BIOMARKERS OF POLLUTION

EARLY DIAGNOSTIC TOOL FOR WATER POLLUTION

Dr. Kanchan Kumari

NEERI, NAGPUR
Water quality monitoring: Methods

(1) Physico-chemical and
(2) Bio-monitoring
<table>
<thead>
<tr>
<th>Core parameters (9)</th>
<th>General parameters (19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Chemical oxygen demand (COD)</td>
</tr>
<tr>
<td>Temperature</td>
<td>TKN</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Ammonia</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>Total dissolved solution (TDS)</td>
</tr>
<tr>
<td>Biochemical</td>
<td>Total Fixed sites.</td>
</tr>
<tr>
<td>oxygen Demand (BOD)</td>
<td>Total Suspended Solids (TSS)</td>
</tr>
<tr>
<td>Nitrate - N</td>
<td>Turbidity</td>
</tr>
<tr>
<td>Nitrite - N</td>
<td>Hardness</td>
</tr>
<tr>
<td>Fecal coliform</td>
<td>Fluoride</td>
</tr>
<tr>
<td>Total coliform</td>
<td>Boron</td>
</tr>
</tbody>
</table>

- Chloride
- Sulphate
- Total Alkalinity
- P-alkalinity
- Phosphate
- Sodium
- Potassium
- Calcium & Magnesium
Chemicals may exist in different forms, while bioavailability and toxicity varies considerably with different chemical forms.

Interaction of chemicals (additive, synergistic or antagonistic) may be important yet difficult to determine.

Major problems exist in assessing or predicting biological effects from chemical / physical data.

Gives the momentary conditions that exist at the time of sample collection. This means that the short-term events are missing that may be critical to ecosystem.
Biodiversity and community studies are traditionally used to determine the biological quality of the environment.

They provide indices which reflect the impact of ecological traits, stress factors and anthropogenic activities.
Limitation of Bio-monitoring

Disturbances can only be detected *a posteriori* when change has become significant.

By the time degradation is recorded a number of species have already disappeared, which limits the effectiveness of the ecological approach.

Benthic macro-invertebrates do not respond to all impacts.

Seasonal variations may prevent comparisons of samples taken in different seasons.
Fig. Schematic representation of the sequential orders of response to pollutant stress under biological system.
Many pollutants are metabolised in the liver

Metabolites are excreted and temporarily stored in the bile fluid

Pollutants Exposure
Biomarker definition

Biochemical, cellular, physiological or behavioral variations

that can be measured in tissue or body fluid samples or at the level of whole organisms

that provide evidence of exposure to and/or effects of one or more chemical pollutants
TOXIC CHEMICALS – Pesticides, metals, etc

DYSFUNCTIONAL EFFECTS

• Decrease blood oxygen
• Decrease/increase plasma electrolyte
• Decrease energy stores
• Altered metabolism
• Decrease swimming ability
• Suppressed immune system
• Anemia
• Decrease growth rate

ADAPTIVE RESPONSES (Detoxify the toxicants)

• Increase ventilation rate
• Cortisol
• Increase plasma glucose
• Increase metallothionien
• Increase mixed function oxidases
• Avoidance behavior

Homeostasis disturbed
Sub-lethal physiological changes the fish exhibit have practical application in water pollution control

1. Establishment of Water Quality Criteria
2. Monitoring of ecosystem health in the field
3. An early warning system to detect sudden changes
ENZYMES:
- Lactic dehydrogenase (LDH)
- Succinic dehydrogenase (SDH)
- AchE activity
- Serum glutamine pyruvate transaminase (SGPT/ALT)
- Serum glutamate oxaloacetate transamine (SGOT/AST)
- Creatinine phosphokinase (CPK)
- Alkaline Phosphatase (ALP)

Why enzymes?
1. The subtlest changes in enzyme concentration can induce large effect on metabolic pathways.
2. Under stress conditions, when ATP is limiting factor, synthesis of enzymes are important for survival.

