Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 134 (2019) 53593-53597

ISSN: 2229-712X

Use of Plankton as Bioindicators in Water Quality Management for Sustainable Use in Fishery Production: A Review

Daniel Omoha Igwe[1], Paul Ola Igboji[2] and Godfrey Iheanyi Mbagwu[1]
[1]National Institute for Freshwater Fisheries Research (NIFFR), P M B 6006, New Bussa, Niger State, Nigeria.
[2]Department of Soil Science and Environmental Management, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, P M B 053 Abakaliki, Nigeria.

ARTICLE INFO

Article history:
Received: 4 September 2019;
Received in revised form:
27 August 2019;
Accepted: 7 September 2019;

Keywords
Plankton,
Bioindicators,
Freshwater,
Environmental quality,
Natural resources,
Anthropogenic Activities.

ABSTRACT

Bioindicatora are living organisms which can be used to screen the health of the natural ecosystem. Plankton assesses the ecological changes taking place in freshwater environment. The assessment of water quality using plankton promotes water quality and yield. The quality of aquatic ecosystem reflects the quality and species of organisms that colonize it. In Nigeria, the freshwater ecosystem represent over 50% of the natural resources that sustain over 45% of the over 220 million population. Water bodies of the world represent over 75% of global natural resources that sustain over 60% of world population of over 6 billion, projected to reach over 9 billion by 2055. Hence, the place of water bodies cannot be underestimated in sustainable livelihood and standard of living. Their pollution due to massive anthropogenic activities are worrisome. Hence, the constant monitoring of their quality has been called by marine and other scientists. This review details the role of plankton in water quality and yield assessment.

Introduction

Plankton describes the phytoplankton and zooplankton communities (Walsh, 1978). They react rapidly to ecological changes and are viewed as excellent indicators of water quality and trophic conditions due to their short time and rapid rate of reproduction (Pradhan *et al.*, 2008). Planktons is also main source of nutrition for many fish (Parmar, 2016). In addition, certain plankton such as cyanobacteria produce toxins which are harmful to fishes. Thus, plankton is both useful and harmful to aquatic habitats (Pradhan *et al.*, 2008).

The sustainability of aquatic resources is heavily dependent on high quality water. In developing countries, assessing water quality through constant monitoring of planktons as bio-indicators remains the cheapest and easily available method (Ovie et al., 2011). Their quality determines fish populations. Hence, the physico-chemical, as well as biological properties of water are very paramount (Sandhya and Benarjee, 2016).

Despite many technological advances, scientists still turn to biota of natural aquatic systems for the quality of water ecosystem. According to Asthana and Asthana (1988), the quality of aquatic ecosystem is reflected in the quality and species of organisms that colonize it. These organisms detect changes in aquatic or terrestrial environment, both positive and negative and are generally called "bioindicators" (Parmar *et al.*, 2016). According to Trishala *et al.* (2016), bioindicators are living organisms such as plants, plankton animals and microbes whose activities, populations, morphology, physiology or behaviour gives information or predicts the conditions of the environment where they are domiciled.

Water quality indices include nutrients, clarity, biochemical oxygen demand, chemical contaminants and bacteria content (Campell *et al.*, 2008). Niaz and Rasul (1998) reported the merits of biological indicators over chemical indicators for the study of pollution dynamics of aquatic ecosystem. According to the scientists, biological indicators respond to all the physical, chemical factors and can be applied at broader scale in their discourse.

Classification of bioindicators and their role in aquatic ecosystem stability

Bioindicators are grouped into intolerant or sensitive and tolerant or insensitive biota as regards to responses to pollution (Sumampouw *et al.*, 2014). The existence of sensitive organisms to the pollution of river indicates the good condition of the water ecosystem. All species assemblages tolerate a limited range of chemical, physical and biological conditions which can be used for the evaluation of environmental quality (Sumampouw *et al.*, 2014).

