Use of score methods in water quality monitoring
“Bio-monitoring”

Dr. Subodh Sharma
Kathmandu University
Interrelationships between the steps used in monitoring

What type of monitoring is required?
- **Biological:**
  - in-situ/ex situ tests?
  - mortality/sub-lethal tests?
  - whole organisms/sub-organism level?
  - Bio-accumulation studies?
  - biotic indices?
  - Bio-monitors/bio-probes?
- **Chemical:**
  - continuous? automatic?manual?
What determinands/tests/assays, etc. are required?
What level of accuracy is required?
What sampling methodology / deployment regime should be used:
- frequency?time(s) of day?
- sampling sites?

What information is required to fulfil the aims of the sampling programme?
What decisions are to be made on the basis of these results?

What resources are available?

Strictly define monitoring programme

What is the best way to interpret the results?
What is the best way to present the results?

Result output and presentation

REVIEW
Bio-monitoring

PRINCIPLES OF BIO-MONITORING:
- The first category comprises the Bio-assays (Experimental)
  - Eco-toxicological tests, bio-accumulation tests, bio-degradation tests, eutrophication tests.
- The second category comprises the Bio-assessments (Observational)
  - taxa density, taxa richness, proportion between the communities.

ADVANTAGES:
- Biological communities act as continuous monitors.
- Biological communities respond to a wide range of different water quality.

LIMITATIONS:
- Specific cause of the change is not identifiable.
- A comprehensive assessment demands considerable effort in sampling.
<table>
<thead>
<tr>
<th></th>
<th>Bacteria</th>
<th>algae</th>
<th>Macro-invertebrates</th>
<th>Macrophytes</th>
<th>fish</th>
<th>Birds/mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquatic zone</td>
<td>++</td>
<td>-/+</td>
<td>++</td>
<td>-/+</td>
<td>++</td>
<td>+</td>
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<tr>
<td>(water body)</td>
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<tr>
<td>Riparian zone</td>
<td>_</td>
<td>-</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
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<tr>
<td>(banks)</td>
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<tr>
<td>Terrestrial zone</td>
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<td>-</td>
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<td>++</td>
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<tr>
<td>(floodplains)</td>
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</table>

- = not suitable  
+ = suitable  
++ = well suitable
Advantages of using Benthic macro-invertebrates

- Good indicators of localized conditions.
- Integrate the effects of short-term environmental variations.
- Easily identifiable to family level.
- Sampling is relatively easy.
- Serve as food for fish.
- Are abundant in most streams.
Advantages of using Fish

- Fish are good indicators of long-term effects.
- Fish community structure is reflective of integrated environmental health.
- Fishes are at the top of the aquatic food chain and are consumed by humans.
- Relatively easy to collect and identify.
Advantages of using Algae

- Algae are good indicators of short-term impacts.
- Algae are primary producers.
- Sampling is easy, inexpensive, requires few people.
- Relatively standard methods exist for characterizing algal communities.
- Algal communities are sensitive to some pollutants.
Principal approaches to assess water quality

- **Saprobic approach**
  - is based on the pollution tolerance of the indicator species present.

- **Diversity approach uses three components**
  - richness
  - evenness
  - abundance

- **Biotic approach**
  - incorporates quantitative measure of species diversity with qualitative information on the sensitivity of indicator species.
The Saprobic Index

\[ S = \frac{\sum (s \cdot h)}{\sum h} \]

where \( S \) = Saprobic Index, \( s \) = saprobic value for each indicator species, \( h \) = frequency of occurrence of each species.

the value of \( S \) normally ranges from 1 to 4 for ambient waters.

Major criticisms of saprobic systems:

The taxonomy is not far enough advanced.

The pollution tolerances of species are very subjective.

No information on the community as a whole is provided.
The Diversity Index

\[ H' = \sum \frac{N_i}{N} \log_2 \frac{N_i}{N} \]

where \( H' \) = index value, \( N \) = total number of individuals of all species collected, and \( N_i \) = number of individuals belonging to the \( i^{th} \) species.

They are strictly quantitative.
Relatively independent of sample size.
Assumptions made are highly subjective.
Biotic Indices

- Chutter’s Biotic Index
  - South Africa (1972)

- Extended Biotic Index
  - UK (1978)

- Trent Biotic Index
  - England (1964)

- Chandler’s Score
  - Scotland (1970)

- BMWP Score
  - UK (1978)

- Modified BMWP Score
  - UK (1979)

- Indice Biotique
  - France (1968)

- Indice Biologique de Qualite Generale
  - France (1982)

- Indice Biologique Global
  - France (1985)

- Belgian Biotic Index
  - Belgium (1983)

- NEPBIOS
  - Nepal (1996)
Comparison between Trent and Extended Biotic Index

CALCULATED WATER QUALITY ACCORDING TO WOODIWISS, 1978

CALCULATED WATER QUALITY ACCORDING TO WOODIWISS, 1964
Comparison between two French Indices

CALCULATED WATER QUALITY ACCORDING TO TUFFERY & VERNEAUX, 1968

CALCULATED WATER QUALITY ACCORDING TO WOODIWISS, 1978

CALCULATED WATER QUALITY ACCORDING TO TUFFERY & DAVAINÉ, 1970
Comparison between French and Belgian Biotic Indices
Comparison between British & American Indices

CALCULATED WATER QUALITY ACCORDING TO WOODYSS, 1978

CALCULATED WATER QUALITY ACCORDING TO EXTENCE et al., 1887

CALCULATED WATER QUALITY ACCORDING TO HILSENHOFF, 1988
Conclusions & Recommendation

- Biological assessment methods are an integral part of river water quality monitoring.
- It is recommended that sampling methods be standardized.
- Where river conditions permit, benthic macroinvertebrates should be used.
- Every country should establish its index system.
- In large rivers colonization samples should be used.
- Other indicator organisms should also be used.
Sampling & analysis procedure  
(Field and laboratory exercise)

**In Field**
- Select DIFFERENT sites
- Fill protocol 1a
- Sample and analyze

**In Lab**
- Sorting, Identification and listing of the samples
- Scoring or indexing

**Indices:** Trent Biotic Index, Belgian Biotic Index  
**Scores:** BMWP Score, NEPBIOS

**Recommendation**
Further details can be obtained from,
Dr. Subodh Sharma
Aquatic Ecology Center
Kathmandu University, Dhulikhel, Kavre.
P.O. Box: 6250, Kathmandu, Nepal.
Email: sharmaku@yahoo.com
Fax: 00977-11-61443
Tel: 00977-11-61399, 61511