Haematological parameters including Spectral analysis of the haemoglobins as function of pesticides were also studied along with different antioxidants, hormones and metabolites.
Organophosphates/ Carbamates

Blocks function of acetyl-cholinesterase

Increases levels of acetylcholine, an important neurotransmitter

Effect: Disruption of nerve impulse transmission across synapse
Fig: Site of action of Pesticides at Cholinergic Synapses
Fig.: Catalytic mechanism of acetylcholinesterase
Modes of Action (Acute Exposure)

Disruption of nerve impulse transmission (Action potential)

[Diagram showing the process of nerve impulse transmission]

OUTSIDE OF CELL

Na⁺ channel

K⁺

Na⁺

Plasma membrane

INSIDE OF CELL

K⁺ channel

Protein
Neuron function (action potential)

- Many Na⁺ channels open quickly.
- Na⁺ channels close, additional K⁺ channels open.
- Additional K⁺ channels close.
- Threshold.
- Isopotential point.
- Organochlorine.

Membrane voltage (mV): RMP = -70 mV, 0, +35 mV

Time (m/sec): 0, 1, 2, 3, 4, 5, 6, 7
Advantages of biochemical monitoring (Biomarkers of pollution)

- The eco-toxicological approaches based on biomarkers measured rely on the fact that changes occur at low level of biological organization before community is affected.

- Biomarkers give information on the biological effects of pollutants rather mere quantification of their environmental levels.
Main advantages of using biomarkers at low levels of biological organization is the possibility to detect the deleterious effects of pollutants before being evidenced at higher levels of biological toxicity.

In short, biomarker of pollution is a predictive and preventive tool for the assessment of water quality.
Animal studied (3 common fishes):

- *Labeo rohita* (*Rohu*)
- *Catla catla* (*Catla*)
- *Cirrhinus mrigala* (*Naini*)

The test organism should be:
- Sensitive
- Ecological and economical importance.
- Available throughout the year.
## BEHAVIOURAL CHANGES

<table>
<thead>
<tr>
<th>Pesticides</th>
<th>Endosulfan</th>
</tr>
</thead>
</table>
| **Labeo rohita** | ✚ Rapid swimming movement  
              ✚ Swimming activity in two unique pattern  
              ✚ Round swimming motion covering a circular distance  
              ✚ Rapidly rotating the whole body at the same position |
| **C. catla** | Faster movement than control |
| **C. mrigala** | Erratic Rapid movement.  
                       Decolouration of the body. |
<table>
<thead>
<tr>
<th>Pesticides</th>
<th>METHYL PARATHION</th>
</tr>
</thead>
</table>
| *Labeo rohita* | Less swimming movement  
Less activity  
Staying at a position for a longer period of time  
Sometime back swimming also noted |
| *C. catla* | Lethargic  
Less activity |
| *C. mrigala* | Less activity  
Body in inverted position but alive |
<table>
<thead>
<tr>
<th>Pesticides</th>
<th>CARBARYL</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Labeo rohita</em></td>
<td>Flocking near the aerator</td>
</tr>
<tr>
<td><em>C. catla</em></td>
<td>Respiration faster than control.</td>
</tr>
<tr>
<td><em>C. mrigala</em></td>
<td>Flocking near the aerator</td>
</tr>
</tbody>
</table>
Key Enzymes

