The Physico-Chemistry and Benthic Macro-Invertebrate Diversity and Abundance of Nwaniba River, Akwa Ibom State, Nigeria

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ARTICLE INFO

Abstract

The physico-chemical parameters and benthic macro-invertebrates’ diversity and abundance of Nwaniba River in Akwa Ibom State were studied between October, 2014 and January, 2015. Surface water samples and benthic macro-invertebrate samples were collected from six (6) sampling stations according to standard methods. The mean values of the measured water parameters were: Temperature (28.31±0.41) °C, Dissolved Oxygen (3.74±0.17) mg/l, Conductivity (16.41±1.80) µs/cm, Salinity (0.028±0.001) ppt, Total Dissolved Solids (15.75±4.53) mg/l and pH (6.9±0.12). A total of 7 macro-invertebrate species belonging to 3 classes were encountered in the following order of abundance: Insecta (55.0%), Mollusca (40.0%) and Annelida (5.0%). The most abundant species were Chironomus spp and Neritina cristata accounting for 8 (40.0%) and 5 (25%) respectively. Whereas Segmentoribis augustus, Neritina rubricata, Pachymelania byronensis and Tubifex tubifex were the least abundant with 1 (5%) organism each. The low abundance of benthic macro-invertebrates species and the total absence of the EPT indexed taxa, relative to a higher abundance of a pollution indexed taxa (Chironomus spp) may directly indicate the pollution stress level of this Nwaniba River system. Hence, there is need for pollution management of this river.

Keywords: Physico-chemical, Benthic, Macro-Invertebrate, Diversity, Nwaniba River.

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A B S T R A C T

1. INTRODUCTION

It is needless to emphasize on the importance of water in our daily lives, as water used for different purposes has its own requirements for its physico-chemical composition and purity. The physical and chemical characteristics of water are often used as measures for determining its quality and purpose. The functioning of an aquatic ecosystem and its ability to support life forms depends to a great extent, on its physical, chemical and biological characteristics (Bunn et al., 1999).

The consideration of water quality is important in wetland studies because of a host of interacting physical, chemical and biological factors which may influence the trophic structure, biomass (Hellawell, 1986), and consequently its suitability for the distribution and diversity of indigenous organisms (Swingle, 1967). According to Sala et al. (2000), biodiversity loss and its effects are predicted to be much greater for aquatic than terrestrial ecosystem, thus wetland ecosystems ought to be analyzed on regular basis to...
confirm their ability to support different aquatic life forms.

In Nigeria, water availability and quality are deteriorating due to climate change and land use activities e.g. petroleum exploration, logging, sewage discharges etc and these activities impacts greatly on the water quality thus introducing hazardous substances that may suppress indigenous populations and diversity of aquatic organisms (UNEP, 1991; Boyer and Grue, 1995). Aquatic organisms offer valuable information regarding their environmental conditions, thus they can be used as tools when evaluating the physical, chemical and biological impacts of their surrounding (Karr and Chu, 1999). This is the reason, benthic macro-invertebrates are important and integral parts of any aquatic ecosystem as they tend to form the basis of the trophic level, and their diversity and abundance greatly depends on the physical and chemical conditions of the substratum (Sharma and Chowdhary, 2011; Chatzinikolaou et al., 2006). Therefore, they may be considered good indicators of water quality because of their susceptibility to various environmental disturbances and tolerance level.

The various human activities in and around Nwaniba River may have some level of impact on the river ecosystem process (such as sedimentation) and the ecology of its indigenous species resulting from both point and non-point pollution sources. Impact of such disturbances on various aquatic species or non-living elements (i.e water quality) may have long term consequences (Edokpayi et al., 2000). Hence, this study aims at using the abundance and diversity of the benthic macro invertebrates of Nwaniba River to assess its health status and exposure to pressures due to pollution stress.

2. MATERIALS AND METHODS

2.1. Study area

Nwaniba River (Figure 1) lies between latitude 5°2’51”N and longitude 8°2’41”E. This location experiences a mean annual rainfall, mean temperature and relative humidity of about 2500mm, 32°C and 75% respectively. Vegetations such as Pennisetum purpuremm, Nypha frutican, Nymphaea lotus and other tropical hydrophytes were found in the study area. The river is used for artisanal fishing, transportation and domestic purposes.

Fig. 1: Map of Nwaniba River showing sampling stations (1-6)

2.2. Measurement of water variables

Surface water parameters were determined fortnightly between October 2014 and January 2015 between the hour of 7:00am and 9:00am. In-situ measurement of water quality parameters were carried out at the study site using appropriate devices withstand
methods (APHA, 1998). The Dissolved Oxygen concentrations were determined using a DO meter (model Harmam DO meter) and the results expressed as mg/l. The pH was measured using an electronic pH meter (Oakton waterproof instruments phlestr10). Water temperatures were measured in (°C) using a digital thermometer embedded in an Extik meter model Extik EC400 which was also used to measure Salinity, Conductivity and TDS respectively.

