Ecological Health Monitoring Used for River Ecosystems in Jammu and Kashmir India: Challenges and Prospects

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Abstract: ***This paper discussed on status and prospect of ecological health monitoring used for river ecosystems. In Kashmir, phytoplankton, zooplankton and benthic macroinvertebrates have been used the most common bioindicators in ecological health monitoring, which have been used simultaneously in the environmental monitoring framework of the Jal Shakti (PHE) Department, Jammu and Kashmir and other environmental protection agencies as well. Their importance in the ecosystems and advantages for ecological health monitoring in Kashmir have been described in detail. Common methods used for ecological health monitoring have included diversity, biotic indices, multimeric approaches and Functional Feeding Groups (FFGs). Among these techniques, diversity and biotic indices were most frequently used to evaluate the ecological health of streams and rivers in Kashmir. However, multimeric measures have been increasingly applied in recent years to reflecting ecological integrity and integrated ecological health assessment as well. The review reflected that biomonitoring especially ecological health monitoring on Kashmir river systems is not only challenges but prospects as well.***

Keywords: ecological health monitoring, river ecosystems, bioindicators, ecological integrity, review

1. Introduction

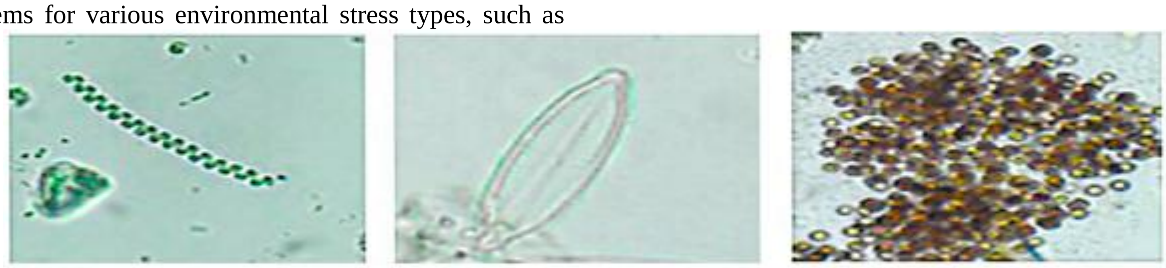
One of the major challenges that mortal society faces moment is achieving those Millennium Development Goals that relate to the use of water coffers (Revenga etal.2005). Still, the pollution, declination and overexploitation of water, especially inland water coffers have rebounded in severe problems among the environmental issues in the world (Corvalan etal.2005; Li etal.2010). Utmost submarine ecosystems have been vulnerable to a wide range of mortal conditioning. Especially, swash ecosystems were fleetly disturbed by heavy pollution sources from artificial backwaters (Kim & An 2015). In addition to the challenges posed by land use change, environmental pollution, and water diversion, submarine systems were anticipated to soon begin passing the added stress of global climate change (Poff et. al.2002). Thus, the water resource operation has been one of the most significant natural resource operation issues of all countries, particularly related to how to find an applicable balance between ecosystem health and profitable development. Likewise, numerous countries have concentrated on erecting up the establishment of the frame as well as styles e.g. biomonitoring system, for the submarine environmental impact assessment and protection. In biomonitoring, the bioindicator groups (phytoplankton, zooplankton, macroinvertebrates) give a broad orders of the ecological health of swash systems, in which each natural group has its own distinct advantages. The colourful analytically natural approaches (e. g. uproariousness, cornucopia, and pollution forbearance) together with the physical and chemical dimension, give precious information for ecological health and environmental assessment (MRC 2010; Kim & An 2015). The endpoints of dimension used for swash ecosystems could be named from any position of natural association (cellular, organ, individual, population, community, and ecosystem) (Li et. al.2010). Still, the literal focus has been on ecological styles and advanced situations of association e. g. species, populations, communities, and ecosystems (Li etal.2010). Regarding the natural styles, two main approaches have been used grounded on community structure, and "index" organisms. An index organism was a species named for its perceptivity or forbearance (more constantly perceptivity) to colourful kinds of pollution or its goods e. g. essence pollution or oxygen reduction (Chapman 1992). The styles to describe community structure or explain the difference between communities has been a primary focus of ecological exploration e. g. phytoplanktonic groups, zooplanktonic groups, oceanographic groups (Cairns et. al.1982). The bioindicators should have the characteristics of (a) taxonomic soundness; (b) wide distribution; (c) low mobility; (d) well - known ecological characteristics; (e) numerical cornucopia; (f) felicity for laboratory trials; (g) high perceptivity to environmental stressor; (h) high capability for quantification and standardization (Rosenberg & Resh 1993; Füreder& Reynolds 2003; Li et. al.2010; Osuji 2014). Biomonitoring involves the use of pointers, index species or index communities. Generally algae, protozoa, macroinvertebartes and fish are used. There are advantages and disadvantages to each. Macroinvertebrates are most constantly used (Rosenberg & Resh 1993). In this paper, we reviewed the history and development of natural monitoring in India, handed the choice of study organisms; handed the importance in the ecosystems and advantages for biomonitoring; handed the approaches of ecological health monitoring. Among the numerous bioindicators of biomonitoring in gutters, aqueducts and lakes, phytoplankton, zooplankton and oceanographic macroinvertebrates have been the major groups generally used for biomonitoring in India. First of all, changes in the phytoplankton community and biomass greatly affected the rest of the pelagic system as well as the oceanographic community (Hoglander et. al.2013). The biomass of phytoplankton affected the light climate for oceanographic macrophytes as well as the nutrient vacuity and oxygen conditions for oceanographic macrophytes through their sedimentation (Fox et. al.2010). High phytoplankton product could lead to high sedimentation rates, performing in plenitude of food for oceanographic communities (Hoglander et. al.2013). Sedimentation of phytoplankton and posterior declination by bacteria also prime to increased oxygen consumption and the threat of oxygen reduction for the benthos (Gihring et. al.2009). Phytoplankton could also affect water quality, by giving water a bad odour when set up in high abundances or by producing poisons that could be released into the water when the phytoplankton degraded or was accumulated in other organisms feeding on the phytoplankton (Zigone & Oksfeldt 2000). Some phytoplankton species caused damage to fish gills, performing in the mortality of wild fish and, for illustration, salmonids in fish granges (Rodger etal.2010). Either, the zooplankton communities in submarine ecosystems are regulated by the variations of physical and chemical conditions which are explosively told by anthropogenic factors (Pourriot&Meybeck 1995). The zooplankton communities, veritably sensitive to environmental variations, were important pointers for assessing the ecological status of submarine ecosystems (Magadza 1994; MRC 2010). They didn't only form an integral part of the lentic community but also contributed significantly, the natural productivity of the fresh water ecosystem (Wetzel 2001). The presence and ascendance of colourful copepod species have been used to characterize the trophic conditions of submarine ecosystems (Park & Marshall 2000; Bonecker 2001). Carnivorous zooplankton was honoured as the main agent for the top - down control of phytoplankton, and the grazing pressure wielded by Cladocera’s and copepods on algae and cyanobacteria was occasionally an important controlling factor of dangerous algal blooms (Boon 1994). For macroinvertebrates, these assemblages were made up of numerous species among which there was a wide range of trophic situations and pollution forbearance (France 1990; Bartram & Balance 1996), hence furnishing strong information for interpreting accretive goods. Community structure of macroinvertebrate assemblages constantly changed in response to environmental disturbances in predictable ways, which was the base for development of bio criteria to estimate mortal influences (Emery et. al.2003). In sluice beach gutters defiled by organic matters or trace essence (De Paw et. al.1996; Pham 2014), species uproariousness and diversity of the macroinvertebrates explosively reduced under the direct and circular impact of pollutants. For illustration, Chironomidae generally held the dominant status at the expenditure of other more sensitive groups, similar as mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichopteran). Benthic macroinvertebrates, especially aquatic insects, have been traditionally used in the biomonitoring of stream and river ecosystems for various environmental stress types, such as organic pollution, trace metals contaminations, nutrient enrichment, acidification, sediments, and toxicants and general stressors (De Paw et al.1996; Pham 2014). Indeed, the macroinvertebrate assemblages constituted the basis of most biomonitoring program currently in Europe and North America. Many countries (or states or water authorities) even have developed their own biotic indices.

