Ecosystem health of pristine environments: structural and functional assessment

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Abstract

There is a great need for developing and homogenizing simple assessment tools and techniques for prioritising important environmental problems on a global basis since eco-technology is not evenly distributed across the world. It is extremely critical to initiate basic ecosystem health assessment investigations in the pristine and oligotrophic Himalayan environments since they serves as top of the world monitors of anthropogenic stress, long range transport, finger printing of pollutants, as well as a sensitive indicators of global change. This paper derives considerably from the successfully adopted eco-technology program in the North American Great Lakes (Canada) and Europe (The Netherlands) in proposing simple, sensitive, rapid and inexpensive structural and functional techniques. The proposed strategy hopefully will result in the development of a sound Biological and toxicological data base for remote and pristine areas such as the Great Himalayas about which very little is known (Baudo et al., 1998). The generation of such a data base will be extremely useful in comparing Himalayan ecosystems with other environments of the world and in monitoring global climate change effectively. An attempt is made in this presentation to review the characteristics of Aquatic Himalayan ecosystems and to find the ways and means of assessing its sensitivity to environmental perturbations.

Climate and diversity:

The Himalayan region covers 5 climactic zones from warm tropical to arctic. The soils range from deep alluvial to thin and bare soils of the alpine. Many microclimates are found due to variation in latitude and altitude and geology. These conditions result in a great variety of aquatic habitats and health status.

Anthropogenic stressors:
(modified from a report by Ministry of Environment and Forests, India by Desh Deepak Verma):
Stressors:

- Firewood, fodder and ground litter collection
- Commercial logging
- Free grazing in forests
- Frequent mild burning
- Charcoal making
- Shifting cultivation
- Spread of invasive species
- Hunting
- Poaching
- Commercial collection of medicinal and aromatic plants
- Fragmentation of habitat
- Road construction
- Water pollution, eutrophication and degradation of aquatic ecosystems
- Promotion of high yield crops including orchards
- Global warming
- Tourism

Ecosystem Heath Assessment Strategy and techniques:

An integrated strategy has been adopted in the North American Great Lakes and European lakes for the assessment of aquatic ecosystem health (Fig. 1, 2). Proven techniques followed in North America and Europe could be useful for assessing the ecosystem health of Himalayan ecosystems. A basic battery of structural and functional tests is included here for adoption to Himalayan research.

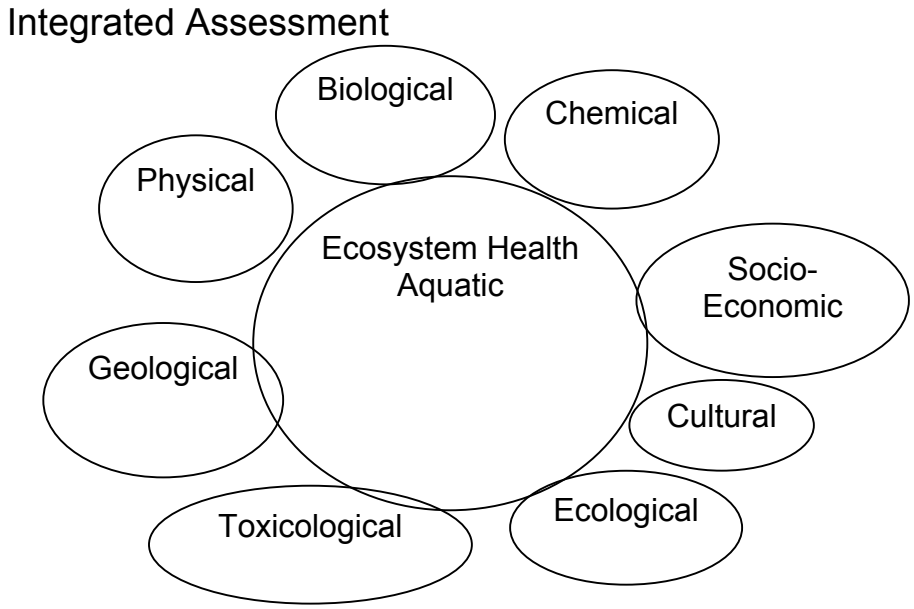

Figure 1. Multi-disciplinary strategy for aquatic ecosystem health assessment

Structural assessment: Biotic Inventory of the Microbial food web (MFW)
(adopted from research from the Great Lakes: Munawar and Munawar, 1996; Munawar *et. al*, 1989, 1992)

- Epifluorescence microscopy (formalin preserved)
    - Bacteria, autotrophic picoplankton and heterotrophic nanoflagellates
- Protargal stain microscopy (Lugol's Bouin preserved)
    - Ciliates
- Phase contrast microscopy (Lugol's iodine preserved)
    - Phytoplankton (nanoplankton and netplankton)

Functional Assessments: bioassays and biomarkers

- Screening
- Trend monitoring
- Monitoring of spatial variation
- Bioassays and biomarkers in test batteries
- Site-specific risk assessment (e.g., bioavailability, Triad, tiered approaches)
- Assessment ecosystem damage: ecological indices

A bioassay is a test performed in the laboratory or in the field (caged organisms) in which organisms are exposed to environmental samples, during which the following can be monitored:

- survival
- growth, development
- offspring, population growth
- physiological parameter

Biomarkers (biochemical markers) give response in short time and at relatively low concentrations; before response of animal can be seen. Biomarkers are therefore predictors of effects (early warning). Disadvantage of biomarkers: relation of response with animal fitness or performance is often rather vague.