2.3. Collection of benthic macro-invertebrate samples

Benthic macro-invertebrate samples were collected with a Van-Veen grab. The sediment was poured into polyethylene bags, labeled and taken to the laboratory for analysis. The sampled sediments were poured into a sieve with 0.5mm mesh size for washing, as described by Holme and Mc-Intyre (1984) and George et al. (2009). The residue retained in the sieve was poured into a clean tray for sorting. The sorted macro-benthos was identified, using the guides of Macan (1959) and Edmunds (1978). The numbers were counted and recorded.

2.4. Data Analysis

Water quality and biological data for benthic macro invertebrates were analyzed using quantitative indices to determine central tendency of the measured water quality parameters, the relative abundance and diversity of species and groups, correlation analysis and Canonical correspondence analysis (CCA) using PAST and SPSS softwares versions 3.0 and 17 respectively.

3. RESULTS AND DISCUSSION

3.1. Physico-chemical parameters:

Table 1 shows the spatial variations of Range, Mean and Standard error of physico-chemical parameters of Nwaniba River measured during the study period.

Although the water quality parameters of Nwaniba River were within recommended limits as stipulated by NESREA for tropical aquatic lives, the observed spatial variations of water quality parameters of this river system could be attributed to riparian vegetation cover, and various human activities around the sampling stations.

3.2. Macro benthic invertebrate composition and abundance

A total of 7 species of macro benthic invertebrates belonging to three taxa were encountered (Table 2). The most abundant taxa were Arthropoda with a percentage composition of 55%, while the least was Annelida with percentage composition of 5%. The Chironomus spp. in the class Insecta was the most diverse recording the highest abundance, while Neritina rubricata, Pachymelania bryonensis, Segmentorbis angustus, Tubifex tubifex recorded the least abundance.

3.3 Diversity indices

High values of Shannon-Wiener Index _H were recorded for phylum Arthropoda (1.30) and a value for Annelida (0). Higher values for species Dominance _D were recorded for phylum Annelida (1.0) and the least value of (0.29) for Arthropoda. Evenness ranged between (0.84) for Mollusca and (1) for Annelida (Table 3).

The benthic macro-invertebrate diversity, distribution and abundance were relatively low. Diversity indices values considered as a strong bio-indicator of ecosystem health (Gaskill, 2004), may have revealed the health status of
this river system (Table 3). According to Yakub and Ugwumba (2009), bigger lotic water bodies tend to have low macro invertebrate richness. Major human activities (like saw milling) may have affected the nutrient level of this river, thus compromising the sedimentation structure of the river system.

Both increased nutrient levels and sedimentation are known elements of pollution and they have negative impacts on macro invertebrate abundance (Aura et al., 2010). Harding et al. (1999) suggested that high periphyton biomass due to nutrient enrichment and sedimentation, may favor richness of species of Chironomids, Mollusks and Annelids at the expense of EPT indexed taxa, a suggestion which is similar to the observations in the present studies.

3.4. Correlation Analysis

The following Correlation existed between the measured water quality parameters and benthic species encountered. Water parameters such as pH and TDS showed positive relationships with Mollusca at P<0.05 (Table 4).

3.5. The relationship between Physicochemical variables and plankton abundance

The Canonical correspondence analysis (CCA) ordination diagram was employed to express the relationships existing between benthic biota and the water variables (Figure 2).

A higher abundance of *Chironomus spp.* in this river system could be attributed to: their possession of haemoglobin - a pigment that transports and stores dissolved oxygen (Tyokumbor, 2002); a well-known fact which helps this insect to adapt and thrive in polluted water environment. The positive correlation that existed between Mollusca abundance with pH and TDS suggested that they require water with high TDS and pH and these could be attributed to their mode of nutrition. Result of the CCA revealed that Insect group had much preference to Station 3, with TDS as the most influencing factor.

Table 1: The Spatial variations, Range, Mean and Standard error of water quality parameters at studied sites

