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

Core parameters (9)	General parameters (19)	
pH Temperature Conductivity Dissolved oxygen Biochemical oxygen Demand (BOD) Nitrate – N Nitrite – N Fecal coliform Total coliform	Chemical oxygen demand (COD) TKN Ammonia Total dissolved solution (TDS) Total Fixed sites. Total Suspended Solids (TSS) Turbidity Hardness Fluoride	Boron Chloride Sulphate Total Alkalinity P-alkalinity Phosphate Sodium Potassium Calcium & Magnesium

PHYSICO- CHEMICAL ANALYSIS : WHY BOTHER

- 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.

BIOMONITORING

!! 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.

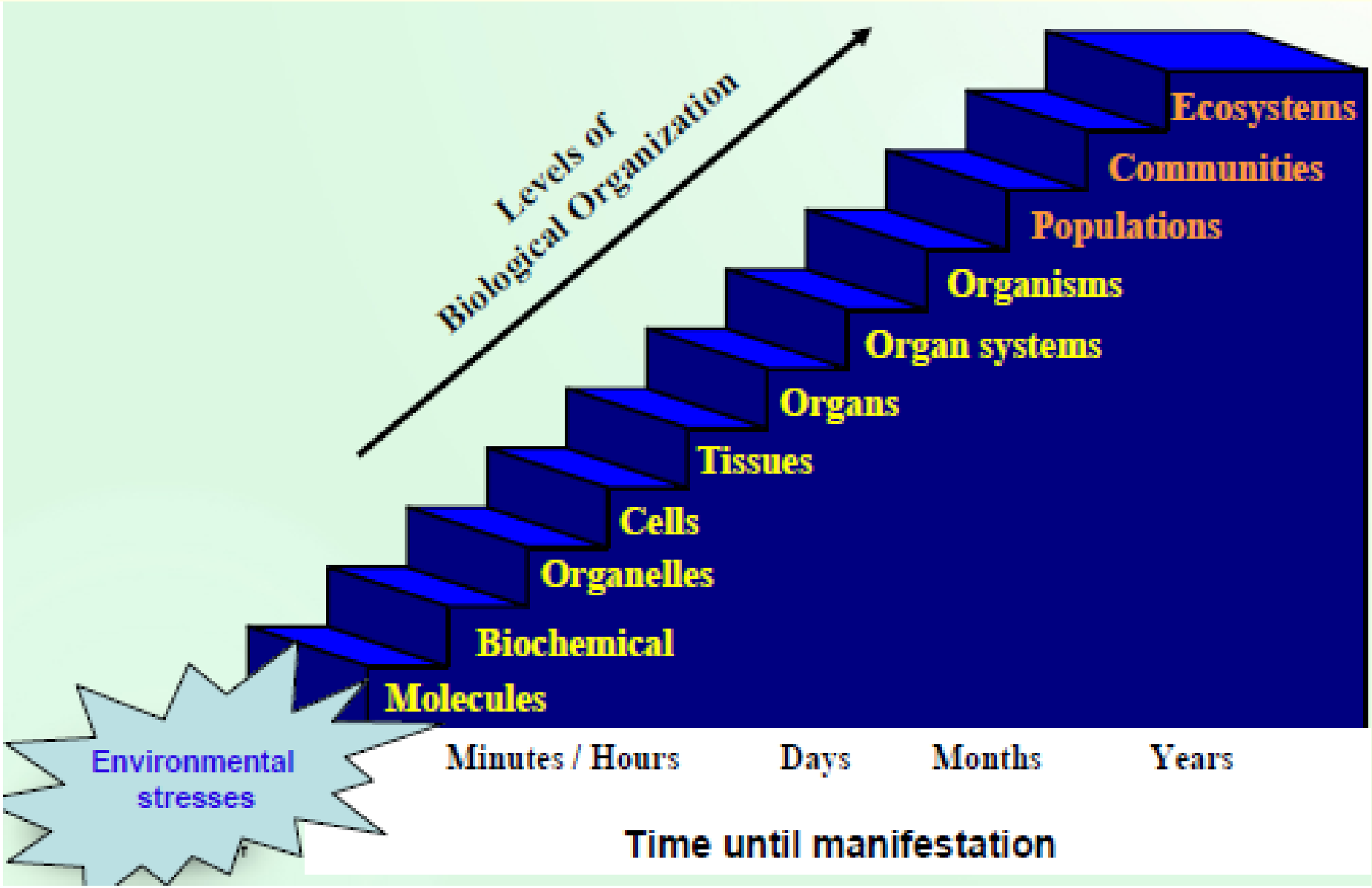
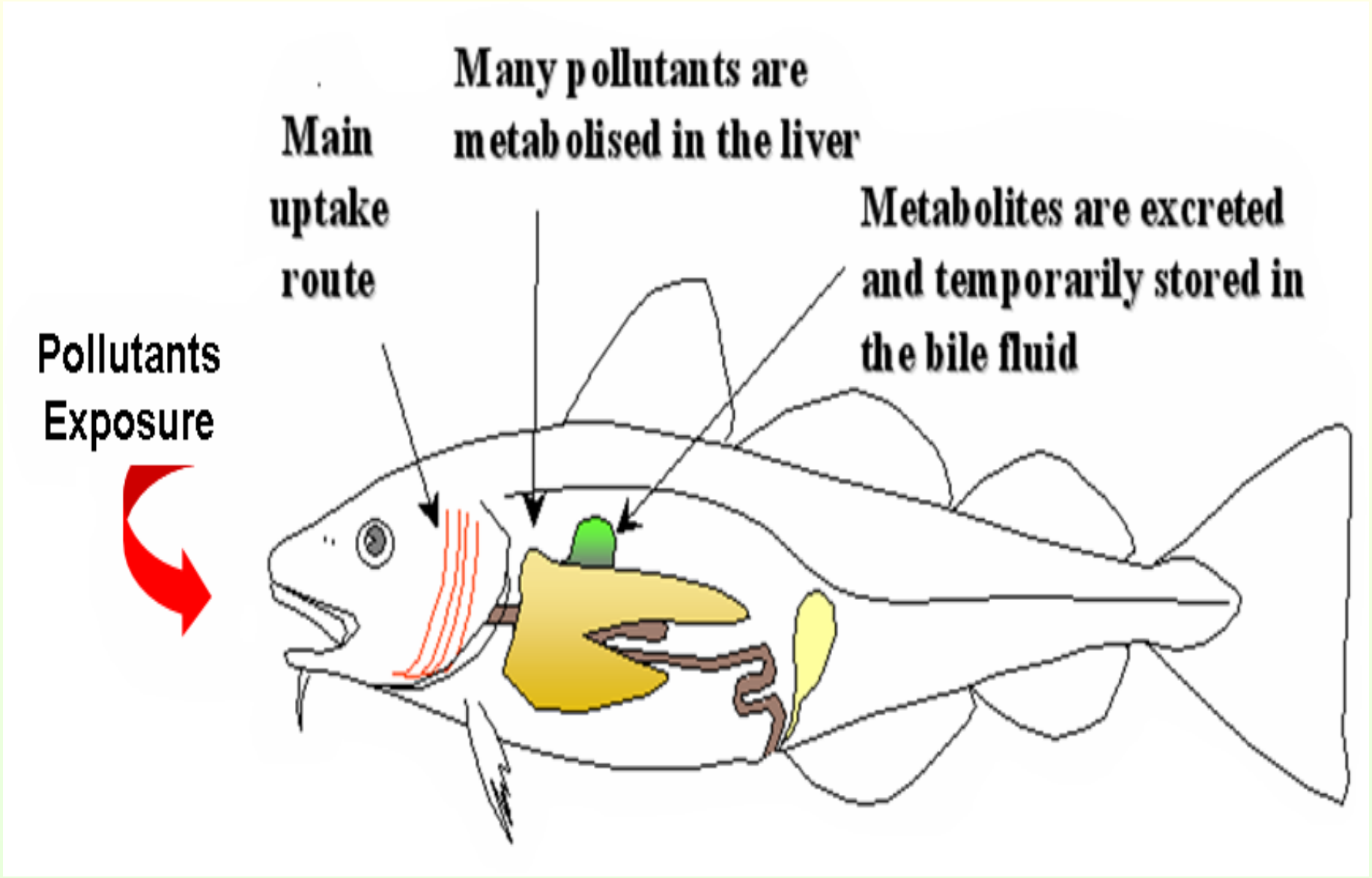


