Concept paper on water quality assessment using benthic macro-invertebrates and application of assessment tool to Indian rivers and streams

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ABSTRACT

The development of assessment system is based on a set of parametric data covering streams types in different Eco –regions. Altogether, 374 benthic macro-invertebrate samples were taken using a standardized multi-habitat sampling procedure and a large number of parameters describing the streams and their catchments are recorded for all sampling sites. A large number of metrics will be tested, independently and in combinations, for each of the stream types, to identify the degradation of a site. This multimetric assessment system is used to classify a stream stretch into an Ecological Quality Class ranging from 1 (high quality) to 5 (bad quality) and often provides information on the possible causes of degradation.

Introduction

Water is a very important natural resource and is being presently exploited indiscriminately by humans. As a result, the water resources are getting depleted and polluted by anthropogenic sources and clean and fresh water has become a rare commodity almost all over the world. There has therefore always been a strong need to develop a suitable water quality assessment tool which should be less time consuming, requiring minimum expenditure and be reliable and can be applicable to larger number of rivers and streams flowing in different ecoregions.

Water quality assessment is the overall process of the evaluation of the physical, chemical and biological nature of water in relation to natural quality, human effects and intended uses, particularly usages that may affect human health and the health of the aquatic system itself. Any water quality assessment has the following common objectives:

▪ Identification of status and trends in water quality, both in terms of concentrations and its effect/impact.
▪ Identification of the mass flow of contaminants in surface water and effluents for assessing the fluxes.
▪ Formulation of standards.
▪ Comparison of existing conditions with standards and classifications for surface waters for intended uses.
▪ Water quality mapping of rivers & streams.
▪ Selection of treatment method for mitigating the pollution.

Water Quality Assessment Methods

Two basic types of assessment methods have been developed viz.

Physico – Chemical Methods

Traditionally, pollution control agencies all over the world relied on physico –chemical approaches to regulate the discharges of pollutants into the rivers & streams. This approach involved specification of standards and reduction in the loads and concentrations of a number of priority pollutants in surface water and wastewater. Over time, it has become apparent that a chemical-specific approach, by itself, can not adequately serve to provide the complete spectrum of information to protect the surface waters from pollution effects and requires certain other parameters of biological nature to completely explain the fate of pollutants discharged.

Biological Methods

Bio-monitoring has been found an important tool in understanding the ecosystem dynamics with varying degrees of anthropogenic pressures. The biological communities like plankton, periphyton micro-phytobenthos, maco-zoobenthos, aquatic-macrophytes, macroinvertebrates, fishes etc. have been used to assess the water quality of rivers & streams. The integration of biological method with physico-chemical method help to provide inexpensive system which can generate necessary information with maximum efficiency.

Advantages of Biological Assessment

a) The biological methods are quite quick, economical and can be integrated with other relevant studies.
b) Much less equipments are required and large area can be surveyed in less time resulting in large amount of information suitable for assessment.
c) Provide cheaper option in comparison to physico-chemical assessment, where chemical analytical equipment, manpower and operational cost is very high.

Experience from North America, Europe, Australia and India has demonstrated that most useful biological assessment methods for routine monitoring of wadeable streams & rivers are based on benthic macroinvertebrates which are the organisms without backbone, large enough to be seen without magnification, widespreadly and commonly available in streams and rivers worldwide and are thus, broadly, used as bio-indicators. Generally, due to their large number of species and their wide range of systematic origin (e.g. worms, molluscs, crayfish and insects), benthic macroinvertebrates are capable of

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reflecting different human-induced deteriorations like organic pollution, acidification, habitat modification and overall stream degradation and disturbances and enable a comprehensive assessment of streams and rivers. The bio-assessment by such organisms has the following benefits:

(a) It demonstrates a strong relationship to pollution & helps detect variety of environmental stream types.

(b) Sufficient numbers of macro invertebrates are comparatively easy to identify with naked eye, thus, reducing the assessment cost.

(c) These comprise species with both short & long life span, which allows integration of data over various time scales.

(d) The macroinvertebrates taxa based score system may be used to construct/develop suitable water quality models that can be applied to larger streams and rivers and thus the outcome may help to manage the water resources.

