/l. Station 3 recorded higher values in nitrates indicating significant input of organic discharge in the area. Input of nutrients (eutrophication) promotes excessive algae growth, thus depleting the level of available dissolved oxygen as well as being an important factor in the distribution and abundance of Diptera species especially *Chironomus* species which are pollution tolerant species. This observation was consistent with Popoola and Otalekor (2011) ^[24] wherein dipterans (*Chironomus*, *Culex* species) were abundant in nutrient

enriched stations of Awba reservoir.

Turbidity was highest at station 3 and least at station 2. The high turbidity at station 3 accounts for less hemiptera and coleopteran species found at station 3 as increases turbidity tends to impair their predatory activities. This collaborates with the findings of Kerr (2000)^[17] and De Lange (2012)^[7]. Results by analysis of variance showed that there was significant difference in the physico-chemical parameters between the three sampled stations.

Species Diversity and Distribution

Human and natural stream disturbance results in changes to the diversity of aquatic insects, in terms of the number of taxa and the most abundant group ranking. The number of taxa recorded is low in contrast to what is obtainable from other stream with similar bio-geographical zone; which is due to unfavourable conditions within the stream. Ibemenuga and Inyang (2006)^[14] reported on good water quality and food supply; as factors that influences the survival, growth and abundance of the macroinvertebrates fauna in a stream.

A total of 177 aquatic insects individuals were collected over the sampling period with the highest number of individuals found at station 1. The individuals belong to 6 orders and 12 families. Percentage composition was highest at station 1 followed by station 3 and lowest was recorded at station 2. Fig According to the studies carried out by Ibemenuga and Inyang (2006)^[14], the distribution of animals among available habitat is generally mediated by water velocity, immediate substratum of occupation, food availability, predation intensity and tolerance of the physico-chemical conditions of the system. Station 2 had less insects present due to the stony substratum and this is in agreement with the report of Ogbobu and Akinya (2001) that stones usually had little or no insects. Chironomids require a substratum with high organic matter content as well as preferring muddy bottom to sandy bottom; occurring more at Station 1 and 3 with muddy bottom, this is in accordance with the findings of Edema *et al.*, (2002)^[9]. Aquatic coleopterans are widely distributed in streams and ponds with organic detritus as observed in station 1 and 3 and this is in accordance with the findings of Elliott (2008)^[10]. He also points out that high flow velocity resulting from sudden or severe spates (rainfall) can have detrimental effect to the coleopterans as observed at station 2.

Hemipteran species were the second widely distributed insects around the stream; Berchi *et al.*, (2011)^[5] points out that difference in pH and dissolved oxygen have no detectable effect on the occurrence of species but physical condition of the habitat (size, depth of stream and temperature) tends to affect their distribution. He also points out that aquatic Hemipterans tend to be more distributed in habitat of standing or slow moving water as observed in Station 1 and 3.

Insects communities found within the three stations had a Shannon weaver index of 2.10, 2.22 and 2.26 respectively and this represent a relatively diverse and well distributed community and agree with the findings of Kerkhoff (2010)^[18] that typical values are generally between 1.5 and 3.5 and rarely greater than 4. Station 2 had the highest Margalef index of 3.01 with station 1 having the least value of 2.46.

In general, the distribution of individuals throughout the stream tends to be relatively low; studies carried out by Supatra and Sanchai (2012) show that individuals were very relatively low during the rainy season than during the dry season; resulting

from substrate disturbance by floods.

Aside biotic factors, the quality of a water body has a role to play in the abundance, diversity and distribution of aquatic insect. Thus, conservation measures should be implemented in order to improve the quality and health status of the Unizik stream, encouraging high diversification of the fauna found wherein.

5. References

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