Fig. Schematic representation of the sequential orders of response to pollutant stress under biological system.


Many pollutants are metabolised in the liver
Main uptake route
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***

Homeostasis disturbed

DYSFUNCTIONAL EFFECTS

- Decrease blood oxygen
- Decrease/ increase plasma electrolyte
- Decrease energy stores
- Alterred 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

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.

Modes of Action (Acute Exposure)

Organophosphates/Carbamates

↓

Blocks function of acetyl-cholinesterase

↓

Increases levels of acetylcholine,

an important neurotransmitter

↓

Effect: Disruption of nerve impulse transmission across synapse

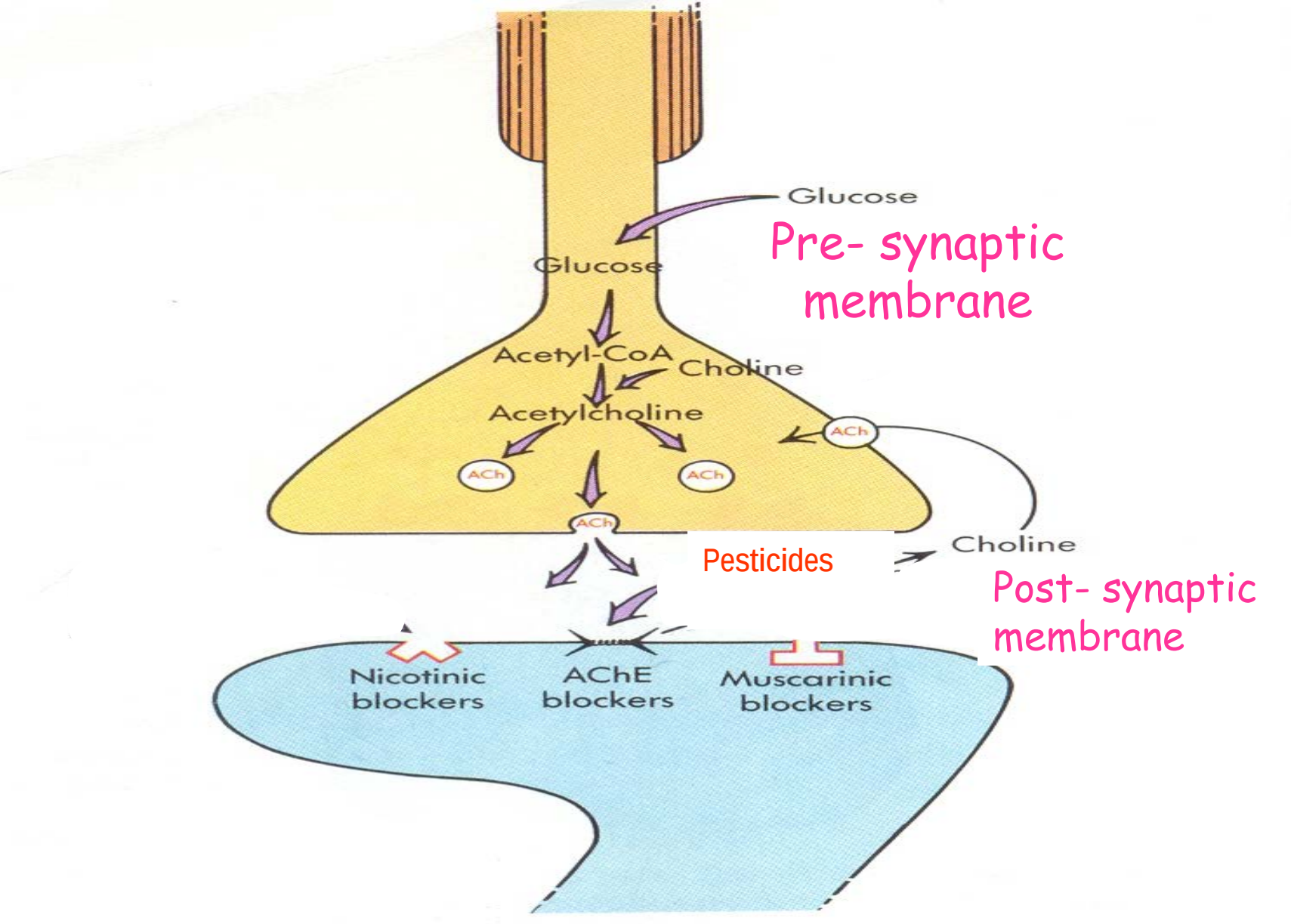


Fig: Site of action of Pesticides at Cholinergic Synapses

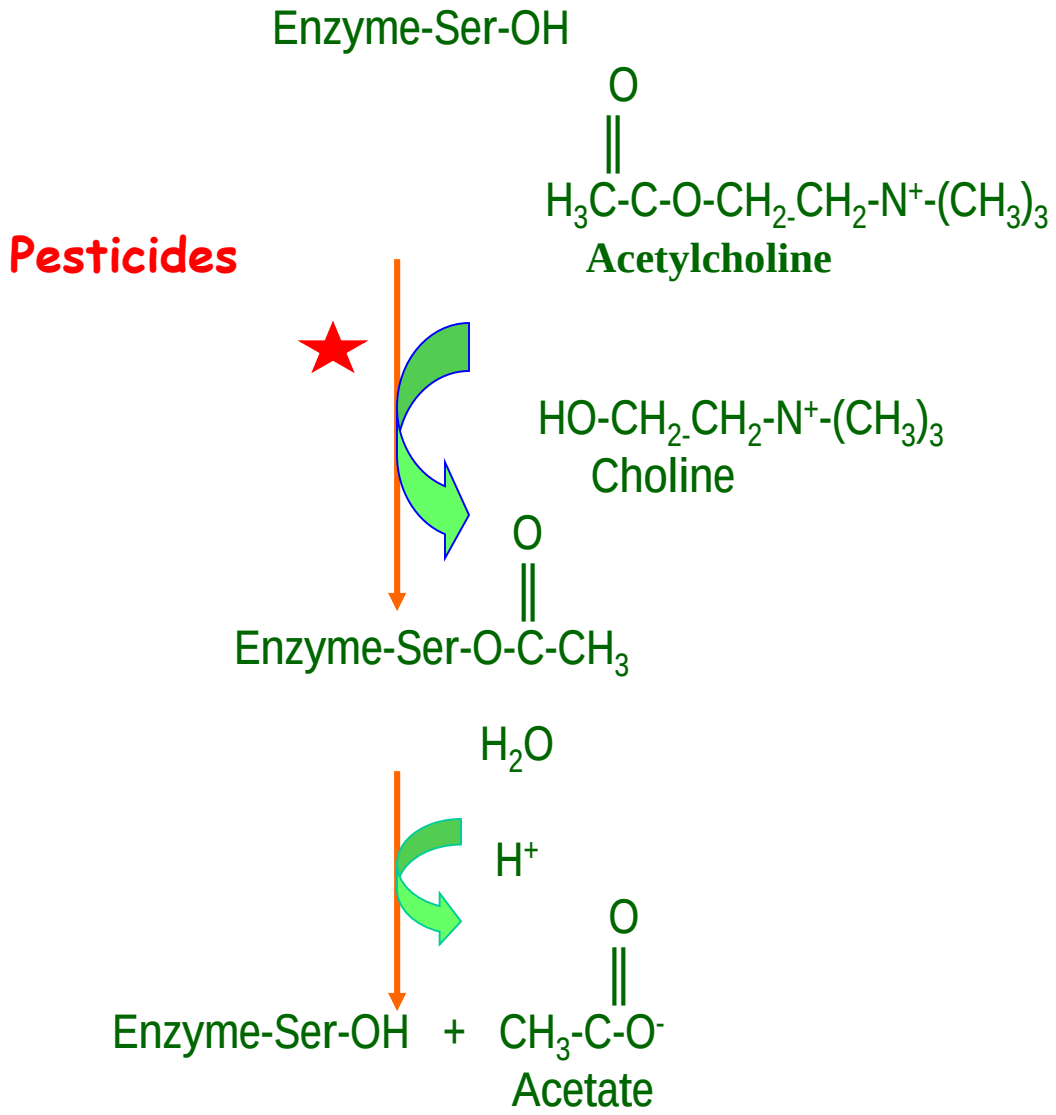
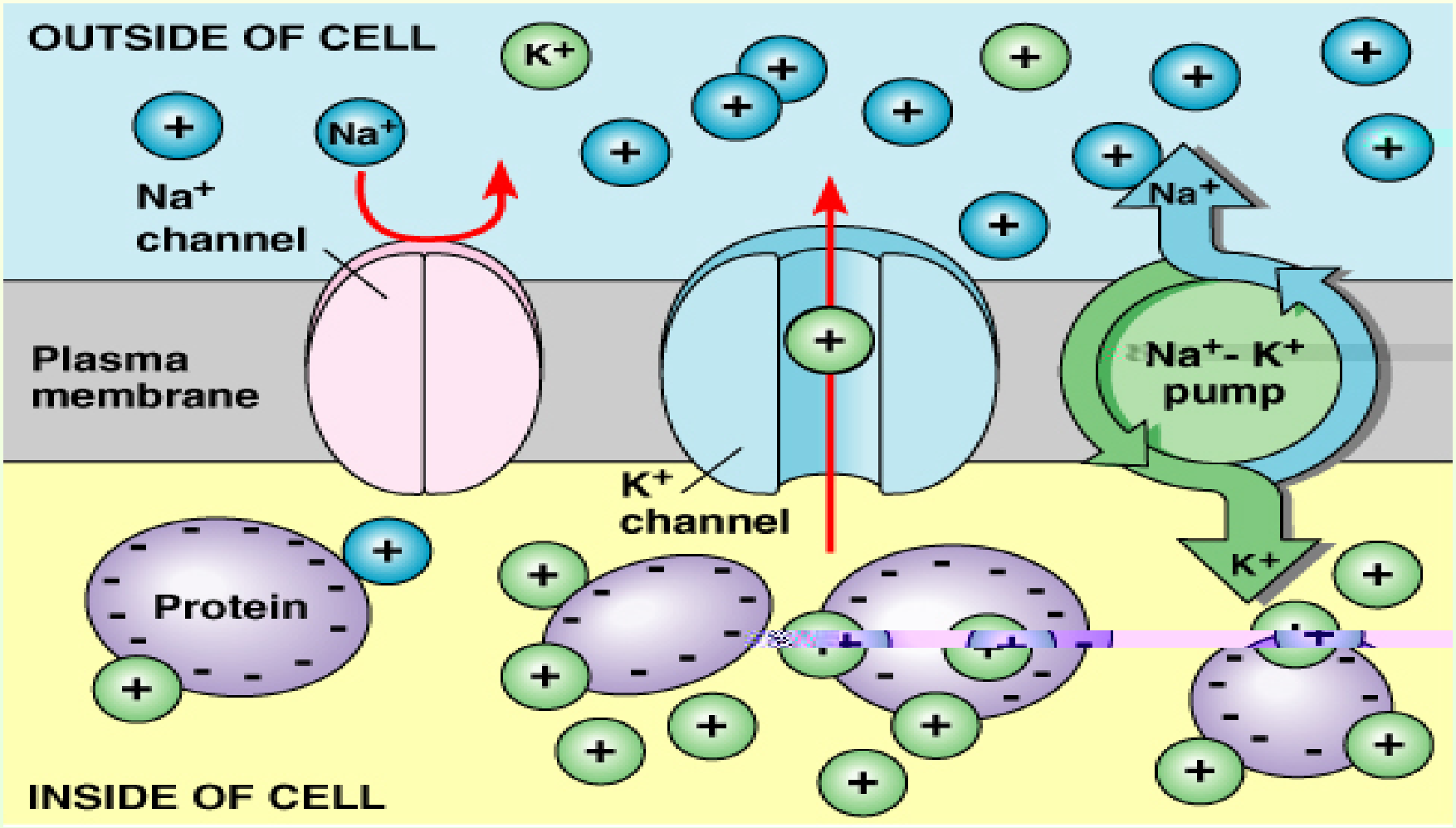