- Biomarkers could be used in animals collected from the field (see flow chart). Early warning principle!! more test animals required
- organisms can be collected in the field
- effective in combination with bioassay setup (caged animals)

- Biomarkers could be used in cell cultures, as in vitro tests. Test material: water samples, preferably concentrated to 100-1000x concentration in the field. In this way one has a very sensitive assay for toxicity. Function would be: detecting unknown chemical substances.
- fewer test animals required
- rapid, high throughput
- extrapolation difficult
- exposure conditions may lead to artefacts

Data Integration, Synthesis and Modeling:

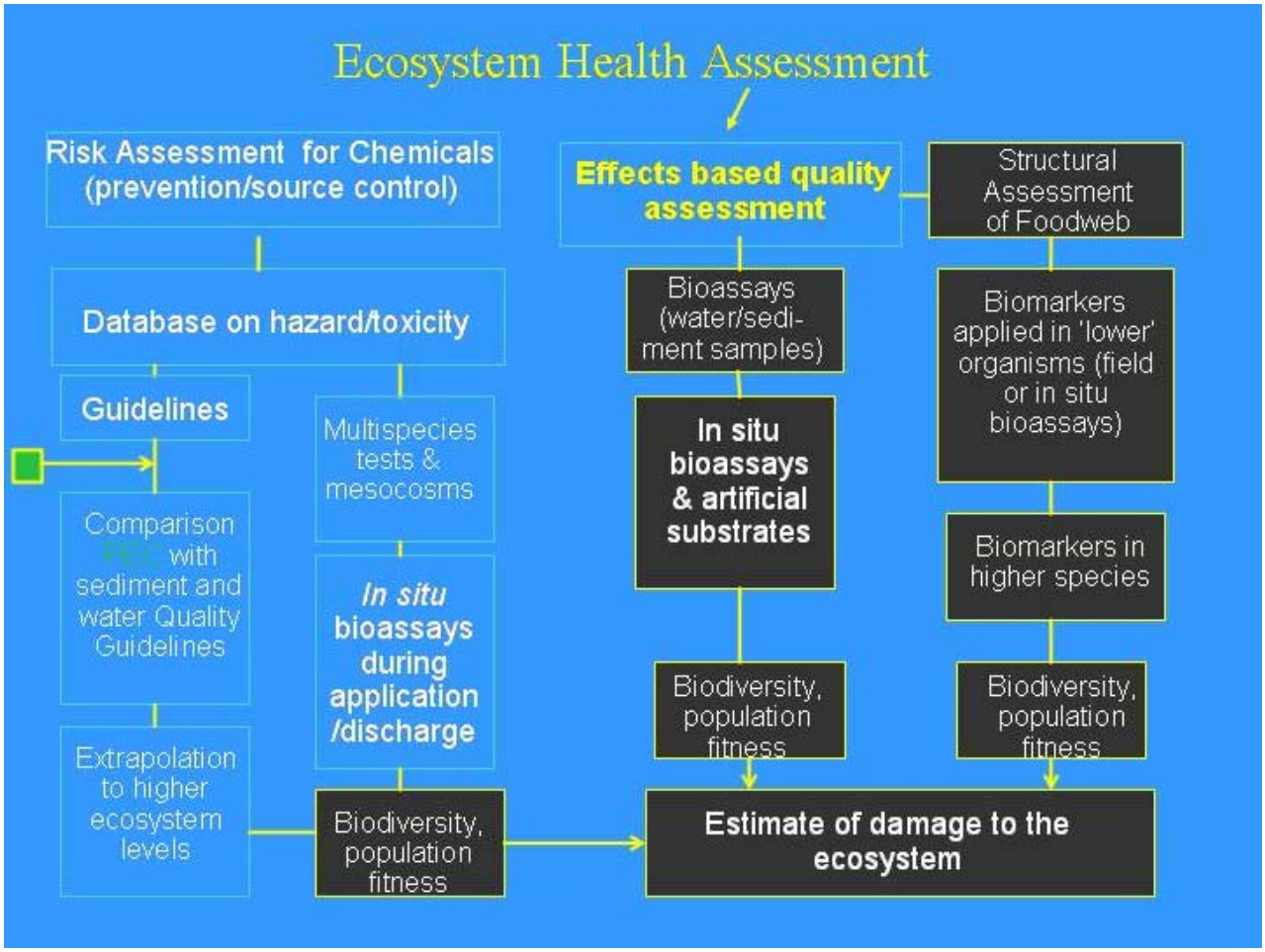

Figure 2. An integrated strategy for ecosystem health assessment (adapted from den Besten, personal communication)

Conclusions:

The Great Himalayas were erected 50 million years ago due to uplifting of the Asian plate resulting in the formation of the highest peak: Mount Everest and its pristine and beautiful habitats. The Himalayan ecosystems has undergone rapid environmental deterioration since the conquest of Mount Everest in 1953 in a short period of only 50 years. Very little is known about the impact of environmental perturbation of the Himalayan ecosystems (Ruggiu et al, 1998). The proposed frame of work for the structural and functional assessment of the base of the food web is extremely essential in understanding the food web dynamics of a great variety of Himalayan aquatic ecosystems. The exploration of the microbial food web is of these pristine and remote areas are of prime importance because of their sensitivity. The reported existence of autrophic picoplankton at high irradiance and prevalence of heterotrophic organisms such as bacteria and heterotrophic flagellates present unique hypotheses for exploring the unknown dynamics of high altitude, ultra-oligotrophic and pristine ecosystems of the Great Himalayas.

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