The use of biomonitor is described as biomonitoring and is thus defined by Li *et al.* (2010) as a systematic use of indicator organism or their responses to determine the condition or change of the environment. One of the criteria used when an organism is proposed as a biomonitoring agent is a simple correlation between pollutant levels present in the organism and those in its environment (Signh *et al.*, 2014). Biomonitoring aims to assess the state of the natural environment and levels of pollution. Biomonitoring is divided into passive and organism associations which are natural component of ecosystem. Active biomonitoring includes all methods which insert organisms under the control conditions to be monitored (Signh *et al.*, 2014). The common biomonitoring methods for aquatic pollution includes biota population, bacteria test, acute toxicity and residue analysis.

Tele: +234(0)9061277585
E-mail address:pauligboji@gmail.com

Characteristics and role of plankton as bioindicators

Bioindicators needs taxonomical soundness. It must be easy to be recognized by non-specialists. Likewise, low mobility and high ability for qualification and standardization (Leis et al., 2008). Others include, easy sampling and suitability for laboratory experiment, high sensitivity to environment stressors and accumulation of high levels of pollutants without death. Again, enough abundance and wide distribution for repetitious comparison (Leis *et al.,* 2008).

The effect of pollutants on the indicator species are clearly recognizable and its application is relatively cost effective. Their studies, according to Signh *et al.* (2014) require simple techniques which can easily be repeated by different individuals from time to time. According to the scientists, using of plankton as bio-indicator is feasible in different ecosystem and is suitable for assessing large areas. Plankton indicator species are also easier to interpret and less ambiguous than direct sampling and assessment of all plant and animal communities in a given ecosystem (Leis *et al.,* 2008). Nevertheless, the application of plankton as bioindicators in environmental monitoring is also beset with problems (Leis *et al.,* 2008). These include: the difficulty of presenting indicator species with sufficient number of individuals, lack of widespread locality for areas under investigation and lack of knowledge on the physiological processes of uptake and retention of toxic substances or environmental contaminants.

Plankton as indicators of ecological niche

Plankton are useful organisms for detecting changes in the environment. The presence of pollutants and effects on the habitat are made possible (Leis *et al.*, 2008). Hence, plankton is common yardstick for assessing anthropogenic activities. Some plankton indicators can be developed specifically to assess human exposure through the food chain to environmental risks. Some are at high risk, others intermediate and lower trophic levels and form part of diet of man. Hence, directly and potentially relevant to human exposure (Leis *et al.,* 2008). Plankton indicators according to the authors are also relevant for predictions and recognition of environmental stresses and how to prevent or assuage the situation with appropriate management practices.

The place of phytoplankton as biological indicators

Phytoplankton, also known as microalgae are the micro-plant organisms without differentiation into roots, stems and leaves (Bellinger *et al.,* 2010). They contain chlorophyll and require daylight to live and develop. They are autotrophic by obtaining their nutrients from inorganic sources namely: nitrates, phosphates and photosynthetically through complex carbon compounds using CO_2 and sunlight energy (Ayodhya, 2013). They are primary producers in marine and inland waters (Zhonetal, 2008). Phytoplankton remain one of the most rapid bioindicators of water quality due to their short life span, quick responses to inorganic phosphorus and nitrogen (Ayodhya, 2013). Phytoplankton have been used successfully for monitoring water pollution (Parmar et al., 2016). According to Campbel *et al.* (2008) phytoplankton biomass is among the most reliable indices of water quality; with Oligotrophic giving 0.21–0.55 mg m^3; mesotrophic, 0.57– 2.55 mg $m^{3,}$ eutrophic, 3.0 – 6.55 mg m3 and extremely eutrophic, >31.17 mg $m^{3.}$.(Gokee, 2016). Phytoplankton represent an interface between habitat and biotic components of the food web (Gokee, 2016). According to the author, phytoplankton are sessile, cannot migrate to avoid pollution and must tolerate wide environmental conditions or disappear. They are also species rich with each group having their tolerances. Phytoplankton have short life span and respond rapidly to changes in their environment. They are also spatially dense and easy to sample and store. They are also smaller in size compared to other biota and hence, are potentially more sensitive to pollution at lower concentrations (Gokee, 2016). Table 1 summarizes the groups of phytoplankton as bioindicators as reported by many scientists.