Endosulfan Toxicity: LDH, AchE
Methyl Parathion: CK, SGPT and AchE
Carbaryl: ALP and SGOT
<table>
<thead>
<tr>
<th><strong>KEY ENZYMES</strong></th>
<th><strong>Endosulfan</strong></th>
<th><strong>Methyl Parathion</strong></th>
<th><strong>Carbaryl</strong></th>
<th><strong>Spent Wash</strong></th>
<th><strong>Synergistic</strong></th>
<th><strong>Metal {Cr}</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KEY ENZYMES</strong></td>
<td>LDH</td>
<td>CK</td>
<td>ALP</td>
<td>CK</td>
<td>AchE</td>
<td>SGPT</td>
</tr>
<tr>
<td></td>
<td>AchE</td>
<td>AchE</td>
<td>SGOT</td>
<td>LDH</td>
<td>ALP</td>
<td>SGOT</td>
</tr>
<tr>
<td></td>
<td>SGPT</td>
<td></td>
<td></td>
<td>SDH</td>
<td>CK</td>
<td>ALP</td>
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</tbody>
</table>
“Integration of Biomarker Approach in Pollution monitoring Programme of Aquatic Ecosystem”
Selected Water Bodies of Nagpur

Major Water Bodies of Nagpur City
1- Nag River
2- Pili River
3- Gorewada Lake
4- Futala Lake
5- Ambajhari Lake
6- Sukravari Pond
7- Sakardhara Pond

Experimental setup for 96 hr LC50 determination
Surface and darting movement of fishes.
Accumulation of fishes near aerator.
Overview of Field Sampling

<table>
<thead>
<tr>
<th>S. No</th>
<th>Sample code</th>
<th>Geographical position</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Latitude</td>
</tr>
<tr>
<td>1.</td>
<td>NG/W1</td>
<td>21° 7'29.95&quot;N</td>
</tr>
<tr>
<td>2.</td>
<td>NG/W2</td>
<td>21° 8'6.26&quot;N</td>
</tr>
<tr>
<td>3.</td>
<td>NG/W3</td>
<td>21° 8'34.94&quot;N</td>
</tr>
<tr>
<td>4.</td>
<td>NG/W4</td>
<td>21° 8'25.77&quot;N</td>
</tr>
<tr>
<td>5.</td>
<td>NG/W5</td>
<td>21° 8'14.01&quot;N</td>
</tr>
<tr>
<td>6.</td>
<td>NG/W6</td>
<td>21° 8'26.84&quot;N</td>
</tr>
<tr>
<td>7.</td>
<td>NG/W7</td>
<td>21° 9'0.83&quot;N</td>
</tr>
<tr>
<td>8.</td>
<td>NG/W8</td>
<td>21° 9'54.71&quot;N</td>
</tr>
</tbody>
</table>

Fig- Sampling at Nag River
Activities

- develop and implement strategies:
  - characterization of wastes
  - appropriate disposal of POPs
  - Environmentally sound management of POPs

- identification of contaminated sites,

- preparation and dissemination:
  - Of the training and awareness raising materials
  - technical guidance for the management of POPs wastes

- nominated as a Stockholm Convention Regional Centre (SCRC) for Asia Region by (MoEF & CC), New Delhi in September 2010

- endorsed as Regional Centre for Capacity Building and Technology Transfer at COP-5 meeting during April 25-29, 2011 at Geneva.
The centre is assisting the parties of the Asia region in fulfilling their obligations of the Stockholm Convention
CSIR-NEERI nominated as a Stockholm Convention Regional Centre (SCRC) for Asia Region by (MoEF & CC), New Delhi in September 2010

Endorsed as Regional Centre for Capacity Building and Technology Transfer at COP-5 meeting during April 25-29, 2011 at Geneva

Sub-Regional Workshop on “Pilot testing of guidance for the review and updating of National Implementation Plan in India” June 18-21, 2012

1st NIP on POPs

Training programme on “Capacity building for Environmentally Sound Management of PCB oil and PCBs containing equipments at ship breaking yard, Alang, Gujarat, India”

Workshop on “Electronic Interactive Toolkit for Environmentally Sound Management of Industrial Chemicals” December 19-20, 2013

Regional Stakeholders Meeting on “Dioxin / Furans: The Unintentional POPs” February 12, 2013
Jan 2014

International Symposium on
“Halogenated Persistent Organic Pollutants”
January 16-17, 2014