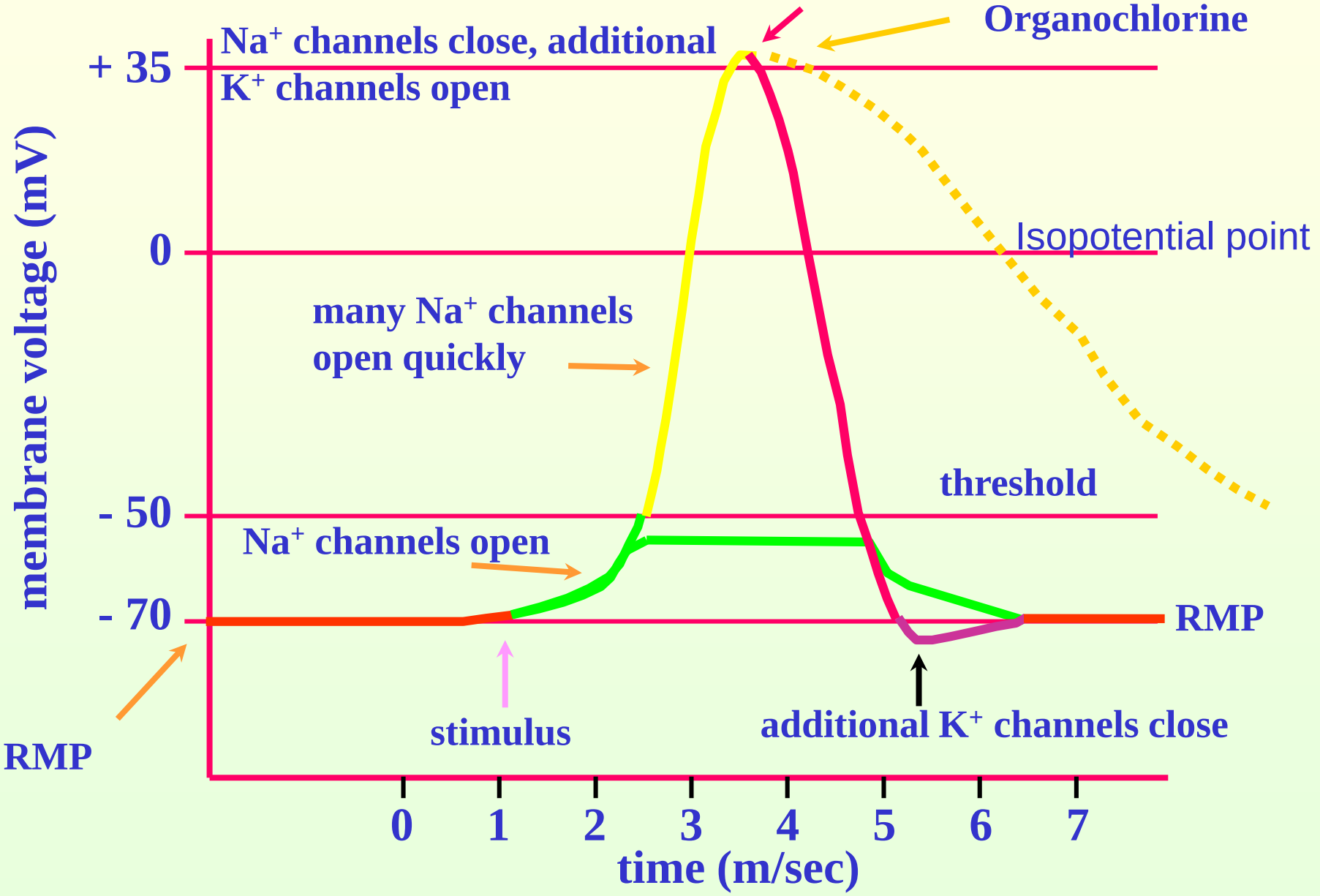
Fig:- Catalytic mechanism of acetylcholinesterase

Modes of Action (Acute Exposure)

Disruption of nerve impulse transmission (Action potential)



Neuron function (action potential)



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)

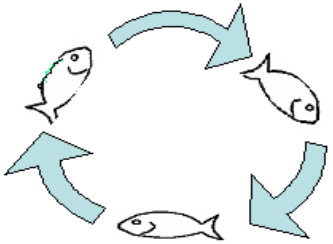
Catla catla (Catla)

Cirrhinus mrigala (Naini)

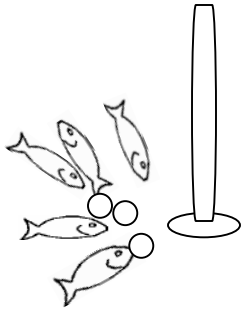
The test organism should be:

- Sensitive
- Ecological and economical importance.
- Available throughout the year.