| Water Parameters | Spatial Variations | Range | Mean ± Std. Err. |
|------------------|--------------------|-------|-----------------|
| Temperature (°C) | Station 1 28.7     |       |                 |
|                  | Station 2 28.2     |       |                 |
|                  | Station 3 28.3     |       |                 |
|                  | Station 4 28.1     |       |                 |
|                  | Station 5 28.3     |       |                 |
|                  | Station 6 28.2     |       |                 |
|                  | **25.5-31.7**      |       | **28.31 ±0.41** |
| Dissolved oxygen (mg/L) | 3.6 |       |                 |
|                  | Station 2 3.8      |       |                 |
|                  | Station 3 3.7      |       |                 |
|                  | Station 4 4.0      |       |                 |
|                  | Station 5 3.8      |       |                 |
|                  | Station 6 3.5      |       |                 |
|                  | **2.1-5.4**        |       | **3.74 ±0.17**  |
| Conductivity (µ/cm) | 17.2 |       |                 |
|                  | Station 2 17.9     |       |                 |
|                  | Station 3 26.2     |       |                 |
|                  | Station 4 16.4     |       |                 |
|                  | Station 5 16.9     |       |                 |
|                  | Station 6 15.5     |       |                 |
|                  | **14.1-58.6**      |       | **16.41 ±1.8**  |
| Salinity (ppt)   | 0.029              |       |                 |
|                  | Station 2 0.028    |       |                 |
|                  | Station 3 0.027    |       |                 |
|                  | Station 4 0.029    |       |                 |
|                  | Station 5 0.028    |       |                 |
|                  | Station 6 0.028    |       |                 |
|                  | **0.01-0.09**      |       | **0.028 ±0.01** |
| pH               | 6.9                |       |                 |
|                  | Station 2 6.8      |       |                 |
|                  | Station 3 6.9      |       |                 |
|                  | Station 4 6.9      |       |                 |
|                  | Station 5 7.1      |       |                 |
|                  | Station 6 6.8      |       |                 |
|                  | **6.3-8.2**        |       | **6.9 ±0.12**   |
| Total Dissolved solids (mg/L) | 9.4 |       |                 |
|                  | Station 2 8.2      |       |                 |
|                  | Station 3 15.5     |       |                 |
|                  | Station 4 8.6      |       |                 |
|                  | Station 5 23.0     |       |                 |
|                  | Station 6 30.6     |       |                 |
|                  | **6.3-99.4**       |       | **15.75 ±4.5**  |
Table 2: Benthic Macro Invertebrate Diversity, Distribution and Abundance at studied sites

| Benthic Macro Invertebrate | Spatial Distribution | Total | Percentage Abundance |
|---------------------------|----------------------|-------|----------------------|
|                           | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 | Station 6 |
| Mollusca                  |           |           |           |           |           |           |
| *Neritina afra* (Sowerby, 1836) | -      | 3        | -        | 1        | 1        | -        | 5 | 25% |
| *Neritina rubrivate* (Sowerby, 1836) | -      | 1        | -        | -        | -        | -        | 1 | 5% |
| *Pachymelania bryonensis* (Wood, 1828) | -      | -        | -        | 1        | -        | -        | 1 | 5% |
| *Segmentorbus angustus* (Jickeli, 1874) | -      | -        | 1        | -        | -        | -        | 1 | 5% |
| Arthropoda                |           |           |           |           |           |           |
| *Chironomus sp.* (Meigen, 1803) | -      | -        | 2        | 3        | 1        | 2        | 8 | 40% |
| *Ceratopogonid sp.*       | -      | -        | 2        | -        | -        | -        | 1 | 15% |
| Annelida                  |           |           |           |           |           |           |
| *Tubifex tubifex* (Muller, 1774) | -      | -        | -        | -        | 1        | -        | 1 | 5% |
| TOTAL                     | 0      | 4        | 5        | 5        | 3        | 3        | 20 |

Table 3: Diversity index of benthic macro invertebrate group at studied sites

| Diversity index | Macro invertebrate Taxa | Annelida | Arthropoda | Mollusca |
|-----------------|-------------------------|----------|------------|---------|
| Dominance_D     | 1                       | 0.29     | 0.34       |
| Shannon_H       | 0                       | 1.30     | 1.21       |
| Evenness_e^H/s  | 1                       | 0.91     | 0.84       |

Table 4: Pearson Correlation between water quality parameters and benthic macro invertebrates (P < 0.05)

|                | Temp. (°C) | DO (mg/l) | pH    | Salinity (ppt) | Conductivity (µS/cm) | TDS (mg/l) |
|----------------|------------|-----------|-------|----------------|----------------------|-------------|
| Annelida       | 0.017      | 0.272     | -0.162| -0.119         | 0.110                | 0.010       |
| Arthropoda     | 0.000      | 0.162     | 0.176 | 0.078          | -0.152               | -0.96       |
| Mollusca       | -0.223     | -0.375    | 0.474*| -0.123         | 0.072                | 0.503*      |
Fig. 2: Canonical correspondence analysis (CCA) triplot ordination diagram with 3 benthic macro-invertebrate groups, 6 quantitative variables and studied stations 1 to 6

4. CONCLUSION

The water quality parameters of Nwaniba River may still fall within recommended limits as stipulated by NESREA for tropical aquatic organisms, however, the sporadic distribution and the lower benthic macro invertebrates diversity and abundance (with a higher abundance of the pollution-tolerant taxa; *Chironomus spp.*) serves as biological measure reflecting that Nwaniba River could be under stress of organic pollution from anthropogenic sources such as saw dust, human feaces, detergents etc. Hence, need for strict pollution management of this natural resource.

Conflict of Interest
There is no conflict of interest.

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