The place of zooplankton as biological indicators

Zooplankton are micro drifting organism in water that depend on phytoplankton and bacteria for food (Ajayi, 2014). They are poor swimmers, instead relying on tides and current as a transport mechanism (Parmar et al., 2016). They are secondary producers in the food web. The three major groups of zooplankton are copepod, cladocera and rotifers (Adigun, 2005). Zooplankton play important role as bioindicators and help to evaluate the level of water pollution (Parmar, 2016). Through polluting substances of industrial origin, life cycle of zooplankton are disturbed (Binachi *et al.,* 2003). The population and abundance of zooplankton are also affected by water quality (Ovie *et al.,* 2011). The qualitative and quantitative analysis of zooplankton have led to the establishment of bioindicators indices and systems essential for assessment of water pollution (Kamari *et al.,* 2008). Characteristically, zooplankton community are composed of highly sensitive organisms that respond to a large number of environmental changes in relatively short period of time. An increase in zooplankton biomass has been linked to a rising level of eutrophication because of increased resource availability which in turn leads to growth in the biomass of phytoplankton (Neto *et al.,* 2014). Zooplankton offer several advantages: they have worldwide distribution and their communities are sensitive to changes in environmental factors, as well as the amount of organic matter in aquatic ecosystem (Ismail, 2016). Table 2 summarises groups of zooplankton as bioindicators as reported by many scientists.

Conclusion

Plankton still represent an important biota of natural ecosystem. Despite many technological advances, they still remain important indicators for assessing water quality. In view of the place of freshwater bodies in the life of man, and the activities associated with their pollution, there is need for constant monitoring to preserve life of aquatic communities that sustain man. All over the world, aquatic environment is being threatened by massive pollution arising from agriculture, industries, municipal wastes, sewage and burning of fossil fuel. These activities have tremendous impact on aquatic lives and the overall environment. Researchers have focused on various methods of testing water pollution. In developing countries, with less technological know-how like Nigeria, bioindicators will remain viable option for testing aquatic pollution and safeguarding the fresh water bodies that are sources of drinking and domestic water.

References

Adigun, B (2005). Water quality management in agriculture and fresh water zooplankton production for use in fish hatcheries. Innovative Ventures, New Bussa, Niger State: 13pp.

Ajayi, O (2014). Basic solution to problems in fish farming. Fresh Innovative Multitic, New Bussa: 61pp.

Asthana, D.K and Asthana, M (1998). Environmental problems and solutions. S. Cland and Company, New Delhi, India: 3975pp

Ayodhya, D.K (2013). Use of algae as bioindicators to determine water quality of river mula from mine city Maharashtra, India. Universal J. of Environmental Res. And Tech. Vol. 3(1): 79 – 85

Bellinger, E.G and Sigee, P.C (2010). Freshwater alage: Identification and use as bioindicator. John Wiley and Sons, Ltd: 40pp

Binachi, F; Accri, F; Aubry, F.B; Berton, A; Camatti, E; Cassin, D and Comaschi, C (2003). Can plankton communities be considered as bioindicators of water quality in the lagoon of Vernice. Marine Pollution Bulletin vol 46: 964 – 971

Campbell, P.E; Manning; Webber, M.K and Webber, D.F (2008). Planktonic communities as indicators of water quality in mangrove lagoons. A Jamaican Case Study. Transitional Water Bulletin 3: 39 – 63.

Fonge, B.A; Tening, A.S; Egbe, E.A; Yinda, G.S; Fongod, A.N and Achu, R.M (2012). Planktons as bioindicators. African J. of Environmental Sci. And Tech. Vol 6(6): 247 – 257.

Gokee, G (2016). Algae as an indicator of water quality. In: Thajuddin and Dhanasekarau, D. (eds). Algae – organisms for imminent biotechnology. IntechOpen.com/books/algae-organisms-for-imminent-biotechnology/algae-las-an-indicator-for-water-quality.

