WATER AND WASTEWATER MONITORING

Biological Monitoring

by
Risky Ayu Kristanti
Faculty of Engineering Technology
kristanti@ump.edu.my

Chapter Description

- Aims
  - Student review the appropriate methods and organisms.
  - Student design the site selection and sampling frequency.
  - Student examine the physiological and bio-test control.

- Expected Outcomes
  - Student should be able to review the appropriate methods and organisms.
  - Student should be able to design the site selection and sampling frequency.
  - Student should be able to examine the physiological and bio-test control

- Other related Information
  - Environmental Protection Agency
  - Natural Resources Conservation Service

- References

  - Burden, Foerstner, McKelvie, and Guenther (2002) **Environmental Monitoring Handbook**, The McGraw-Hill Companies, Inc.
  - Jamie Bartram and Richard Balance. 1996. **Water Quality Monitoring: A Practical Guide to Design and Implementation of Freshwater Quality Studies and Monitoring Programmes**, CRC Press.

BIOLOGICAL MONITORING

Biological monitoring or biological assessment is the measurement of a substance or its metabolite in biological material in order to provide a quantitative estimate of its uptake into the body by all routes of exposures

BIOLOGICAL INDICATORS

- Fish
- Habitat
- Algae
- Benthic macroinvertebrates
  - insects in their larval or nymph form, crayfish, clams, snails, and worms)

ADVANTAGES OF BIOMONITORING

- Biomonitoring clearly determine if a waterbody has healthy aquatic life
- Biomonitoring are the most effective way to evaluate cumulative impacts from nonpoint sources (both chemical and non-chemical stressors)
- Biomonitoring help to provide an ecologically based assessment of the status of a waterbody and help prioritize waterbodies for TMDLs based on the severity of biological damage
- Biomonitoring directly measure the combined impacts of any and all stressors on the resident aquatic biota and can be used to determine the effectiveness of permit controls

DISADVANTAGES OF BIOMONITORING

- High variability may make detection of change or trends difficult
- Specific pollutants or sources causing impacts may not be revealed
- Complex relationships with habitat, bioregion
- Collection may be inexpensive, but analysis may be expensive and time-consuming

BIOMONITORING

Determine support of aquatic life uses

- Biological criteria
  - Benthic macroinvertebrate diversity and abundance impacted by stream biological, chemical, and physical conditions
  - Varying tolerance
    - Stonefly nymphs are very sensitive to DO
    - If no stoneflies, check DO
- Biological surveys

BIOMONITORING

Determine the severity of the pollution problem and to rank stream sites

- Monitored stream data compared to data from reference site

Characterize the impact of pollution and of pollution control activities

- Identify problem sites along a stream

TYPES OF BIOMONITORING

- Biological Monitoring of Exposure
- Biological Monitoring of Effective Dose
- Biological Effects Monitoring
- Biological Monitoring of Susceptibility

BIOMONITORING OF EXPOSURES

Biological monitoring attempts to estimate the internal dose of a chemical exposure.

Internal dose is dependent on the:

- Amount of chemical recently absorbed
- Amount of chemicals stored in the whole body
- Amount of chemical bound to critical sites of action

Advantage: All routes of exposure assessed and provides a more accurate assessment of health risk than atmospheric monitoring

BIOMONITORING OF EXPOSURES

Biological monitoring of occupational exposure to chemicals refers to the concentrations of the chemicals or their metabolites in biological samples e.g. blood, urine, exhaled air, faeces, adipose tissue, hair, nails, saliva, milk (measuring the exposure or body burden).

BIOMONITORING OF EFFECTIVE DOSE

Carboxyhemoglobin (exposure to carbon monoxide)

Protein and DNA addicts (exposure to reactive substances in DNA or target tissues)

BIOLOGICAL EFFECTS MONITORING

Biological monitoring of non-adverse reversible effects - early biochemical changes which are reversible and non-adverse biomarkers of exposure:

- Inhibition of delta-amino laevulinic acid dehydratase by lead
- Inhibition of pseudocholinesterase by organophosphates

BIOLOGICAL EFFECTS MONITORING

Reversible non adverse effects or early detection of health impairment:

- Urinary excretion of alpha1 and beta2 microgobulins due to lead, cadmium, mercury

Indicate pathological damage:

- liver dysfunction (transaminases), kidney dysfunction (albumin in urine)

BIOMONITORING OF SUSCEPTIBILITY

Biomarker of susceptibility – indicator of inherent or acquired ability of organism to respond to challenge of exposure to specific substance

- e.g. ability to acetylate amines – genetically determined and varies with ethnic origin – slow/rapid acetylators
- genetically based low level of anti-trypsin – increased risk of emphysema

BIOLOGICAL METHODS

- Ecological methods
- Physiological and biochemical methods
- Controlled biotests
- Contaminants in biological tissues
- Histological and morphological methods

INTEGRATED ASSESSMENT OF WATER BODY

Monitoring fish and macroinvertebrate community

- identifying fish species and measuring length
- macroinvertebrate community

Qualitative habitat assessment

Water chemistry

pH, major cations and anions trace elements and isotopes

QUALITATIVE HABITAT ASSESSMENT

Universiti Malaysia PAHANG
Engineering • Technology • Creativity

Habitat assessment consist of various variables:

- Stream width
- Depth
- Substrate types
- Substrate embeddedness
- Depth of fine material
- Cover for fish
- percent macrophytes and algae
- bank erosion
- riparian land use
- canopy
- stream feature
- stream flow

DETERMINATION OF BIOTIC SCORE

- Taxon or species richness; the easiest measure of biodiversity
- BMWP score; the Biological Monitoring Working Party score
- ASPT index value; the Average Score Per Taxon

MULTI METRIC INDEX

- is the index of biological integrity (IBI)
- Used for macroinvertebrates and fish
- Scoring system based on multiple attributes (metric) which measure community richness, pollution tolerance and feeding groups
- Metrics selected based on how well they indicate anthropogenic stressors
- Individual metrics are aggregated into an index

Examples of IBI scores *(from Lyons 1992)*

IBI score	Rating	Attributes
100-65	Excellent	Comparable to the best situations with minimal human disturbance; all regionally expected species are present.
64-50	Good	Species richness somewhat below expectations. Loss of intolerant species. Trophic structure shows signs of imbalance.
49-30	Fair	Signs of additional deterioration including decreased species richness, loss of intolerant forms, increased abundance of tolerant species, increased numbers of omnivore species and less specialized feeding species.
29-20	Poor	Relatively few species; dominated by tolerant forms, habitat generalists, and omnivores; few or no top carnivores, growth rates and condition factors sometimes depressed; hybrids sometimes common.
19-0	Very poor	Very few species present, mostly tolerant forms, hybrids, or exotics; few large or older fish; DELT fish (fish with deformities, eroded fins, lesions, or tumors) sometimes common.
No score		Thorough sampling finds few or no fish; impossible to calculate IBI.

Conclusion of The Chapter

- The biological monitoring is important to measure community richness, pollution tolerance and feeding group.
- By the individual metric, anthropogenic stressors can be identified.

References

Jamie Bartram and Richard Balance. 1996. Water Quality Monitoring: A Practical Guide to Design and Implementation of Freshwater Quality Studies and Monitoring Programmes, CRC Press.

Lyons, J.: 1992, "Using the index of biotic integrity (IBI) to measure environmental quality in warmwater streams of Wisconsin", *General Technical Report*, NC-149, North Central Forest Experiment Station, U.S. Forest Service, St. Paul, Minnesota.