Organochlorines Dynamics in Indonesian Tropical Climate

A Study in Segara Anakan Estuarine

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- Transportation of POPs in the environment result from a complex equilibrium between sorption-desorption, volatilization-precipitation, and inputs and losses
- Fate and distribution of POPs in the environment influenced by the interaction between all compartments, biotic and abiotic, which depend to their physico chemical characteristics.

Linking the basic science – applied research - risk management

Indonesian Government

- aware of the risk of persistent organic pollutant (POPs) for public health and the whole ecosystem
  - banned the use of POP pesticide since 1973
  - banned the use of POPs in public health programs to control pests and vector borne diseases since 1990
- signed the Stockholm convention at 23 Mei 2001
- However, POPs are still detected in the environment (Noegrohati, 1995, 2004, UNIDO 2003, UNU, 2003)
- POPs detected are mostly POPs pesticides: HCB, HCHs, Heptachlor and Hepox, Endrin, and predominated by DDT and its degradation product


Segara Anakan

- Located in the south coast of Central Java and relatively still in pristine condition
- Shielded from Indian Ocean by Nusakambangan Island,
- Continuously collects the inflowing fresh waters from volcanic area of West Java, through Citanduy river basin, from agriculture area of Central Java through Cibeureum, Cimeneng and Cikonde rivers and other small rivers,
- Seawater input from the Indian Ocean by tidal actions through the western opening.
- Sedimentation were around 3.000.000 m3 per year (Saputra, 2003).

POPs reach Segara Anakan through:

- **Waterways transportation** especially by suspended particles
- **Atmospheric transportation**: dry and wet precipitation

Climate parameters and its consequences

Parameters			Dry	Rainy
Temperature	°C		28	30
Total Rainfall	mm/month		0.7	374.7
Water velocity	m/sec	Estuarine	0.2	0.3
		River	0.3	0.7
Salinity	‰	Estuarine	25.7	2.2
		River	17.5	0.1

Processes might influence the POPs Dynamics

Dry season

- Higher salinity
  - higher sedimentation including the deposited POPs
  - Higher salinity → salting out effect → more POPs into the sediment
- More evaporation

Rainy season

- More surface run-off entering the river carried out into the estuarine
- More fresh water influx → less saline → POPs desorption from the sediment
- Faster water velocity → washing out of the estuarine
- More precipitation

The expected exposure and effect of POPs in Segara Anakan Estuary

- **The influence of dry and rainy season:**
  - Estuarine sediment may act as scavenger and as source of POPs for the biota
  - Estuarine water act as POPs transporter for parent compoun d and its degradation product
- **Bioaccumulation in local biota**
  - Sesille bioindicator: local mussel *Geloina* spp.
  - Local saltwater spawners: *Mugil* spp
  - Highest trophic level: human milk
- **Risk of POPs to local residents?**

Organization of the study

- Dissipation and degradation pattern of p,p’-DDT in soil environment
- POPs dynamics in Segara Anakan estuarine
- Risk evaluation for fish meal consumers and breast milk fed babies in Segara Anakan area

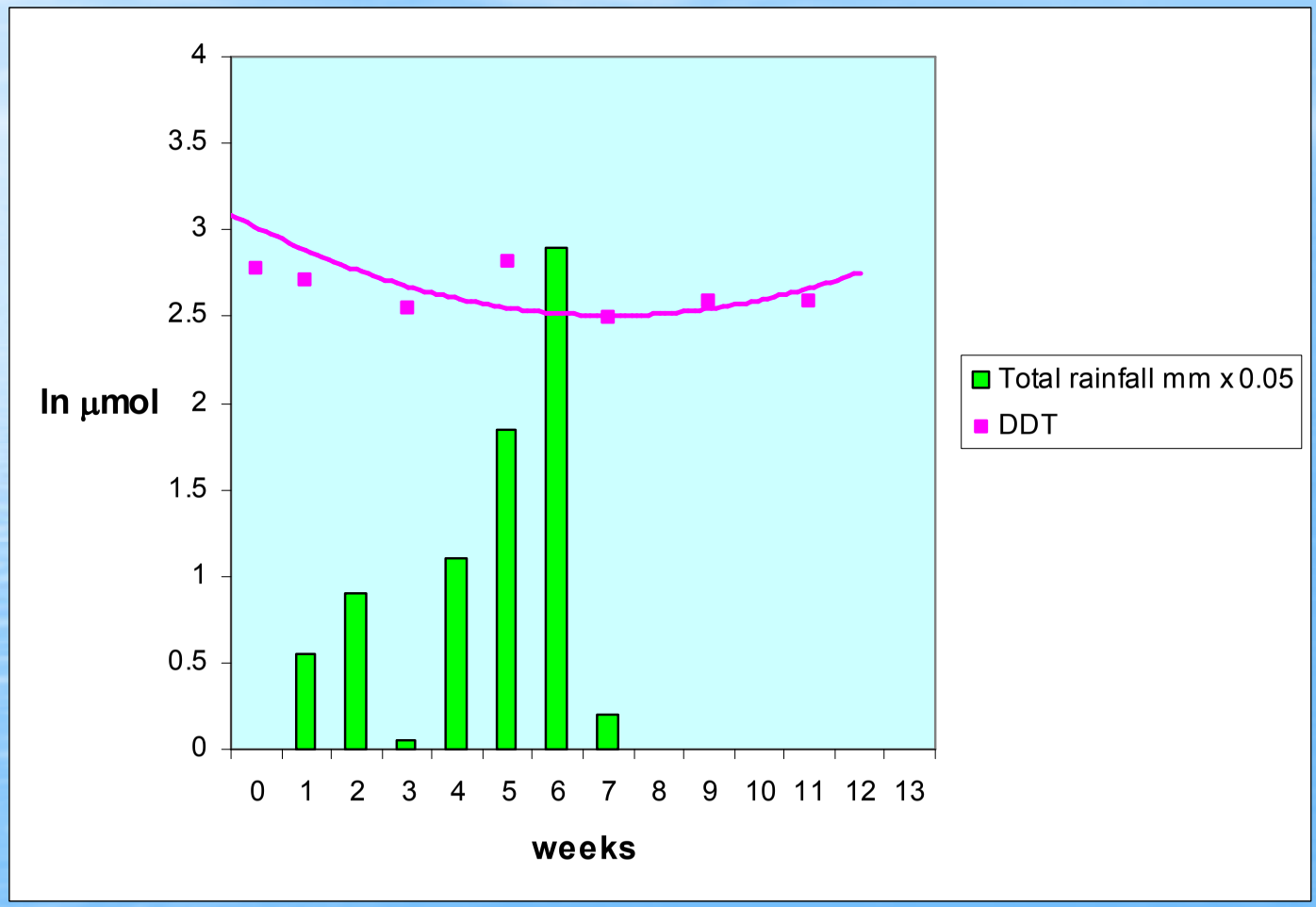
Dissipation and degradation pattern of p,p'-DDT in soil environment

