

FULL LENGTH RESEARCH ARTICLE

THE USE OF BIOLOGICAL INDEX OF POLLUTION (BIP) IN ASSESSING QUALITY OF RURAL WATER SOURCES IN ZARIA, NIGERIA

*HASSAN, A. S.¹, OKUOFU C. A.² & BALOGUN, J. K.³

¹Department of Biological Sciences

Kaduna State University, Kaduna, Nigeria.

²Department of Water Resources

Faculty of Engineering, Ahmadu Bello University, Zaria, Nigeria

³Department of Biological Sciences

Ahmadu Bello University, Zaria, Nigeria

*(Corresponding author)

danmasaniashres@yahoo.com

ABSTRACT

The biological index of pollution (BIP) which hinges on the responses of aquatic biota to pollution of water sources was used to assess the quality of some water sources in Zaria area, Nigeria. Water samples were collected from 15 stations comprising three open water sources (lakes) and twelve hand-dug wells on a monthly basis for a period of 24 months. Ten liters of the samples from wells were concentrated to 50 ml by filtering through 70 meshes per cm² plankton net. Collections from the lakes was by means of dragging net over a 3 meter distance in the water. The water was also concentrated to 50 ml. Using the BIP of Horasawa as modified by Palmer, the water quality situation of the sources were classified into betasaprobic and alphasaprobic. Some of the water sources, especially in the rainy season, gradually shifted in quality from betasaprobism to alphasaprobism. The BIP method gave a satisfactory indication of the quality status of each water source especially when the results obtained were compared with the result of physico-chemical analysis of the water sources. However, unless the water sources contain both phytoplankton and zooplankton, which are key variables in the BIP computation, the index proved difficult to apply.

Key Words: Rural Water Sources, Water Quality, Biological Index.

INTRODUCTION

From hydrological statistics, the volume of water world-wide amounts to some 1.4 x 10⁹ km³. This quantity of water should have been sufficient to meet all human needs as well as the existing supplies in order to satisfy the demands created by the rapidly increasing world population. However the current effort to find water irrespective of its quality has come to the fore in recent times. It must be stressed that finding water alone without due consideration of its quality is not sufficient. Biswass (1981) recognized this and stated succinctly that the quantity and quality of water are closely interrelated and must be considered simultaneously in all water management strategies.

Water pollution, brought about by the discharge of wastes into water bodies has been responsible for impairing the different uses to which water could have been put in many parts of the world. In some cases, pollution even renders the water totally unusable regardless of its availability. A lot of information is available on the physical, chemical and bacteriological indices of water pollution (Jaleel *et al.* 1991; Randenkova-Yanova *et al.* 1995; Daniel & Carlos 1996; Rahman 1996).

The most common approach to water quality assessment is the monitoring of physico-chemical indices. Even though chemical indices are valuable and necessary, but do not provide all information needed in water quality assessment. According to Hosmani (2008), one of the most striking features of the past water assessment procedures has been reliance placed upon physical and chemical techniques, with relative neglect of biological parameters, which show the degree of ecological imbalance in water sources. This necessitates the idea of shifting emphasis to biological indices in determination of water quality.

The technicalities involved in the application of many of the existing procedures for detecting water pollution or assessing its quality however have created serious limitations in their adoption for routine use in many instances especially in developing countries.

A number of water quality indices are currently being experimented on and recommendations for application are being proposed: Shannon Weaver Diversity Index (Shannon & Weaver 1963, Trivedi 1979); Total Species Abundance (Baurbour *et al.* 1999; Vinson 2000); Biological Monitoring Working Party (Mackie 2001); Modified Hilsenhoff Species-level Biotic Index (Hilsenhoff 1987; Madaville 2002; SWCS 2004); Percentage Dominant Taxon (CEW 2002); Average Score Per Taxon (Madaville 2002); Benthic Macroinvertebrates as Biological Index of Water Quality (Sripongpun 2008) are widely used as indices of water quality.

The use of aquatic biota to detect pollution in water is an option that has recently become attractive to some researchers. The biological index of pollution (BIP) was first proposed by Horasawa (Horasawa 1942) and again by Palmer (Palmer 1980). This paper reports on the use of BIP to assess the quality of rural water sources in Zaria, northern Nigeria.