2. Bioindicators Usage

The biomonitoring used the species uproariousness and the viscosity of phytoplankton, zooplankton and oceanographic macroinvertebrates were included in the environmental monitoring. Also, the below natural groups have been used to cover the water rates in Kashmir. still, other submarine organism groups similar as fish and submarine macrophytes were also used for the biomonitoring. Their effectiveness when used independently has been demonstrated by numerous studies, e. g., Whitton and Rott (1996), Vis et al. (1998), Potapova (1999), Coste et al. (2008), Li et al. (2010), and Dao and Bui (2016) for phytoplankton; Thorp et al. (2005), Nguyen (2007), Ferdous et al. (2009), and MRC (2010) for zooplankton; Rosenberg and Resh (1993); Lenat and Barbour (1994), Statzner et al. (2001), Li et al. (2010), MRC (2010), and Pham et al. (2015) for oceanographic macroinvertebrates.

2.1 Phytoplankton

Phytoplankton was among the most common organisms on the earth and extensively distribute in numerous different environmental conditions similar as water, soil, air, on trees (Dao & Bui 2016). Still, they substantially presented and well developed in submarine territories including lakes, ponds, budgets, gutters, aqueducts and abysses (Horne & Goldman 1994). Phytoplankton was good pointers of environmental status and quality due to their quick response to changes in environmental pressures similar as nutrient vacuity (Figure 1). In Kashmir, a variety of examinations have been conducted fastening on morphological diversity of phytoplankton (Zutshi, D. P. andB. Gopal, 2000; Kant, S. andP. Kachroo, 1980; Kanon, L. andK. Krishnamurthy, 1985; Palmer, M. C., 1969). still, publications on commerce between phytoplankton and environmental parameters and water quality grounded on phytoplankton from gutters in Kashmir were limited (Javid & Yadav 2009). Javid and Chaubey (2020) applied the species uproariousness and viscosity of phytoplankton to estimate the water quality of Ujh and Jhelum River. Either, the authors reported there was a significant relation between phytoplankton cornucopia and inorganic nitrogen and water temperature (Sarwar, S. G. and D. P. Zutshi).



Spiralina *Naviculla* *Microcystis*

Figure 1: Phytoplankton in freshwater bodies of kashmir used as bioindicators for water quality of oligotrophic (a, Micrasteriasfoliacea), mesotrophic (b, Aulacoseiragranulata) and eutrophic conditions (c, Eudorina elegans). Scale bars = 20 μm.

2.2 Zooplankton

Zooplankton have an intermediate position in the food web, concerning phytoplankton and creatures of advanced trophic situations in food chain similar as shrimps and fishes. Zooplankton are generally small, with little capability to swim against water currents. They include representatives of nearly every taxon of the beast area and do in the pelagic terrain either as grown - ups (holoplankton) or eggs and naiads (meroplankton) (Goswami 2004; MRC 2010). Changes in the water quality as well as zooplankton quality were pointers of rate and magnitude of artistic eutrophication (Kulshresthaetal.1989; Chari & Abbasi 2003) (Figure 2). So far, several examinations on zooplankton from India have been published on morphological biodiversity of zooplankton (Kant, S. and P. Kachroo, 1980; Goswami, S. C.2004; Ferdous, Z. & Muktadir, A. K. M.2009). The signaled zooplankton publications described the zooplankton community in India waters and reported the cornucopia, composition, biomass and their distribution. Either, cephalopod paralarvae would be concentrated. And, some of examinations have been conducted fastening on biodiversity of zooplankton (Ferdous, Z. &Muktadir, A. K. M.2009). still, information and understanding on the commerce between zooplankton and environmental parameters and water quality grounded on zooplankton from gutters in India was limited.

Figure 2: Photographic pictures of Cladocera.1 = Alonaaffinis; 2=Postabdomen of Alonaaffinis; 3= Postabdomen of Alonarectangula with 8 - 9 denticles; 4 = A. monacantha; 5= Postabdomen of A. monacantha; 6= Bosmina longirostris; 7 = Ceriodaphnia sp.; 8= Ceriodaphnia sp. with ephippium; 9 = Chydorus ovalis.