BEHAVIOURAL CHANGES

Pesticides	Endosulfan
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.**

Pesticides	METHYL PARATHION
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** 

Pesticides	CARBARYL
Labeo rohita	**Flocking near the aerator** 
C. catla	**Respiration faster than control.**
C. mrigala	**Flocking near the aerator**

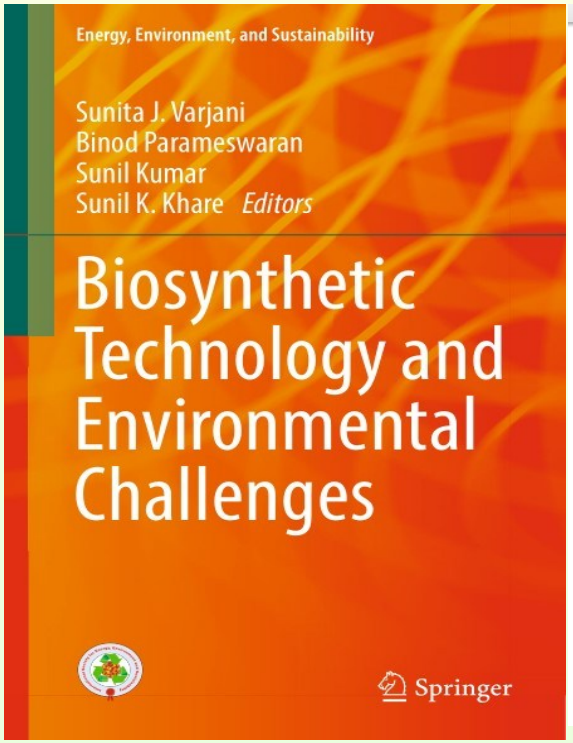
Key Enzymes

Endosulfan Toxicity: LDH, AchE
Methyl Parathion: CK, SGPT and AchE
Carbaryl: ALP and SGOT

SUMMARY OF KEY ENZYMES

	Endosulfan	*Methyl Parathion*	*Carbaryl*	*Spent Wash*	*Synergistic*	*Metal {Cr}*
KEY ENZYMES	LDH	CK	ALP	CK	AchE	SGPT
	AchE	AchE	SGOT	LDH	ALP	SGOT
		SGPT		SDH	CK	ALP

❖“Integration of Biomarker Approach in Pollution monitoring Programme of Aquatic Ecosystem”



Integration of Biomarker Approach in Pollution Monitoring Programme of Aquatic Ecosystem

Kanchan Kumari and Ankur Khare

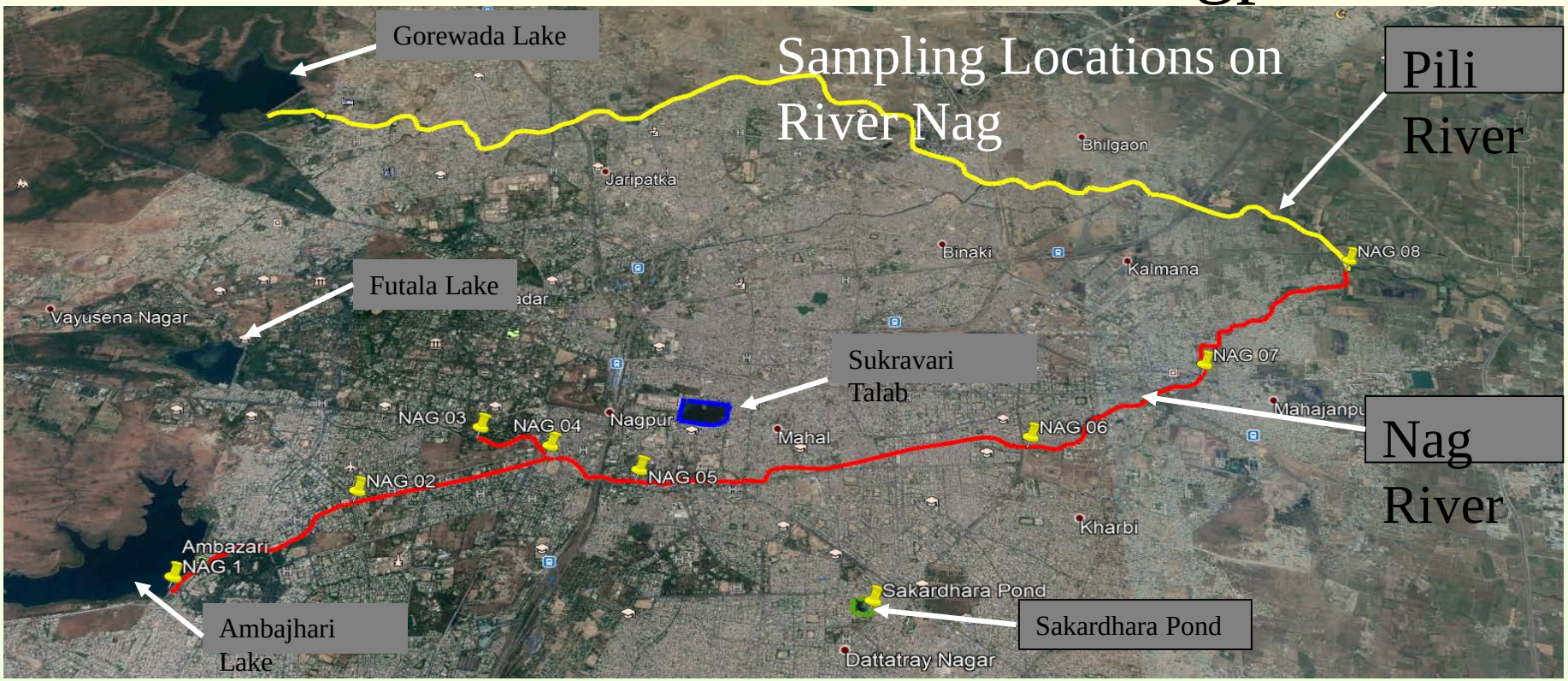
Abstract Water bodies are subjected to a considerable pressure from sewage and industrial wastes. Monitoring methods adopted so far have helped in the assessment level of contaminants in water but not the interaction of these pollutants with living organisms. Water quality testing programmes use two traditional methods for water quality assessment that includes physico-chemical parameters and bio-monitoring. Looking at the limitations of these two traditional methods, a new method known as ‘biomarkers of pollution’ should be adopted. Evaluating various biomarkers in sentinel species can be of great help in environmental monitoring programme as they forecast various risks and hazards associated with the habitats of aquatic animals. Several countries have adopted Biomarkers in their environmental monitoring programmes; however, to make it a routine and well-recognized tool in the water quality monitoring programme, efforts are still required from scientific communities. The major advantage of Biomarkers is that bioavailability or potential exposure to toxicants can be demonstrated which is not possible in chemical analysis. Persistent organic pollutants (POPs) are chemical substances that do not degrade easily and persist in the environment and detecting some classes of POPs, for example organochlorine compounds, are very difficult as the limits of detection are very low. With the advancement of analytical methods, these chemicals can be now detected in every environmental matrices but changes caused physiologically in living organ-isms remains unknown. This limitation can be overcome with the help of biomarkers which can detect whether organisms are exposed meaningfully and the physiology is altered in comparison to normal. Whenever any pollutants enter the biological system, it brings molecular changes and the response time of molecular changes are faster than it appears at community level. This leads the scientific communities to start some research work in this area in order to develop some early warning signal or biomarkers. Measurement of molecular changes at the level of body fluids, cells or