MATERIALS AND METHODS

Study area: Zaria lies between 11^o.00' N and 11^o.13'N and longitudes 7^o.30' E and 7^o. 47'E. There are a number of rural communities surrounding the ancient city, which have poor access roads, and most lack potable water supply (Fig. 1). The inhabitants of these villages are predominantly subsistent farmers whose major source of water is from hand dug wells. In few instances water is obtainable from

impoundments, with all year round availability of water. The water table rises significantly in the wells during the rainy season up to a few meters to the surface, but drops as dry season progresses to over 10 meters. The rainy season corresponds with the months of May to October, while the dry season is from November to April.

Sampling: Fifteen sampling stations were selected from three rural communities in Zaria: Bomo; Shika Village and Tudun Sarki. Three of the water sources were impoundments, referred to as open water sources (OWSs), while the other twelve were hand-dug wells, termed restricted water sources (RWSs). The three OWSs were the University (Kubanni) impoundment; Boma lake and Shika Dam. The hand-dug wells were located at Bomo (3), Kurmin Bomo (3), Shika village (3) and Tudun Sarki (3). Samples were collected once a month from each of the 15 sampling stations for 24 months.

Plankton Sampling and Preservation Procedure:

(a) Water samples were collected from open water sources (OWSs) by dragging plankton net of 70 meshes/cm² over 3 meter distance in the water and concentrating the collected samples to 50 ml. Ten liters of the water samples from wells (RWSs) were collected and concentrated to 50 ml. by filtering through 70 meshes per cm² plankton net.

(b) Samples for phytoplankton identification and enumeration were preserved in Lugol's solution and for zooplankton in 4% formalin respectively. The plankton were examined and counted under the microscope by means of the survey count described by the International Standards for Drinking Water (WHO 1963) and Standard Method for the Examination of Water and Waste Water (APHA 1998), using a Sedwick-rafter counting cell.

Enumeration of Plankton: Enumeration was by the use of the formula:

$$N = N_x \times \left(\frac{ac}{bd} \right)$$

- where N = Number of organisms/Litre
 N_x = Number of organisms/1000 fields of standard Sedwick-rafter counting cell 1 mm deep from 1 ml concentrated sample.
 and a = Number of fields in the counting cell
 b = Number of fields counted
 c = Volume of concentrate (50 ml)
 d = Volume of the original sample collected (πr² x 3 meters)

After counting the BIP was calculated as previously described based on Horasawa (1942) and Palmer (1980).

