Biomonitoring: An appealing tool for assessment of surface water Quality

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Abstract

Biomonitoring offers an appealing tool for the assessment of surface stream pollution in aquatic ecosystem. The bioindicator Benthic Macroinvertebrates for their advantages and disadvantages in practical biomonitoring of surface stream pollution. The common biomonitoring parameters are classified as Biological Monitoring Working Party (BMWP) Score and Sequential Comparison Index are discussed. The potential applications of biomonitoring are proposed to mainly include evaluation of water quality and toxicology prediction and researches on toxicological mechanism for surface water.

This study gives an introduction of biomonitoring concept and its application as complementary procedure of physico-chemical monitoring of water bodies for water quality assessment, because of some limitations i.e. analysis cost, unavailability of water in summer season and very low concentration of pollutants or chemical entities to be detected by analytical instruments or analysis methods (scope) etc. In this paper, we present a review on concepts and current use of biomonitoring approaches i.e. Use of Benthic Macro invertebrates as bio indicator of water quality of water bodies i.e. River stream, lakes and canals. Benthic macroinvertebrates are the most common indicators in biomonitoring, which can be used separately for water quality assessment.

Keywords: water, pollution, water quality, biomonitoring, Benthic macroinvertebrates, river stream, saprobic score (BMWP), diversity index, biological water quality, use of water, bio mapping.

Introduction

India is healthy in water resources, filled with a network of rivers and blessed with snow cover in the Himalayan range that contains a variety of water requirements of the country. However, with the rapid increase in the population of the country and the need to satisfy the increasing demands of water for irrigation, municipal and industrial usage, the available water resources in many parts of the country are getting depleted and the water quality has deteriorated. Indian rivers are polluted due to the discharge of untreated and treated wastewaters (sewage and industrial effluents). (Internet, 2016)

To ensure that the water quality is being maintained or restored at accepted level, it is important that the monitoring is done on regular basis. Water quality monitoring helps in evaluating the nature and extent of pollution control required and effectiveness of water pollution control measures already in practice. It

also helps in mapping the current water quality trends and prioritizing pollution control efforts done by Industries and controlling authorities.

Water quality Assessment is the overall process of evaluation of the physical, chemical and biological nature of water in relation to natural quality, human effects and intended uses, particularly uses which may affect human health and the health of the aquatic system itself. While Water Quality Monitoring is the actual collection of information at set locations and at regular intervals in order to provide the data, which may be used to define current conditions, establish trends, etc.

In India, Central Pollution Control Board (CPCB) has derived primary water quality criteria (PWQC) as required in the designated best uses of river stretches to identify beneficial uses of water in terms primary water quality criteria parameters. In this way, the 'Designated-Best-Use' concept was evolved.

Monitoring of environmental components is an important prerequisite for pollution control activities. It is difficult to monitor water quality only by using physico-chemical methods. To overcome this difficulty, environmental scientists, all over the world, are exploring the possibility of using biomonitoring techniques in addition to physicochemical monitoring.

Bio monitoring is the introduction of biological variables for assessment of the structural and functional aspects of aquatic ecosystems. There are many Methods of biomonitoring is available i.e. Bioaccumulation monitoring -for measurements on chemical concentrations in biological material. Toxicity monitoring -for measurements on the direct bio molecular and physiological responses of individual organisms towards toxicants in an experimental setup, including bioassays and biological early warning systems. Ecosystem monitoring- for measurements on the integrity of ecosystems which is in many cases related to all kinds of environmental perturbations. This type of biomonitoring will include inventories on species composition, density, diversity, availability of indicator species, rates of basic ecological processes, etc.

This study uses the different Benthic macroinvertebrates species as indicator of water quality. Out of the million or more-animal species in the world, more than 98% are invertebrates. They don't have an internal skeleton made of bone. Many have fluid-filled, hydrostatic skeleton (i.e. jellyfish or worm). Others have a hard-outer shell (i.e. insects and crustaceans). Common invertebrates include the protozoa, annelids, echinoderms, mollusks and anthropods (jointed limbs for movement). this invertebrate requires clear, cool water, adequate oxygen, stable flows and a steady source of food in order to completer their life cycle.