K. Kumari (✉) · A. Khare
Environmental Impact and Sustainability Division, CSIR-National Environmental Engineering Research Institute (CSIR-NEERI), Nehru Marg, Nagpur 440 020, India
e-mail: k_kumari@neeri.res.in; onlinekanchan1@gmail.com

A. Khare
e-mail: ankurkharebhu@outlook.com

S. J. Varjani et al. (eds.), *Biosynthetic Technology*

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 LC_{50} determination

Surface and darting movement of fishes.

Accumulation of fishes near aerator.

Overview of Field Sampling

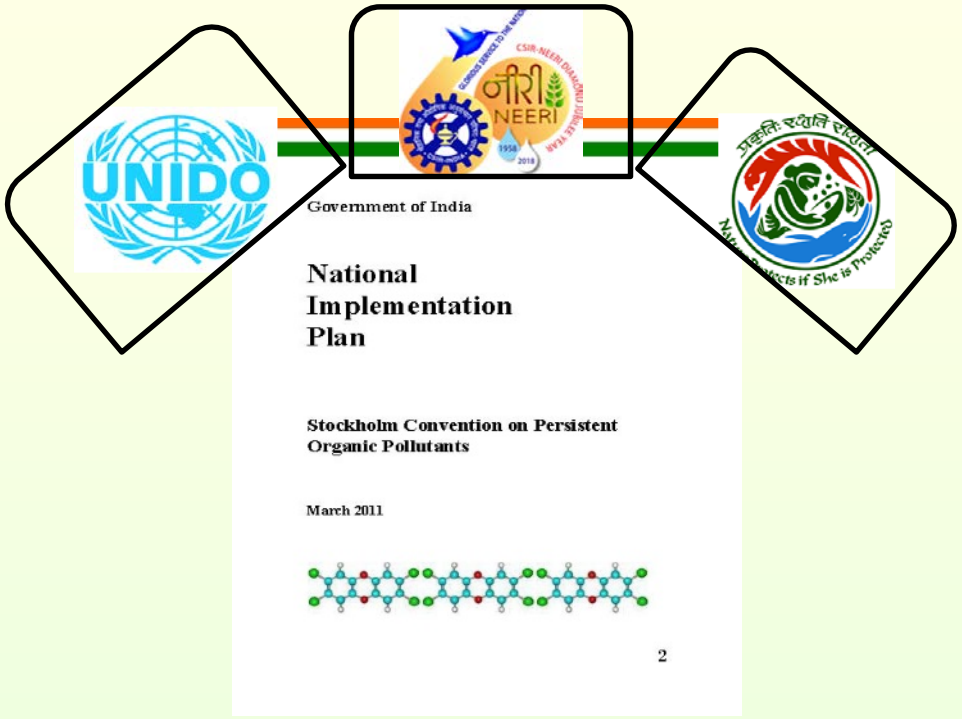
S. No	Sample code	Geographical position	
		Latitude	Longitude
1.	NG/W1	21° 7'29.95"N	79° 2'36.20"E
2.	NG/W2	21° 8'6.26"N	79° 3'39.83"E
3.	NG/W3	21° 8'34.94"	79° 4'24.81"E
4.	NG/W4	21° 8'25.77"N	79° 4'53.22"E
5.	NG/W5	21° 8'14.01"N	79° 5'28.76"E
6.	NG/W6	21° 8'26.84"N	79° 8'3.44"E
7.	NG/W7	21° 9'0.83"N	79° 9'18.64"E
8.	NG/W8	21° 9'54.71"N	79°10'30.63"E