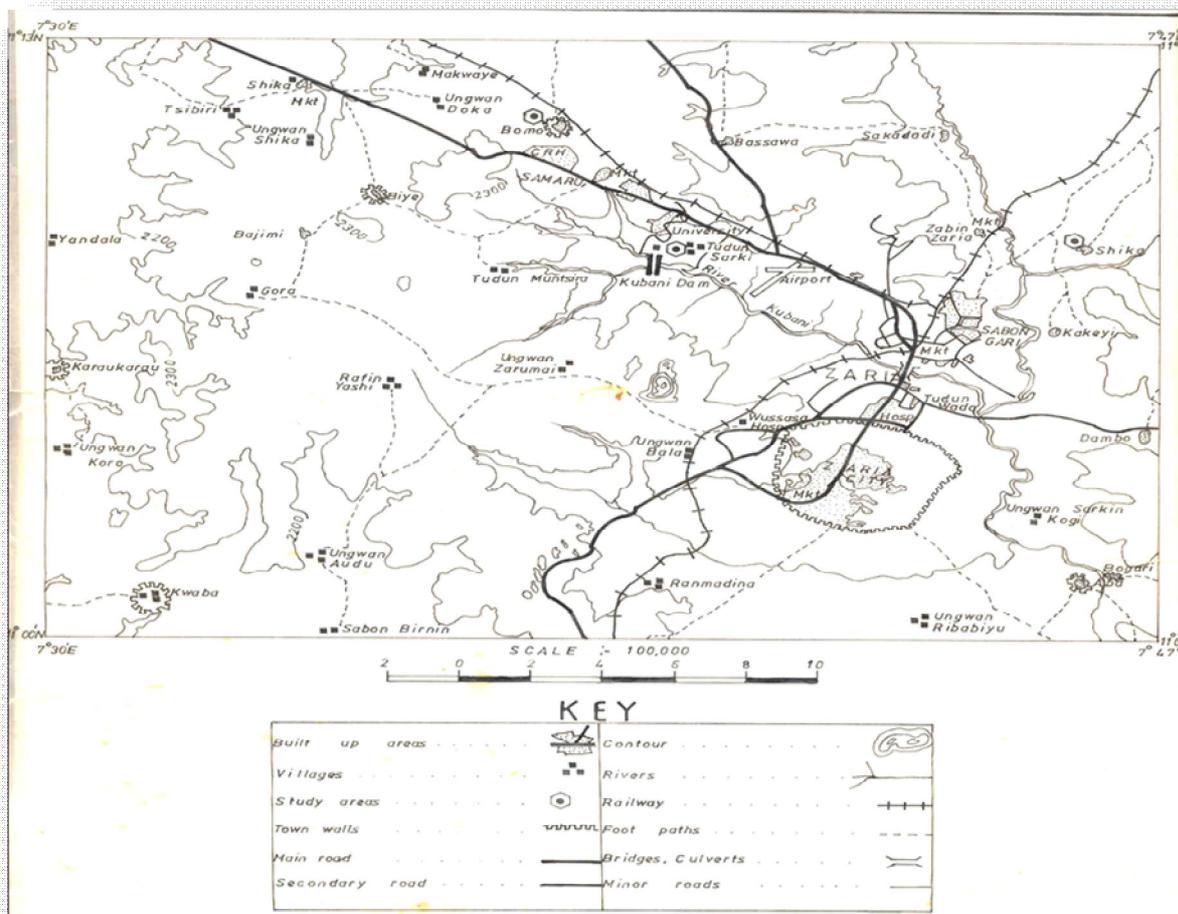


FIG.1. ZARIA AND ITS ENVIRONS SHOWING THE STUDY AREA

RESULTS AND DISCUSSION

Figure 2 below shows the monthly variations in the phytoplankton recorded per month during the period of sampling of all the water sources.

Figure 3 below represents the monthly variation in zooplankton population per station for the 24 months of sampling.

Stations 1, 2, 3, 4, 5, 12, 13 and 14 were devoid of any zooplankton. Similarly, no phytoplankton was recorded in stations 3, 12, 13 and 14.

Figure 4 below, shows the monthly variations in the BIP's of the water sources. The sources were either betasaprobic (with moderate decomposition of organics), or alphasaprobic (with extensive organic decomposition).

There was a gradual shift in the recorded BIP from beta to alpha-saprobism as the dry season advanced. This shift represents a reduction in the quality of the water sources. The unprotected nature of the water sources subjects then to both allochthonous and outothonous influence of decaying organics. In figure 5 the BIP of the different sampling stations is represented.