Oct 2014

Training Programme on
“Capacity building for promoting synergistic implementation of BRS Conventions in Sri Lanka”
October 28-30, 2014

2015

Measures in relation to waste and contaminated sites under the development of National Implementation Plan on Persistent Organic Pollutants (POP’s) Under Stockholm Convention

2016

International Seminar on “Persistent Organic Pollutants”
May 13, 2016
Venue: CSIR-NEERI, Nagpur

Recent
### Few Current R & D Studies:

<table>
<thead>
<tr>
<th>Study</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td>Determination of Polybrominated Diphenyl Ethers (PBDEs) in Environmental matrices</td>
<td>Institutional capacity building for sustainable management of chemicals and wastes with special focus on Persistent Organic Pollutants</td>
</tr>
<tr>
<td>Risk Assessment and Socio-Economic Analysis of Methylated Tetra and Penta Siloxane</td>
<td></td>
</tr>
<tr>
<td>National Inventory development of Mercury in Waste sector in India</td>
<td></td>
</tr>
<tr>
<td>Organizing five awareness raising workshops on improving mercury management in India</td>
<td></td>
</tr>
<tr>
<td>Development and Promotion of Non-POPs Alternatives to DDT</td>
<td></td>
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Invitation

Sponsorship Details
The workshop will also provide a unique platform for gap and need analysis to all stakeholders, research institutions and regulatory authorities. The sponsorship details are as follows:

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<tr>
<th>Slab Name</th>
<th>Amount (INR)</th>
<th>Allowances</th>
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<tr>
<td>Platinum Sponsor</td>
<td>Above 2,00,000/-</td>
<td>• Slot for Presentation</td>
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<td>• 5 free registrations</td>
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<td>• Promotions in all Materials</td>
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<tr>
<td>Gold Sponsor</td>
<td>Above 1,25,000/- 1,75,000/-</td>
<td>• Slot for Presentation</td>
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<td></td>
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<td>• Promotions in Banners and Hoardings</td>
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<tr>
<td>Silver Sponsor</td>
<td>1,25,000/-</td>
<td>• Slot for Presentation</td>
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<tr>
<td></td>
<td></td>
<td>• 2 free registrations</td>
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</tbody>
</table>

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UNEPI Special Program on Chemical and Waste Management

“Management of Persistent Organic Pollutants in India: Need and Gap Analysis”

17th & 18th July, 2019
CSIR-NEERI, Nagpur

CSIR-National Environmental Engineering Research Institute
Stockholm Convention Regional Centre on POPs for Asia Region
CSIR under Ministry of Science and Technology, (Govt. of India)
Nehru Marg, Nagpur, 440020- India
Stockholm Convention Regional Centre for Capacity Building and Technology Transfer in Asia Region

CSIR-NEERI is endorsed as Stockholm Convention Regional Centre (SCRC) on Persistent Organic Pollutants (POPs) for Asia Region at COP-5 meeting held during 25-29th April 2011 at Geneva. SCRC has to serve different parties/countries in the Asia region to help them in their capacity building and transfer of technologies related to POPs and new POPs. Besides India, CSIR-NEERI is serving ten countries of Asia region viz. Bangladesh, Maldives, Mongolia, Myanmar, Nepal, Philippines, Thailand, Sri Lanka, UAE and Vietnam. The goal of the SCRC is to provide technical assistance for building capacities of the parties of the Asia region in relation to monitoring and assessment of POPs in the environment, transfer of technologies, raise awareness and promote identification and environmentally sound management (ESM) of POPs and POPs contaminated sites in the region. The Centre is also assisting the parties of Asia region in fulfilling their obligations of the Stockholm Convention.

Expected Outcomes

- Identification of Country’s weak areas for capacity building for management of Chemical and Wastes.
- Preparation of future road map to solve the identified problems.
- Long term capacity building to meet the obligations under BRS conventions.
Thanking You......!

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