Fig- Sampling at Nag River

Stockholm Convention & POPs

CSIR-National Environmental Engineering Research Institute

Stockholm Convention Regional Centre on POPs for Asia Region

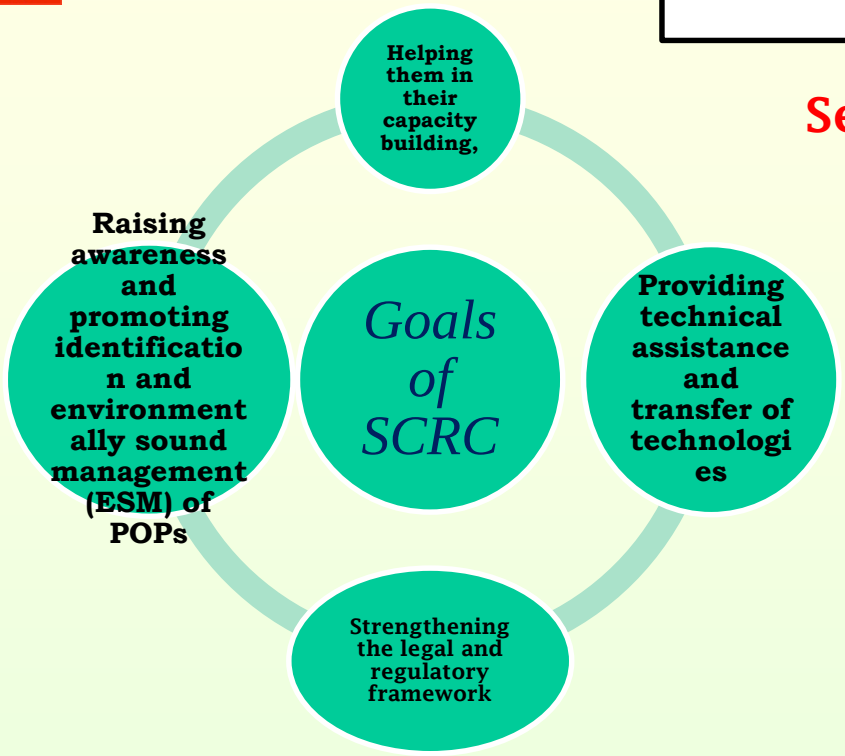


Activities

- ✓ **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.

GOALS OF SCRC



Serve different parties/countries in the Asia region

Country / Party	National Flag
Bangladesh	
India	
Maldives	
Mongolia	
Myanmar	
Nepal	
Philippines	
Thailand	
Sri Lanka	
UAE	
Vietnam	

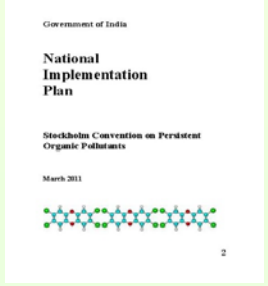
- The centre is **assisting the parties of Asia region in fulfilling their obligations** of the Stockholm Convention

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

2010

March 2011

1st NIP on POPs



April 2011

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

Nov 2011

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

June 2012

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

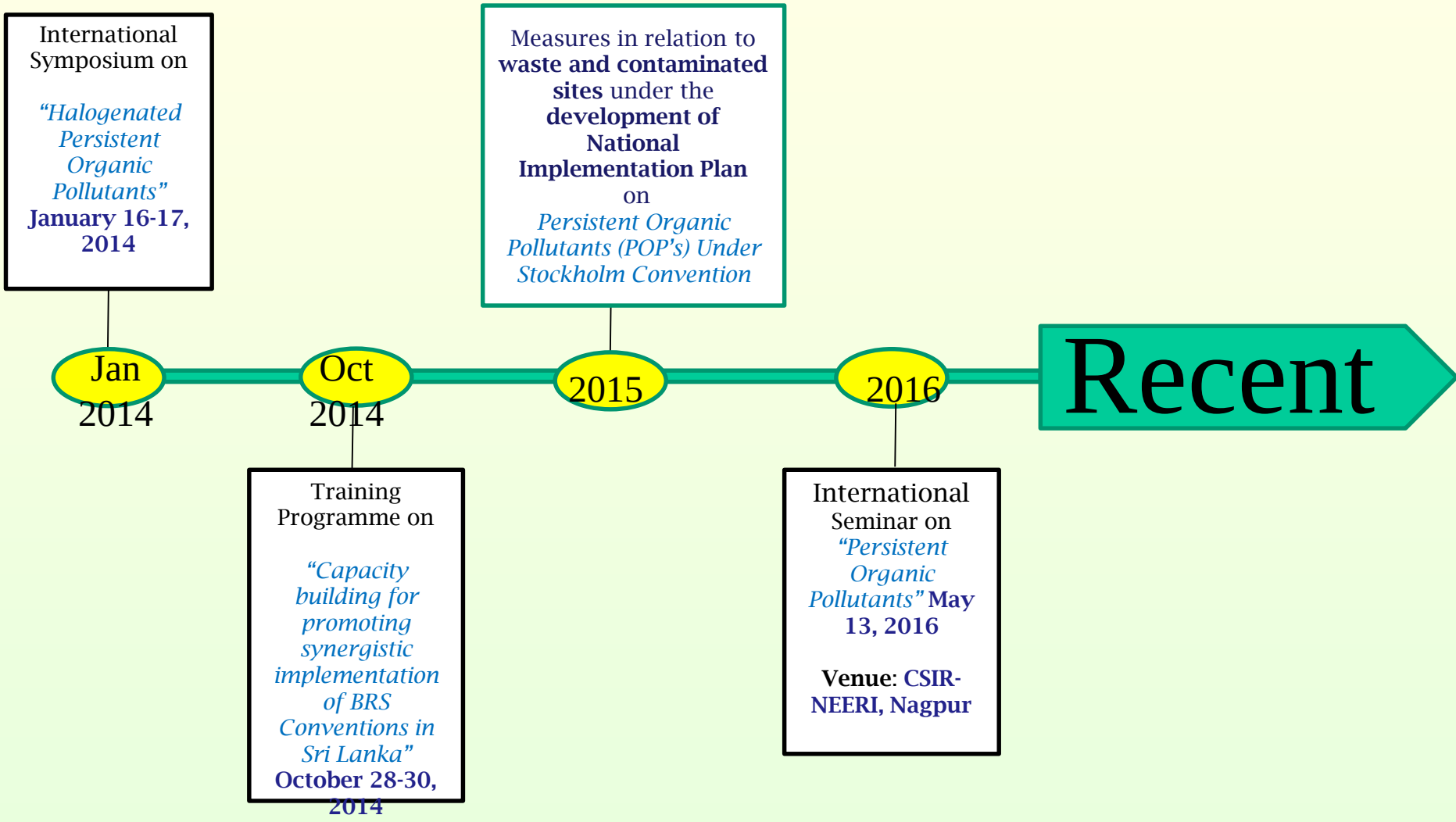
Feb 2013

Regional Stakeholders Meeting on *"Dioxin / Furans: The Unintentional POPs"* **February 12, 2013**

Dec 2013

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

Cont.