Materials and Methods

This study involves the various methods for sampling of invertebrates i.e. rapid monitoring and use of artificial substratum. Artificial substratum (USEPA) helps to colonize the Benthic invertebrates in the fabricated cage i.e. sampler, which is filled with natural pebbles and immersed in the stream for one month. There after retrieving it, the species of animals which are colonized on the substratum are collected and evaluated for water quality. (USEPA)

Location and Duration of Monitoring

To get genuine results, Bio monitoring needed to be done during the biologically mature period of the year. In India, monsoon season occurs for a limited period of time but the intensity is very high. The entire biological system habituated in the water during the exceptional period is disturbed because of rapid increased flows and flood conditions. After the monsoon period the biological system start rehabitating and

reestablishing. After gradual succession, “mature” ecosystem establishes. This is the right time for biological sampling.

The sampling time for Biomonitoring is preferably selected in the early morning and/or before sunset because many of the species of macroinvertebrates avoid the extreme sun light and temperature and rest under the rocks and bottom sediments.

Reference station for these studies should be fixed in the upstream where there is no human intervention (disturbances) or any anthropogenic pressure and sampling point should be downstream of each discharge point identified after the complete mixing.

Selection of Monitoring Parameters

This study involves the use of two known parameters i.e. Biological monitoring working - party (BMWP) Score or saprobic score and sequential comparison index or Diversity score.

Biological Monitoring Working Party (BMWP) Score or Saprobic Score

This scoring system was basically evolved for British rivers and it was tried with some minor modifications on River Yamuna during the pilot study under the indo-Dutch project (January 1994) by Central Pollution Control Board, the method was found quite suitable. The biological scores allocated to groups of organisms by Biological Monitoring Working Party (BMWP) Score is as shown bellows:

Table-1: Biological Monitoring Working Party (BMWP) Score or Saprobic Score

Group	Families	Score
Mayflies, Stoneflies, River bug, Caddisflies or Sedge flies	Siphlonuridae, Heptageniidae, Leptophlebiidae, Ephemerellidae, Potamanthidae, Ephemeridae, Taeniopterygidae, Leuctridae, Capniidae, Perlodidae, Perlidae, Chloroperlidae, Apheloceridae, Phryganeidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Lepidostomatidae, Brachycentridae, Sericostomatidae	10
Crayfish, Dragonflies	Astacidae, Lestidae, Agriidae, Gomphidae, Cordulegasteridae, Aeshnidae, Corduliidae, Libellulidae	8
Mayflies, Stoneflies, Caddisflies or Sedge flies	Caenidae, Nemouridae, Rhyacophilidae, Polycentropodidae, Limnephilidae	7
Snails, Caddisflies or Sedge flies, Mussels, Gammarids, Dragonflies	Neritidae, Viviparidae, Ancylidae, Hydroptilidae, Unionidae, Corophiidae, Gammaridae, Platycnemididae, Coenagrionidae	6
Bugs, Beetles, Caddisflies or Sedgeflies, Craneflies/Black flies, Flatworms	Mesoveliidae, Hydrometridae, Gerridae, Nepidae, Naucoridae, Notonectidae, Pleidae, Corixidae, Haliplidae, Hygrobiidae, Dytiscidae, Gyrinidae, Hydrophilidae, Clambidae, Helodidae, Dryopidae, Elmidae, Chrysomelidae, Curculionidae, Hydropsychidae, Tipulidae, Simuliidae, Planariidae, Dendrocoelida	5
Mayflies, Alderflies, Leeches	Baetidae, Sialidae, Piscicolidae	4

Snails, Cockles, Leeches, Hog louse	Valvatidae, Hydrobiidae, Lymnaeidae, Physidae, Planorbidae, Sphaeriidae, Glossiphoniidae, Hirudidae, Erpobdellidae, Asellidae	3
Midges	Chironomidae	2
Worms	Oligochaeta (whole class)	1

Principle of Analysis

Macroinvertebrates are sampled from the different habitats of different water bodies at representative sites on river stretches and analysed their score from the (table-1) for each particular species. This value will always be between 0 to 10.the BMWP score >100 and with ASPT value >4 will be indicate the good water quality. (M.H Bhadrecha)