Water Quality Assessment By Aquatic Macroinvertebrates
General

Out of the above biological methods, aquatic macroinvertebrate based assessment method has been reported to be successfully used by European and other countries for preparing water quality maps of important rivers and streams in India. The approach has been used by Central Pollution Control Board, but is confined to the water quality assessment at certain locations only and as such could not be applied to larger rivers. The proposed methodology is new and innovative to asian countries and accordingly the experts from five Asian countries viz. Nepal, India, Bangladesh, Pakistan & Bhutan, and three European countries viz. Austria, Czech Republic and Germany are working together on ASSESS-HKH project to develop assessment tools for river assessment and river basin management for the Hindu Kush-Himalayan (HKH) region. The project has the following main objectives:

1) To develop and validate a three-stage methodology, using benthic invertebrates from a manually calculated overview method to computer-aided analyses and to identify environmental hot spots in rivers of the HKH region.

2) To adapt and develop an information management tool (application software and databases) to perform analysis calculations for quantification and rating of ecological status of rivers based macroinvertebrate data.

3) To interpret ecological data collected in the HKH region to validate the assessment methodology and information management tool and provide a basis for policy recommendation, transnational water resource planning and ecosystem management.

4) To build capacity in the field of recognition and application of criteria for biological indicators in ecosystem management.

5) To disseminate and create awareness about the methodology.

Methodology

Following steps are involved in the methodology being developed:

a) Determination of Stream typology
b) Selection of stream types in the area
c) Selection of stressors / pressures
d) Preselection and Preclassification of reference and impacted sites
e) Multi Habitat Sampling (MHS)
f) Physico-chemical and microbiological analysis
g) Complete sorting and identification of macroinvertebrates
h) Development of macroinvertebrates taxa keys
i) Storage of data in HKH *dip* Data input program

j) Multi metric assessment using Eco data management tool
k) Assignment of water quality classes
l) Development of Water quality maps for representative river sections.
m) Policy recommendations for mitigation strategies for sustainable water management

Sampling methodology

A sample consists of collection of 20 sub samples each of (0.25×0.25) m^2 taken from all microhabitat types. This procedure results in sampling of approximately 1.25 m^2 stream bottom area. Net of mesh size 500 μm is used for collecting the macro invertebrates. Every large boulder or cobble in the area is picked up if it could be lifted and organisms vigorously washed by hand into the net. Finally, substrate with smaller boulders should be disturbed by kicking systematically across the area 3-4 times such that the invertebrates wash downstream into the net. The organisms are then carefully picked from the net surface and preserved immediately in 80% ethanol or 4% formaldehyde. These samples are returned to the laboratory for processing. Specimens collected are sorted and identified to operational taxonomic unit (at least to family level with the help of regional keys) in the laboratory under a dissecting microscope.

A comparison of communities in disturbed river reaches with community under near natural conditions enables one to evaluate the degree of deterioration and provide the avenue for taking appropriate mitigation measures to bring the quality of streams to its original.

Scope of future work:

The procedure described above has been well tested and used by more than 20 institutions from 13 countries and is widely accepted by Europe and North America, Australia and South Africa, and is presently being given increasing importance in countries of the HKH region.

Most of the assessment methods used in the past have focused only on the impact of organic pollution. However the methods developed can focus on the impact of a number of stressors like stream habitat degradation, effect of hydro power generation, toxicity, acidification, eutrophication etc. on the aquatic biota and water quality.

The entire methodology, once developed, applied to streams and smaller / medium rivers of a given ecoregion, can be applied to larger rivers and streams in the country for assessing the status of pollution, sources of pollution and taking appropriate treatment methods for bringing the resource to its better quality.

Conclusion

In recent years, the environment has been put to serious threat due to the discharge of harmful and toxic chemicals of various types which are primarily the byproducts of developmental activities like industrialization, urbanization, use of chemical fertilizers as well as pesticides and burning of fossil fuel emitting green house gases. Huge oil spills in the oceans and radioactive fallout are contaminating air, water and soil. In the event of large scale eco-degradation, it is necessary to monitor the nature and degree of change in environment so that the consumers may be warned and appropriate preventive and specific corrective measures may be adopted. After the UN conference on the Human Environment in Stockholm in 1972, the global Environmental Monitoring System (GEMS) has been set up. Literature is missing today. Environmental monitoring requires authentic data base and is considered as an useful tool in assesses the health of the environment. Furthermore, it is an

indispensable prerequisite for Environmental Impact Assessment (EIA). Biomonitoring is an important exercise in the assessment of water quality. The present paper aims to discus the concept scope and procedure of biomonitoring. The concept of indicator species has been explained, species can be classified in tolerant facultative and sensitive groups. A holistic approach for water quality assessment has been suggested.

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