Ismail, A.A and Adan, A.A.M (2016). Zooplankton composition and abundance as indicators of eutrophication in two small man-made lakes. Trop. Life. Sc. Res. Vol 27(1): 31 – 38

Kamari, P; Dhadse, S; Chaudhari, P.R and Water, R.R (2008). A biomonitoring of plankton to assess quality of water in the lakes of Nagpur City. In: Segupta, M and Dalwani (Eds.). Proceedings of TAAL 2007: The 12th World Lake Conference: 160 – 164.

Komala, H.P; Nanjundaswanmy, L.D; Prasad, A.G (2013). An assessment of plankton diversity and abundance of Arkavathi River with reference to pollution. Advances in Applied Science Res. 4(2): 320 – 324

Leis, S.A; Leslie, Jr D.M; Engle, D.M and Fehmi, S.J (2008). Small mammals as indicators of short term and long term disturbance in mixed Praire. Env. Monitoring and Assessment vol 137: 75 – 84

Li, L; Zheng, B and Liu, L (2010). Biomonitoring and bioindicators used for river ecosystem: Definition, Approaches and Trends. Precedia Environmental Sciences vol 2: 1510 – 1524.

Neto, A.J.G; Dasilva, L.C; Saggio, A.A and Rochao A (2014). Zooplankton communities as eutrophication bioindicators in tropical reservoir. Biota Neotrophica vol 14(4): 54 – 59.

Niaz, M and Rasul, E (1998). Aquatic macrophytes as biological indicators for pollution management studies III. Comparative growth analysis of Eichlnornia Crassipes and pistia stratoites to different salts commonly present in factory effluent. Pakistan J. of Bio. Sc. Vol 1(3): 241 – 243

Onyema, I.C (2013). Phytoplankton bioindicators of water quality situations in the Iyabge Lagoon, Southwestern Nigeria. J. of Life and Physical Science vol 4(2): 93 – 107.

Ovie, S.I; Bwala, R and Ajayi, O (2011). Preliminary study on Limnological stock assessment, productivity and potential fish yield of Omi dam, Nigeria. African J.
of Environmental Science and Tech. Vol 5(11): 956 – 963.

Parmar, T.K; Rawtani, D and Agrawal, Y (2016). Bioindicators: The natural indicator of environmental pollution. J. of Frontiers in Life Sciences vol 9(11): 110 – 118.

Pradhan, A; Bhaumik, P; Das, S; Mishra, M; Kharam, S; Hoqwe, B.A; Makherjee, I; Thakur, A.R and Chanhuri, A (2008). Phytoplankton diversity as indicator of water quality for fish cultivation. Am. J. Env Sci. 4(4): 406 – 411.

Pulleman, M; Creamer, R.H; Helder, J.; Pelosic, C and Rutgers, M (2016). Soil biodiversity, biological indicators and soil ecosystem services as overview of European approach. Sciverse Science Direct vol 4: 529 – 538

Sandhya, K and Benarjee, G (2016). Physico-chemical properties of some selected fresh water fish ponds in relation to fish production in Warangal area. J. of Plant, Animal and Environmental Science vol 6(4): 23 – 31.

Singh, N.K.S; Sudarshan, M; Chakraborty, A; Devi, C.B; Singh, T.B and Singh, N.R (2014). Biomonitoring of fresh water of Laktak Lake, India. European J. of Sustainable Dev vol 3(1): 179 – 188.

Sumampouw, O.J and Risjani, Y (2014). Bacteria as indicators of environmental pollution – Review. Int. J. of Ecosystem vol 4(6): 251 – 258

Trishala, K.P; Deepak, K and Agrawal, Y.K (2016). Bioindicators: The natural indicator of environmental pollution. J. Frontiers in Life Science vol 9(2): 110 – 118.

Walsh, G.E (1978). Toxic effects of pollutants on plankton. In: Butter, G.C (ed). Principles of ecotoxicology, New York; Wiley: 257 – 274

Table 1. Groups of phytoplankton as bioindicators.