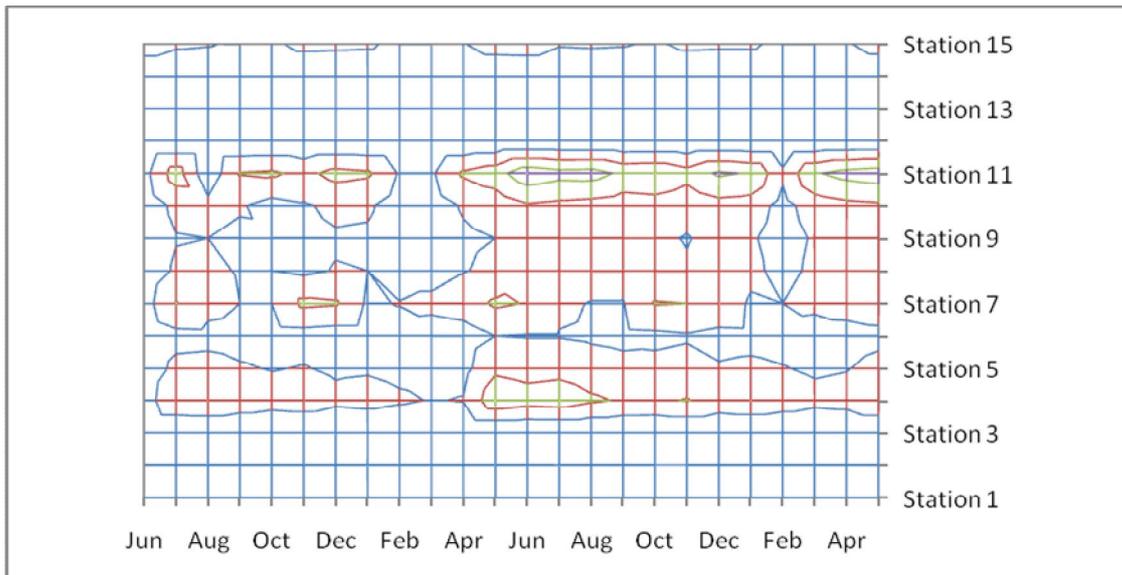


FIG. 2. MONTHLY VARIATION IN PHYTOPLANKTON POPULATION PER STATION FOR THE 24 MONTHS OF SAMPLING

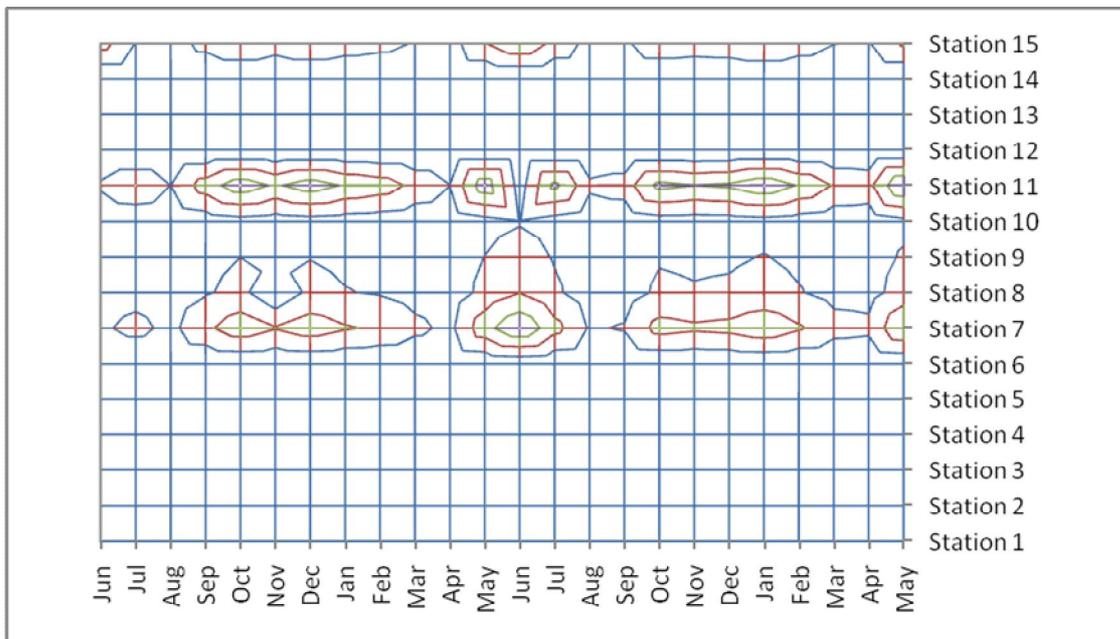


FIG. 3. MONTHLY VARIATION IN ZOOPLANKTON POPULATION PER STATION FOR THE 24 MONTHS OF SAMPLING

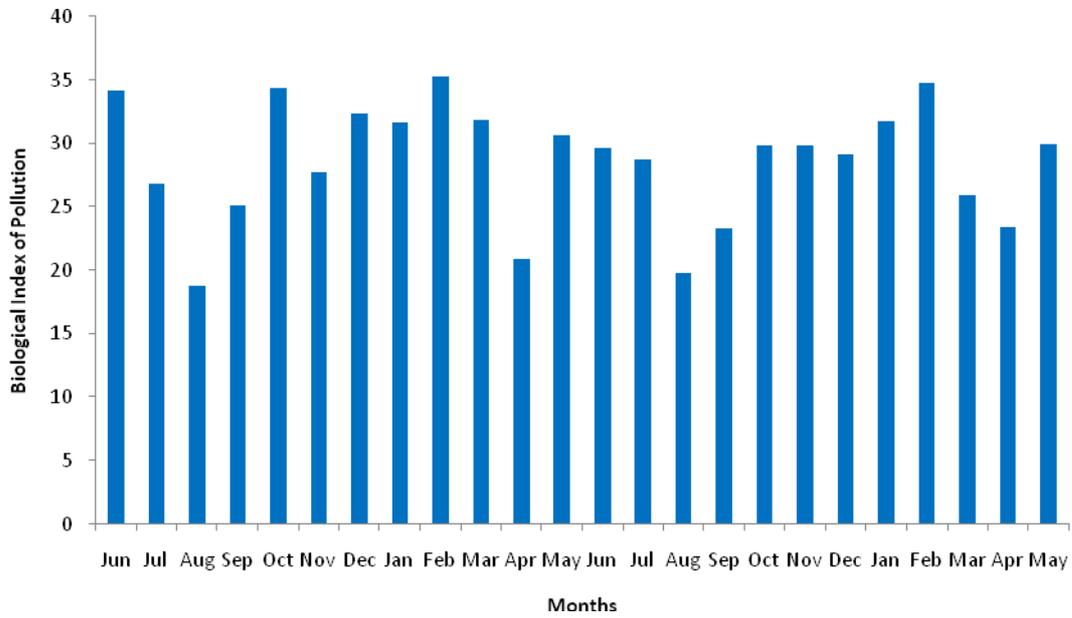


FIG. 4. MONTHLY VARIATIONS IN THE BIP's OF WATER SOURCES

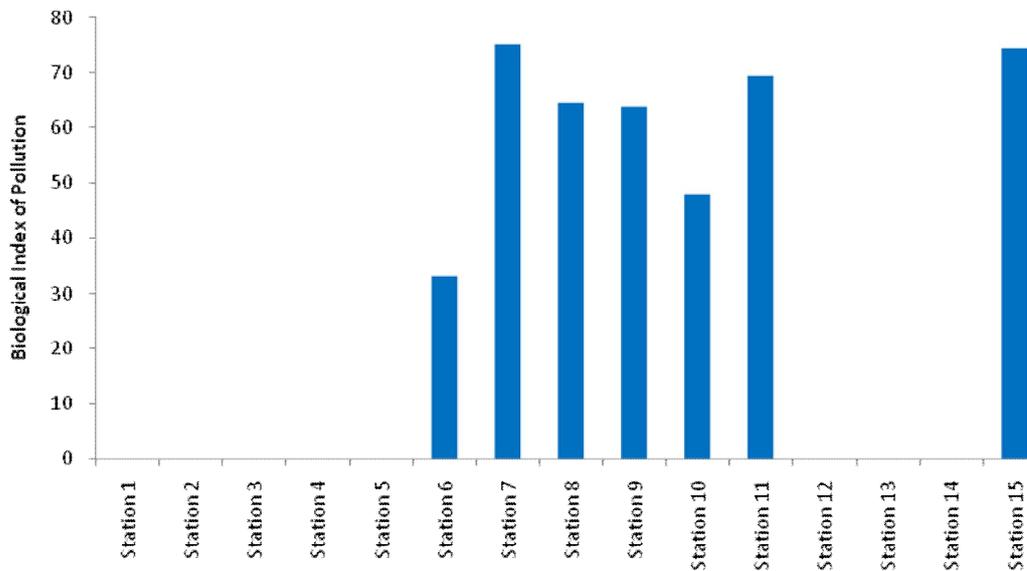


FIG. 5. BIP OF THE DIFFERENT SAMPLING STATIONS

It was observed that the quality of the water in OWSs (S7, S11 and S15) was less than the quality of the well waters. The OWSs were polysaprobic with an average BIP of 73 while the average BIP of the wells was 17.5, hence regarded as being betasaprobic. In some cases (S1, S2, S3, S4, S5, S12, S13 and S14), either zooplankton or phytoplankton were not found in the sample collected for examination. As a result of this, a key variable used in the calculation of BIP was missing, resulting in inability to apply the formula, hence unable to calculate the BIP.

For most parts of the year, the quality of the water from the different sources was poor (Fig. 4) In the rainy season this may be due to enrichment of the water sources through inflows and infiltration of dissolved matter, macronutrients and other pollutants. It was observed that water sources which had proximity to point sources of pollution such as pit latrines and polluted drainage/gutters (S6, S8, S9 and S10) recorded higher BIP hence low quality of the water sources. These stations also were found to contain both phytoplankton and zooplankton, making the calculation of BIP possible.