International Symposium on
"Halogenated Persistent Organic Pollutants" **January 16-17, 2014**
Jan 2014
Oct 2014
Training Programme on
"Capacity building for promoting synergistic implementation of BRS Conventions in Sri Lanka" **October 28-30, 2014**
Measures in relation to **waste and contaminated sites** under the **development of National Implementation Plan** on *Persistent Organic Pollutants (POP's) Under Stockholm Convention*
2015
2016
International Seminar on *"Persistent Organic Pollutants"* **May 13, 2016**
Venue: **CSIR-NEERI, Nagpur**
Recent

Few Current R & D Studies:
Determination of Polybrominated Diphenyl Ethers (PBDEs) in Environmental matrices
Institutional capacity building for sustainable management of chemicals and wastes with special focus on Persistent Organic Pollutants
Risk Assessment and Socio-Economic Analysis of Methylated Tetra and Penta Siloxane
National Inventory development of Mercury in Waste sector in India
Organizing five awareness raising workshops on improving mercury management in India
Development and Promotion of Non-POPs Alternatives to DDT

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-

Slab Name	Amount (INR)	Allowances
Platinum Sponsor	Above 2,00,000/-	• Slot for Presentation • 5 free registrations • Promotions in all Materials
Gold Sponsor	Above 1,25,000/- 1,75,000/-	• Slot for Presentation • 3 free registrations • Promotions in Banners and Hoardings
Silver Sponsor	1,25,000/-	• Slot for Presentation • 2 free registrations

Organizers

Mentors

Dr. Rakesh Kumar
Director,
CSIR-NEERI, Nehru Marg
Nagpur-440020, India
Tel No. : +91 712 2249999
Fax: +91 712 2249900, Email: director@neeri.res.in

Shri. M. K. Gangeya
Director,
Hazardous Substances Management (HSM) Division,
Ministry of Environment, Forest & Climate Change,
New Delhi
Tel No. : +91 11 24695337; Email: m_gangeya@nic.in

Coordinator

Dr. A. N. Vaidya
Chief Scientist and Head,
Solid & Hazardous Waste Management
Division, CSIR-NEERI, Nehru Marg
Nagpur-440020, India
Tel No. : +91 712 2249764
Fax: +91 712 2249900 Email:
an_vaidya@neeri.res.in

Convener

Dr. (Mrs.) Kanchan Kumari
Sr. Scientist,
Environmental Impact and Sustainability Division,
CSIR-NEERI, Nehru Marg
Nagpur-440020, India
Tel No. : +91 712 2249885-90 (Ext. no. : 332)
Fax: +91 712 2249900
Email: k_kumari@neeri.res.in

Contact Person

Dr. Kanchan Kumari
Sr. Scientist & Convener
Environment Impact and Sustainability Division, CSIR-NEERI, Nehru Marg
Nagpur, Maharashtra, (India), 440020
Tel No. : 0712-2249885-90 (Ext. no.-332) Email: scrc@neeri.res.in/k_kumari@neeri.res.in

Workshop on

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

Under

UNEP Special Program on Chemical and Waste Management

17th & 18th July, 2019

CSIR-NEERI, Nagpur

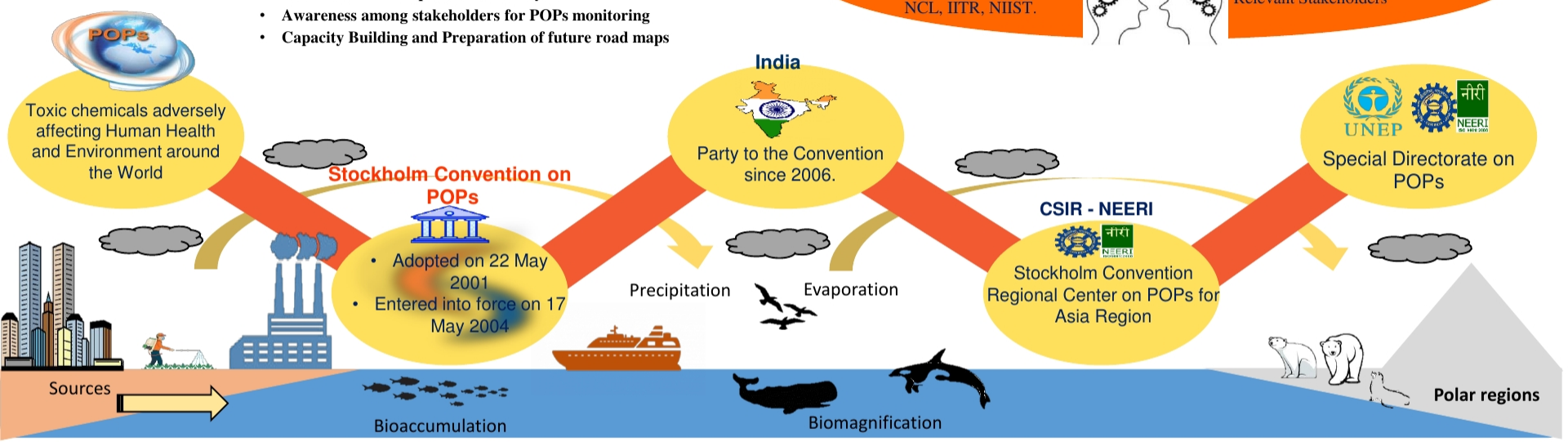
CSIR-National Environmental Engineering Research Institute
Stockholm Convention Regional Centre on POPs for Asia Region
CSIR under Ministry of Science and Technology, (Govt. of India)
Nehru Marg, Nagpur, 440020- India

Objectives of the Workshop

- **Identification of Gaps and need analysis**
- **Awareness among stakeholders for POPs monitoring**
- **Capacity Building and Preparation of future road maps**

Our Experts
UNEP, MoEF & CC, CPCB, ICC, CII, , IITs, SIAM, REIAI, ICAR, CSIR-NEERI, IICT, NCL, IITR, NIIST.

Participants
Government officials, NGOs Industrialists, Academicians, Relevant Stakeholders



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.

scrc@neeri.res.in/k_kumari@neeri.res.in

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.

scrc@neeri.res.in/k_kumari@neeri.res.in

Thanking You……!

Dr. Kanchan Kumari
Senior. Scientist,
Environmental Impact and Sustainability Division,
CSIR-NEERI, Nagpur
k_kumari@neeri.res.in, onlinekanchan1@gmail.com