Total BMWP site score or Average score per taxon(ASPT)

$$= \frac{\text{Total score}}{\text{total numbers of families encountered}}$$

Sequential Comparison Index or Diversity Score

The methodology involves pair wise comparison of sequentially encountered individuals and difference of two Benthic animals can be observed up to the species level, where no taxonomic skill is required. The diversity is the ratio of the total number of different animals (runs) and the total no of organisms encountered. The ratio of diversity has a value between 0 and 1. High diversity of macroinvertebrates always supports good water quality. (Hawkes, 1998)

Diversity index

$$= \frac{\text{total numbers of runs}}{\text{total numbers of species encountered}}$$

These parameters are included in Biological Water Quality Criteria (BWQC), which is reference value given by Central Pollution Control Board (CPCB) for water quality measurement (assessment), which gives water quality characteristics i.e. pollution level, water quality classes and its best designated use. We can also compare the results of both Primary Water Quality Criteria (PWQC) and Biological water quality criteria (BMQC).

Biological Water Quality Criteria (BWQC)

To determine the true health of water bodies, CPCB has derived a Biological Water Quality Criteria (BWQC) for water quality assessment. This method is based on the range of saprobic values and diversity of the Benthic macroinvertebrates species with respect to water quality. This system has been developed after extensive field trials and calibration on the saprobity and diversity information of different taxonomic groups of macroinvertebrates collected from artificial substratum and natural substratum of various water bodies. (Central Pollution Control Board, 1995-1996)

Table-2: Biological Water Quality Criteria (BWQC)

Sr No	Range of Saprobic Score	Range of Diversity Score	Water Quality	Water Quality Class	Indicator Colour
1	7 and more	0.2-1.0	Clean	A	Blue
2	6-7	0.5-1.0	Slight Pollution	B	Light Blue
3	3-6	0.3-0.9	Moderate Pollution	C	Green
4	2-5	0.4-less	Heavy Pollution	D	Orange
5	0-2	0-0.2	Severe Pollution	E	Red

Conclusion

Many Benthic macro invertebrates cannot survive in the polluted water; others can survive in polluted water. In a healthy stream, Benthic macroinvertebrates community will include a variety of pollution sensitive macro invertebrates. In an unhealthy stream, there may be only a few types of non-sensitive macro invertebrates present. Their taxonomical analysis as described in this study can reveal state of water quality.

Bio monitoring using macro invertebrates as bio indicator is the assessment of the biological status of population and communities at risk in order to protect them and can be used as early warning of for undesirable change in an aquatic ecosystem and for overall environmental health.

It can be used for the bio assessment of water quality at raw water intake points for drinking purpose, canal waters and also for river. Major discharge of treated and untreated wastewater/sewage is done in the river so impact of these discharges can be evaluated by this type of assessment study. The flowing water has significant self-purification capacity and following the construction of dam or barrage or development of canal network for irrigation on a river It impairs - with - the environmental (natural) water flow in rivers therefore rivers cannot undergo self-purification, so it affects the self-purification capacity of the river and thus river stretches gets polluted and aquatic ecosystem is sacrificed.

Bio monitoring of rivers based on the results with different water quality color codes can be done, then it is easy to locate various stretches of rivers with their extent of pollution. With this knowledge, appropriate policies can be made to fight the problem and increase the quality of water as a part of efficient resource utilization of the waterbodies.

References

Central Pollution Control Board. (1995-1996). *Bio monitoring of water: Newsletter.* NewDelhi: CPCB.

Hawkes, H. A. (1998, March 1). Origin and development of the biological monitoring working party score system. *Water Research, 32*(3), 964–968.

Internet. (2016).

M.H Bhadrecha. (n.d.). Biomonitoring: a concept and its implications. *National symposium on Advances in Environmental Science.* Gandhinagar: Central Gujarat University.

Manual on integrated water Quality Evaluation,Indo-Dutch project report. (January 1994).

USEPA. (n.d.). *Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers:Periphyton, Benthic*

Macroinvertebrates, and Fish (2nd ed., Vols. EPA 841-B-99-002). Washington, DC. Retrieved from http://www.epa.gov/OWOW/monitoring/techmon.html

USEPA. (n.d.). *Rapid Biological Assessment Protocols.*