In conclusion, the BIP index may successfully be used in establishing the pollution or quality status of water sources provided the source contains both zooplankton and phytoplankton. Its tribute for routine application rests primarily on its ease of application, low cost, adaptability and simplicity.

REFERENCES

- American Public Health Association (APHA) American Water Works Association and Water Environment Federation. 1998. *Standard Method for the Examination of Water and Wastewater*, 20th. Edition. Edited by Mary Ann H. Franson. (Baltimore, USA.: American Public Health Association).
- Biswass, A. K. 1981. *Methods for Water Quality Management* Mc Graw – Hill series on Water Resources and Environmental Engineering. Mc Graw – Hill Inc.
- Citizens' Environment Watch. (CEW) 2002. Benthic Macroinvertebrate Data Analysis. Retrieved Apr. 2002 from <http://www.utoronto.ca/envstudy/cew/action/BenthDataAnalysis.pdf>.
- Daniel, E. L. & Carlos, H. P. 1996. Water Mutagenicity and Toxicity in Rio Tercere (Cordoba, Argentina). *Water Research* 30:41:619-824.
- Hilsenhoff, W. L. 1987. An Improved Biotic Index of Organic Stream Pollution. *Great Lakes Entomologist*. 20:31-39.
- Horasawa, I. 1942. A Preliminary Report on the Biological index of water pollution. *Zoological Magazine*. (Tokyo) 54:37-38.
- Hosmani S. P. 2008. Biological Index of Water Quality. Department of Studies in Botany University of Mysore, Manasagangotri Mysore 570 006, Kamataka, India.
<http://ces.emet.in/energy/Lake2002abs/ses51.html>
- Jaleel, J. M.; Jaffar, M. & Ashraf, M. 1991. Level of Selected Heavy Metals in Commercial fish from five freshwater lakes. *Pakistan Journal of Toxicology and Environmental Chemistry*. 33:133-140.
- Mackie, G. L. 2001. *Applied Aquatic Ecosystem Concepts*. (Dubuque: Kendall/Hunt Publishing Company).
- Mandaville, S. M. 2002. *Benthic Macroinvertebrates in Freshwater – Taxa Tolerance Values, Metrics, and Protocols, Project H - 1*. (Nova Scotia: Soil & Water Conservation Society of Metro Halifax).
- Palmer, M. C. 1960. Algae and Water Pollution. *The Identification, significance and control of algae in water supplies and polluted waters with illustrations in colour* by Harold, J.W. and Adam S. Castle House Pub. Ltd.
- Rahman, A. 1996. Groundwater as Source of Contamination of Water Supply in Rapidly Growing Magacities of Asia: Case of Karachi, Pakistan *Water Science and Technology*. 34 (7): 285-292.
- Radenkova-Yanova, M., Kostakeva, E. & Toshex, D. 1995. Contaminant Migration from Solitary Landfill Leachate Through Soil Monoliths. *Water Science and Technology*. 32: 7 215-219.
- Shannon, C. E. & Weaver, W. 1963. *The Mathematical Theory of Communication*. (Urbana: University of Illinois Press).
- Soil & Water Conservation Society of Metro Halifax. 2004. *Taxa Tolerance Values*. (Nova Scotia: Soil & Water Conservation Society of Metro Halifax).
- Sripongpun G. 1985. Bentic Macroinvertebrates as a Biological Index of Water Quality in the Lower Thachin River. Research and Development Institute, Silpakorn University, Nakorn Pathom. Department of Environmental Science and Department of Biology, Faculty of Science, Silpakorn University www.journal.su.ac.th/index.php/suij/article/view/46/46
- Trivedi, R. C. 1979. Pollution Studies of Chambal River and Surrounding due to Nagda Industrial Complex. Ph.D. Thesis. Vikram University, Ujjain.
- Vinson, M. 2000. Aquatic Macroinvertebrate Monitoring Report (Logan: National Aquatic Monitoring Center, Department of Fisheries and Wildlife, Utah State University).
- World Health Organization, WHO 1963. *International Standards for Drinking Water*, Ed. 2 WHO, Geneva.