Phytoplankton	Indications	Authors
Chlorophyceae		
Chlorella	Eutrophic water/organic pollution	Ayodhya, 2013
Scenedesmus spp	Eutrophic water/organic pollution	Ayodhya, 2013
Pediastrum	Eutrophic water/organic pollution	Ayodhya, 2013
Microspora flocci	Eutrophic water/organic pollution	Onyema, 2013
Spirogyra Africana	Eutrophic water/organic pollution	Onyema, 2013
Cladophoraglomerata	Eutrophic water/organic pollution	Onyema, 2013
Akistrodesmus spp	Acidic to neutral water	Onyema, 2013
Gonatozygon spp	Acidic to neutral water	Onyema, 2013
Staurastrum paraloxum	Acidic to neutral water	Onyema, 2013
Volvox spp	Eutrophic water	Fonge *et al*., 2012
Cosmarium spp	Oligotrophic	Fonge *et al*., 2012
Ulothrix spp	Eutrophic water	Fonge *et al*., 2012
Sphaeocystis spp	Mesotrophic water	Fonge *et al*., 2012
Staurastrum bieneanum	Eutrophic water	Fonge *et al*., 2012
Spirogyra longata	Eutrophic water	Fonge *et al*., 2012
Chlamdomonas spp	Eutrophic water	Fonge *et al*., 2012
Chlosteriopsislongissima	Mesotrophic water	Fonge *et al*., 2012
Monoraphidium setforme	Eutrophic water	Fonge et al., 2012
Monoraphidium setforme	Eutrophic water	Fonge *et al*., 2012
Cyanophyceae		
Oscillatoriasp	Eutrophic water/organic pollution	Ayodhya, 2013
Anabena	Eutrophic water/organic pollution	Gokee, 2016
Aphanizomenon	Eutrophic water/organic pollution	Gokee, 2016
Microcystis spp	Eutrophic water/organic pollution	Gokee, 2016
Chroococcus turgidus	Eutrophic water/organic pollution	Onyema, 2013
Merismopedia gluca	Eutrophic water/organic pollution	Onyema, 2013
Lynbgya spp	Eutrophic water/organic pollution	Onyema, 2013
Spirulina platensis	Eutrophic water/organic pollution	Onyema, 2013
Trichodesmium thiebautii	Alkaline Ph/cation level	Onyema, 2013
Chlorococcus dispersus	Eutrophic water	Fonge *et al*., 2012
Crythropsis pavillardi	Oligotrophic water	Fonge *et al*., 2012
Chlastidium spp	Mesotrophic water	Fonge *et al*., 2012
Dactylococcopsis acicularis	Eutrophic water	Fonge *et al*., 2012
Bacillariophyceae/Diatom		
Melosira	Eutrophic water/organic pollution	Ayodhya, 2013
Navicula	Eutrophic water/organic pollution	Ayodhya, 2013
Nitzschia spp	Eutrophic water/organic pollution	Ayodhya, 2013
Gomphonema	Eutrophic water/organic pollution	Ayodhya, 2013
Asterionella	Eutrophic water/organic pollution	Gokee, 2016
Autacoseira	Eutrophic water/organic pollution	Gokee, 2016
Fragilaria	Eutrophic water/organic pollution	Gokee, 2016
Stephanodiscus	Eutrophic water/organic pollution	Gokee, 2016
Actinoptychus splendens	Alkaline pH/high cation levels	Onyema, 2013
Ditylum brightwelli	Alkaline pH/high cation levels	Onyema, 2013
Hemidiscus cuneiformis	Alkaline pH/high cation levels	Onyema, 2013
Leptocylindricus danicus	Alkaline pH/high cation levels	Onyema, 2013
Chaeceras convolutus	Alkaline pH/high cation levels	Onyema, 2013
Bacillaria paxillifer	Alkaline pH/high cation levels	Onyema, 2013
Gyrosigma spp	Alkaline pH/high cation levels	Onyema, 2013
Hantzschia amphioxys	Alkaline pH/high cation levels	Onyema, 2013
Odontella spp	Alkaline pH/high cation levels	Onyema, 2013
Pleurosigma angulatum	Alkaline pH/high cation levels	Onyema, 2013
Eunotia monodon	Acidic water solution	Onyema, 2013
Aulacoseira spp	Moderate organic pollution	Onyema, 2013
Cyclotella menighiniana	Organic pollution	Onyema, 2013
Pinnularia major	Organic pollution	Onyema, 2013
Pinnularia gibba	Organic pollution	Onyema, 2013

