GANGA POLLUTION BIOTIC INDEX

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ABSTRACT: River Pollution Biotic Index is a data sheet prepared to know the ecological health of the River and it should be correlated every year to know the changes in the ecological status of the river. The present study deals with River Ganges over a stretch from Buxar to Patna. The Ganges Pollution Biotic Index (GPBI) would help the researcher to know the past, present and future health of the River.

Key words: ***Ganga, pollution, Biotic Index, Benthic Invertebrates, Principal Component analysis, GPTS (Ganga Pollution tolerance score).***

INTRODUCTION: In the Ganges river basin, there is a high need for the development of a Ganges Pollution Biotic Index (GPBI) in order to evaluate the ecological status of the Ganges based on a standardized protocol. This study provides a discussion on the methodology which should be followed in order to construct a GPBI, and the primary choices which have to be made.

METHODS AND METHODOLOGY: First of all, it should be decided whether to construct a GPBI from scratch (e.g., Chowdhury et al., 2016) or to modify an existing and generally accepted biotic index (e.g., Fishar & Williams, 2008)

The constructed GPBI should meet the following requirements: (1) simple to use in the field and in the laboratory, (2) fast, (3) reliable, (4) cost-effective, (5) practical, (6) widely applicable to a variety of watercourses and/or lakes, (7) be based on established ecological concepts, (7) limited need for expert taxonomical knowledge, (8) easily understandable, (9) associated to relevant water quality parameters, and (10) be able to discriminate human impacts (Chowdhury et al., 2016; De Pauw & Vanhooren, 1983).

The GPBI should be based on the pollution tolerance of benthic macroinvertebrates. The use of benthic macroinvertebrates for biological water quality assessment has several advantages:

(1) relatively long life cycles which reflect pollution effects over longer time periods, (2) fairly sessile and often confined to one habitat or locality, (3) easy to sample, (4) ubiquitous and abundant, and (5) wide variety of species and traits which reflect a spectrum of environmental processes.

An important consideration is whether one GPBI should be established for the entire Ganges river or whether multiple types of GPBI, i.e., one GPBI per ecological segment or sub-stretch as defined by the Ganga River Basin Environment Management Plan should be developed. The latter might be considered since the Ganges river ranges over a wide variety of ecosystems (Ganga River Basin Environment Management Plan,). If this option is chosen, the division of the Ganges in segments and sub-stretches should be re-evaluated based on the existing ecological boundaries of the river. For certain, separate GPBI's should be developed for the fresh-, brackish-, and saline water zones of the Ganges (De Pauw & Vanhooren, 1983).

Sampling and survey sites:

For the development of the GPBI, a set of survey sites, ranging over a wide variety of pollution levels, should be identified. Unpolluted reference sites are of vital importance. If such sites cannot be identified, 'minimally polluted sites' must be recognized. In the Ganges river basin, the Chambal river could provide unpolluted reference sites (Kumar et al., 2014; Yadav et al., 2014 & 2015).

Data analysis

From these sites, physico-chemical data including temperature, pH, DO (mg/L or %), BOD5, COD, Kjeldahl nitrogen, total nitrogen, NH3, $NO2^-$, $NO3^-$, $PO4^{3-}$, TSS, TDS etc. should be collected (Chowdhury et al., 2016; Fishar & Williams, 2008). Subsequently, the obtained data should be used to evaluate the physico-chemical water quality of the studied sites, either through a chemical pollution index (e.g., Fishar & Williams, 2008) or Principal component analysis(PCA) (e.g., Chowdhury et al., 2016).

Biological samples, i.e., benthic macroinvertebrates, need to be collected from the same sites. A standardized sampling technique should be developed and different sampling procedures must be established for different environments, i.e., the sampling method should be adjusted to the river's depth and current speed (e.g., De Pauw & Vanhooren (1983) and Gabriels et al. (2010)). All habitats must be sampled in proportion to their abundance in the study area..

To obtain maximum comparability and accuracy of the results, a standardized macroinvertebrate identification technique must be developed, preferably based on generally accepted taxonomic keys, i.e., handbooks and publications (De Pauw & Vanhooren, 1983). A correct identification up to species level requires time and taxonomic expertise. Systematic identification up to a more general level, e.g., family or genus, will be more practical, especially in developing countries where taxonomy is not well developed and where a large number of biological samples need to be processed in a restricted period of time (De Pauw & Vanhooren, 1983; Fishar & Williams, 2008). Gayraud et al. (2003), state that family identification of macroinvertebrates is sufficient to differentiate sites of different water quality.

As indicated by Chowdhury et al. (2016) and Gabriels et al. (2010), the influence of seasonality and monsoonal rains on ecology and physico-chemical water quality of rivers cannot be neglected when developing a biotic index system. Sampling surveys should be performed during the dry- and wet season in order to assess the impact of the monsoon. Haentjens (2017) studied the effect of the monsoon on the physico-chemical water quality of the Ganges, however, a similar study on Ganges ecology is still missing. PCA can be applied to evaluate the significance of the seasonality and monsoonal rains impact (Chowdhury et al., 2016).