2.3 Benthic macroinvertebrates

Macroinvertebrates were organisms which didn't have a backbone and were large enough to be seen without a microscope. Submarine macroinvertebrates live in water during some period of their life. These organisms, including insects, crustaceans, worms, moochers, and mollusks, enthrall a variety of niches in the submarine community. numerous countries had a long history of using macroinvertebrates to cover the ecological status of swash ecosystems (Hallawell 1986). With the sensitive life stage and fairly long life span (Hutchinson etal.1998), macroinvertebrates have the capability to integrate the goods of short - term environmental variations (Figure 3). In India biomonitoring grounded on oceanographic macroinvertebartes was considered and enforced (Dang etal.1980; Nguyen 1985, 1995; Berge etal.2006; Pham etal.2000, 2003, 2010). Nguyen et al. (2000, 2003) developed the natural surveillance of freshwater using macroinvertebrate. This was a practical primer and identification key for use in India and studied the macroinvertebrates for assessing the water quality in Kashmir Rivers. These styles were applied for fresh water assessment in North Jhelum. In Doodhganga sluice and wular and mansbal lakes (Dar. J. A and Chaubey 2020) Mien etal.2003 has established the group of phytoplankton, zooplankton, and macroinvertebrates similar as bioindicators in the water quality assessment that reflected basically characteristic of regions with their different terrain still, publications on commerce between oceanographic macroinvertebrates and water physicochemical parameters from gutters in India were limited. Some papers set up the variation of species uproariousness and cornucopia with physicochemical variables in both dry and stormy seasons which were used to develop the natural indicators of oceanographic macroinvertebrates for water quality assessment (Abasi et al 2003; Zutshi 2000 and Dar. J. A 2006) developed the rapid - fire assessment of ecological health grounded oceanographic macroinvertebrates and environmental variables in Indian River Systems.

Figure 3: Freshwater benthic macroinvertebrates used aquatic biomonitoring. From the top left: Baetismuticus, Ceratopsychesilfvenii, Isoperla sp., Protonemuraintricata, Rhyacophilanubila and Taeniopteryxnebulosa. These images have been scaled and do not reflect the real size differences between the taxonomic groups.

3. Common methods used for Ecological Health Monitoring of River Ecosystems in India

There were several different biomonitoring approaches presently employed in swash ecosystems (Reece & Richardson 1999). The selection of an applicable approaches depended on the issues being addressed and available coffers. Implicit biomonitoring styles included diversity indicators, biotic indicators, multimetric approaches, multivariate approaches, Functional Feeding Groups (FFGs), and multiple natural traits (MRC 2010; Li etal.2010). Still, the ways of multivariate approaches and multiple natural traits have been started to apply in not further than two studies on swash ecosystems.

3.1 Diversity indices

Stable ecosystems were characterized by a great diversity of species, most of which were represented by relatively few individuals. The community structure approach examined the numerical abundance of each species in a community. The methods widely used to assess aquatic environmental pollution were based on either a diversity index or a similarity index (Chapman 1996, Li et al.2010). As traditional biomonitoring methods, many diversity indices have been developed to describe responses of a community to environmental variation, combining the components of community structure, taxa richness, evenness and abundance such as Jaccard Index (Chapman 1996), Simpson Index (De Paw et al.1996), Margalef Index (De Paw et al.1996), Shannon - Wiener Index (De Paw 1996, Stirling 2002), Eveness Index (Stiling 2002), Begger - Parker Index (Stiling 2002). Although diversity indices are applicable to a variety of aquatic environmental situations which have not been thoroughly tested for biological relevance. Nevertheless, such indices could be used until other methods or systems have been adequately field tested or developed (Chapman 1996). Up to now, this method is widely used in the environmental monitoring programs. Specifically, the environmental experts and authorities have applied this method to assess the ecological health monitoring programs, for examples the Environmental Monitoring Programs of Jhelum, Kishanganga, Ujh and Chenab River Basins (Kant, S. and P. Kachroo, 1980; Dar. J. A 2009). The Environmental Monitoring Programs of such rivers were done by Public authorities, Universities, individual research institutes and research scholars.