Phytoplankton	**Indications**	**Authors**
Synedra spp	Moderate organic pollution	Onyema, 2013
Surirella spp	Moderate organic pollution	Onyema, 2013
Thalassiosir arutula	Oligotrophic water	Fonge *et al*., 2012
Thalassiothrix frauenfeldii	Oligotrophic water	Fonge *et al*., 2012
Thalassiosira nitscheri	Oligotrophic water	Fonge *et al*., 2012
Caloneisbacillum	Oligotrophic water	Fonge *et al*., 2012
Coscinodiscus lacustris	Oligotrophic water	Fonge *et al*., 2012
Cyclotella meneghirians	Mesotrophic water	Fonge *et al*., 2012
Euglenophyleae		
Euglena acus	Organic pollution	Onyema, 2013
Phacussp	Organic pollution	Fonge *et al*., 2012
Trachelomonas hispida	Eutrophic water	Fonge *et al*., 2012
Euglena spingyra	Eutrophic water	Fonge *et al*., 2012
Dinophyleae		
Ceratium spp	Alkaline pH	Fonge *et al*., 2012
Peridinium	Shallow aqua zone	Fonge *et al*., 2012
Chrysophyceae		
Chrysotephanosphoera globulifera	Acidic water	Fonge *et al*., 2012
Synura uvella	Acidic water/shallow aqua zone	Fonge *et al*., 2012

Table 2. Groups of zooplankton as bioindicators

Zooplankton	**Indications**	**Authors**
Rotifer group		
Keratella tropica	High turbidity/Non polluted water	Komala *et al*., 2013
Keratella quadrata	Non-polluted water	Komala *et al*., 2013
Brachianus carlyciflorus	Eutrophication	Komala *et al*., 2013
Bronchinus caudatum	Non-polluted water	Komala *et al*., 2013
Trichocerca spp	Eutrophication	Ismail and Adnan, 2016
Asplachna spp	Eutrophication	Ismail and Adnan, 2016
Polyarthra spp	Eutrophication or polluted water	Ismail and Adnan, 2016
Lecane	Polluted water	Ismail and Adnan, 2016
Ephiphanes macrourus	Non-polluted water	Komala *et al*., 2013
Diurella spp	Non-polluted water	Komala *et al*., 2013
Gastropus hytopus	Non-polluted water	Komala *et al*., 2013
Cladocera group		
Trichotriate traits	Heavy metal pollution	Komala *et al*., 2013
B. angularis and Rotatona	Eutrophication condition	Komala *et al*., 2013
Moina	Eutrophication condition	Komala *et al*., 2013
Daphnia	Eutrophication condition	Komala *et al*., 2013
Bosmina	Eutrophication condition	Komala *et al*., 2013
Thermocycops spp	Eutrophication condition	Komala *et al*., 2013
Macrocyclops spp	Eutrophication condition	Komala *et al*., 2013
Mesocyclops spp	Eutrophication condition	Komala *et al*., 2013
Cyclops spp	Eutrophication condition	Komala *et al*., 2013
Diaphanosoma spp	Non-polluted water	Komala *et al*., 2013
Nauphus spp	Non-polluted water	Komala *et al*., 2013
Nuplius spp	Non-polluted water	Komala *et al*., 2013
Zoea larva	Non-polluted water	Komala *et al*., 2013
Copepods		
Cyclops	Entrophic conditions	Neto *et al*., 2014
Calanoids	Oligotrophic conditions	Neto *et al*., 2014
Phyllodiaptamus	High acidity level	Parmar *et al*., 2016