The GPBI should include all benthic macroinvertebrate taxa occurring in the Ganges river basin. A Ganges Pollution Tolerance Score (GPTS) should be assigned to each taxon. This can be done through various methods:

1. Extensive literature study, i.e., apply tolerance scores from existing studies.
2. Apply the tolerance score of the biotic index method, e.g., the biological monitoring working party (BMWP), on which the development of the GPBI is based (Fishar & Williams, 2008).
3. The tolerance score can be based on the Saprobien System (Fishar & Williams, 2008)
4. Apply a statistical method, e.g., Chowdhury et al. (2016).
5. Assign tolerance scores based on field observations, i.e., evaluate the tolerance of a taxonomic group in the presence of known pollution (Fishar & Williams, 2008).
6. Assign tolerance scores based on laboratory experiments, i.e., based on ecotoxicological information (Fishar & Williams, 2008).
7. Combine two or more of the above mentioned methods.

The obtained GPTS's can be validated by evaluating their relationship with tolerance scores of existing and generally accepted biotic index methods (Chowdhury et al., 2016).

Qualitative and quantitative analysis: An important decision which needs to be made is whether the GPBI calculation will be based on a qualitative or quantitative method. A qualitative method is based on the presence and absence of taxa and not on taxa abundance (e.g., Fishar & Williams, 2008). Fishar & Williams (2008) provide a simple qualitative biotic index calculation method, i.e., the biotic index equals the sum of the tolerance scores of the observed taxa. A quantitative method is based on both the presence and absence of taxa and on their abundance (e.g., Chowdhury et al., 2016). Chowdhury et al. (2016) provide a simple equation for a quantitative biotic index calculation, i.e., the sum of the taxa products (number of specimens per taxon multiplied by the taxon's tolerance score) divided by the total amount of scored taxa. An alternative is to use a 'semi-quantitative' method, i.e., a taxon is only taken into account when more than one specimen is observed, however, the taxon's abundance is not taken in account (De Pauw & Vanhooren, 1983).

Another important decision is whether the GPBI should be type specific or non-type specific. In a type specific method, the index calculation depends on the examined river-type (e.g., Gabriels et al., 2010). In a non-type specific method, the river-type is not taken into account (e.g., De Pauw & Vanhooren, 1983)

Subsequently, the range of possible GPBI values should be subdivided into ecological water quality classes, i.e., from non-polluted to heavily polluted classes (e.g., Chowdhury et al., 2016; De Pauw & Vanhooren, 1983).

When the construction of the GPBI is completed, the GPBI method should be validated.

Multiple validation methods are possible:

1. The GPBI results can be compared to the results of other biotic indexes, e.g., BMWP, and chemical indexes of the same samples. As such, the level of agreement between the ecological water quality results and physico-chemical water quality results can be used for the validation (e.g., Fishar & Williams, 2008).
2. The correlation between the GPBI results and a suite of standardized biodiversity metrics, e.g., Richness, Shannon Diversity Index, Variance, Abundance, Simpson's

Diversity Index, Community Dominance Index etc., can be used as a validation tool and to assess the ability of the GPBI to reflect different aspects of aquatic communities, such as diversity, sensitivity and pollution tolerance (Chowdhury et al., 2016).

3. The GPBI can be validated through correlation with physico-chemical parameters, e.g., O2 concentration and -saturation, Kjeldahl nitrogen, total nitrogen, ammonium, nitrite, nitrate, total phosphorous, ortho-phosphate, BOD5 and COD (Gabriels et al., 2010).

Important to note, the development of the GPBI will be an iterative process. The assigned tolerance scores should be regularly revised based on newly obtained ecotoxicological information and field observations (Fishar & Williams, 2008). In addition, the list of taxa should be regularly updated to include newly encountered taxa. A GPTS should also be assigned to these new taxa (Chowdhury et al., 2016; Gabriels et al., 2010). The GPBI should be tested at different sites, over different years, including pollution incidents. The GPBI should be able to reveal intermittent or unrecorded chemical pollution accidents (Fishar & Williams, 2008).

Based on the high urgency of a GPBI to evaluate the ecological water quality of the Ganges, it might be useful to first develop a simple, i.e., non-type specific and qualitative, GPBI by modifying an existing and generally accepted biotic index. Over time, a more complex and representative GPBI can be developed based on newly obtained data and experience.

In 1995, De Zwart et al. (1995) already developed a biotic index, i.e., the Biological Saprobity Index (BSI), to evaluate the ecological water quality of all Indian rivers. The BSI was developed by modifying the BMWP system (Metcalfe, 1989), i.e., including Indian species in the benthic macroinvertebrate list. Tolerance scores were assigned based on the Saprobien System and taxonomic identification up to family level was regarded as sufficient. The BSI is a qualitative, non-type specific method which can only be used in fresh water rivers.

Despite the simplicity and promising potential of the BSI, no studies applying the BSI on the Ganges river basin were found. The biotic index developed by De Zwart et al. (1995) could serve as an auspicious starting point for the development of the GPBI. However, the biotic index of De Zwart et al. (1995) should be updated to include state-of-the-art technologies and newly encountered Indian species.

CONCLUSION:

The present study reviews different studies of research on river water pollution and their indices to know the ecological health of the river. In developing countries there is a constant lack of data about the ecological health. The development of GPBI over a stretch or whole of river flow would be very helpful to the researcher and academician. Its needs constant support from the Government, public and researcher in an holistic way.

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