3.2 Biotic indices

Biotic indicators were generally specific for certain types of pollution since they were grounded on the presence or absence of index organisms (bioindicators), which were doubtful to be inversely sensitive to all types of pollution. Similar indicators frequently used macroinvertebrate populations because they could be more fluently and reliably collected, handled and linked. In addition, there was frequently more ecological information available for similar taxonomic groups (Chapman 1996, Li etal.2010). In order to limit the taxonomic demand of earlier biotic indicators to identify organisms to species position, some indispensable indicators have been developed which used only the family position of identification (Hellawell 1986). Generally used biotic indicators for macroinvertebrates in Kashmir are Shannon Index (Kant, S. and P. Kachroo, 1980; Pandit, A. K., 1980; Dar. J. Aetal.2009); From natural data collection over 10 times together with physicochemical pointers, the Shannon Index was grounded on errant polychates and sedentaria polychaetes similar as bioindicators in the water quality assessment that reflected basically characteristic of flowing gutters with their different terrain. The Jaccard Index was set up grounded on the rate of species composition of tubifids and chironomids comparison with all species for water quality assessment. In addition, some others have still used the indispensable approaches to the Saprobic Index which have been developed by Pantle and Buck (1955), Zelinka and Marvan (1961), Liebrmann (1962), Woodiwiss (1964), Granham (1965), Cairns etal. (1968), Sladecek (1973), (Chapman 1996, Pham 2014a).

3.3 Multimetric approaches

Multimetric indicators represented a means to integrate a set of variable or criteria, which represented colorful structural and functional attributes of an ecosystem (similar as taxa uproariousness, relative cornucopia, dominance, functional feeding groups, pollution forbearance, life history strategies, complaint, and viscosity). Thus they handed robust and sensitive perceptivity into the responses of an assemblage to natural and anthropogenic stressors (Carvalho 2002; Li et al. 2010; Vandewalleetal.2010). Currently, multimetric approaches for oceanographic macroinvertebrates have been the most extensively used approaches for swash biomonitoring in USA and other corridor of the world (Sivaramakrishnan et al.1996; Thorne & Williams 1997; Vleketal.2004; MRC 2010). Still, these approaches have been used only in some exploration and systems to estimate the ecological health of gutters in India.

3.4 Functional Feeding Groups (FFGs)

Analyses of Functional Feeding Groups (FFGs) were the crucial factors of swash continuum conception (RCC; Vannote 1980) and have been applied to assess ecosystem - position processes in gutters and washes (Flotemersch et al. 2010; Li et al.2010; Zhang et al.2014). In swash biomonitoring, FFGs measures have been used in the forms of single feeding groups (as absolute or relative cornucopia), rates between two groups, or compound indicator that included several trophic aspects (Pavluketal.2000; Li et al. 2010). In, some exploration thesis of submarine ecology have applied the FFGs to estimate the swash ecology and functions in India. For exemplifications, Kamal. S &R. S. Kumar (2021). Multivariate approaches have been originally introduced to assess the natural status of gutters within the UK, with the development of RIVPACS (Swash Brute vaticination and Bracket System) (Li etal.2010; ECETCO, 2011). This espoused statistical analyses to prognosticate point - specific fauna patterns, which were anticipated in the absence of major environmental stress. Also the natural evaluations were performed by comparing the observed fauna at the point with the anticipated fauna of balance ecosystems (Wright etal.1997; Niemi & McDonald 2004; Li etal.2010). And, multiple natural traits were related to niche characteristics and the natural and ecological functions of species, therefore permitted a view into the function structure of biocoenosis (Haybach 2004; Li etal.2010). Multiple natural traits of submarine in the environment of environmental constraints have been lately developed for brackish biomonitoring (Bonada et al.2006; Li etal.2010). Still, these approaches for water quality assessment and ecological health monitoring have been applied veritably rare in India.

3.5 Prospects in Ecological Health Monitoring of River Ecosystems in India

By now, different biomonitoring ways have formerly been developed to quantify the mortal impacts on the submarine ecosystems. Still, because of the new trends in environmental programs, ecologists are facing to new demands of effective tools for the ecological health evaluation and environmental operation for conservation and restoration (Corvalanetal.2005; Li etal.2010). Besides using professional styles to assess ecological health and water quality in swash systems, the ways of rapid - fire assessment have been developed also. Also, the ecological health monitoring grounded on three organism groups of phytoplankton, zooplankton and oceanographic macro invertebrates have been used extensively to covering the ecological status and the water quality of running waters. Also, the other submarine organism groups similar as macrophytes, meiobenthic or fish are largely suggested to include into the biomonitoring to completely estimating the submarine ecological health and environmental quality.

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