- The study was done in Gadjah Mada University field research centre, Kalitirto, DIY, under tropical local climate
- The soil microcosm
  - 3 series of 10 cm i.d and 35 cm length columns were inserted into the soil surface leaving 5 cm protruding out
  - treated with DDT, DDE, and untreated.

Soil Characteristics

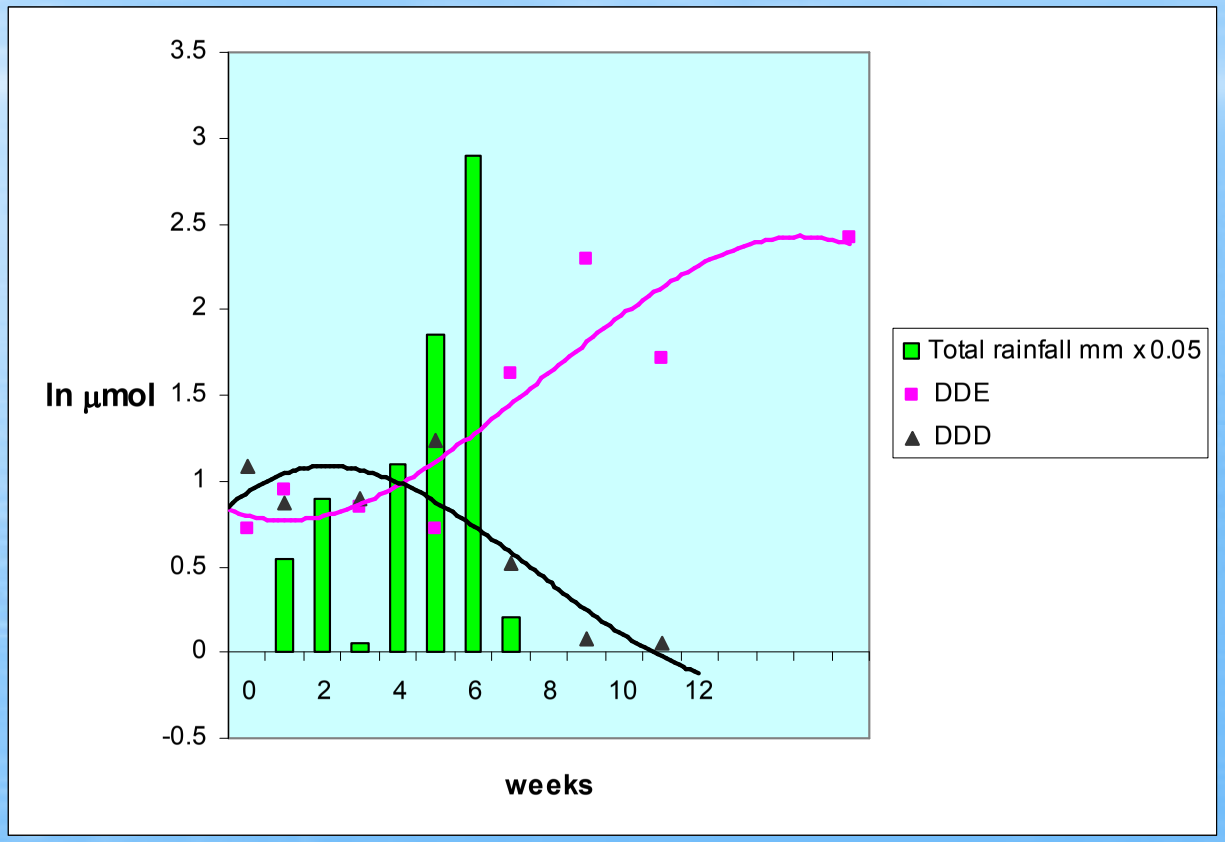
Temperature (°C)	Surface sub-surface (20 cm depth)	31.6 ± 0.7 29.9 ± 0.4
Moisture (%)	Particle size ➢ 2 mm ➢ 0.5 mm	 4.96 5.06
pH	(H2O)	6.40
Organic matter (%) Organic carbon (%)		1.69 0.98
Soil Texture: **Sandy Loam**	➢ Clay (%) ➢ Dust (%) ➢ Sand (%)	12.6 42.0 45.4

Dissipation of p,p'-DDT during rainy season followed by dry season



Biphasic dissipation processes:
p,p'-DDT: Rainy season 0.07; dry season 0.02

p,p'-DDT degradation pattern during rainy season followed by dry season



Reaction Model:

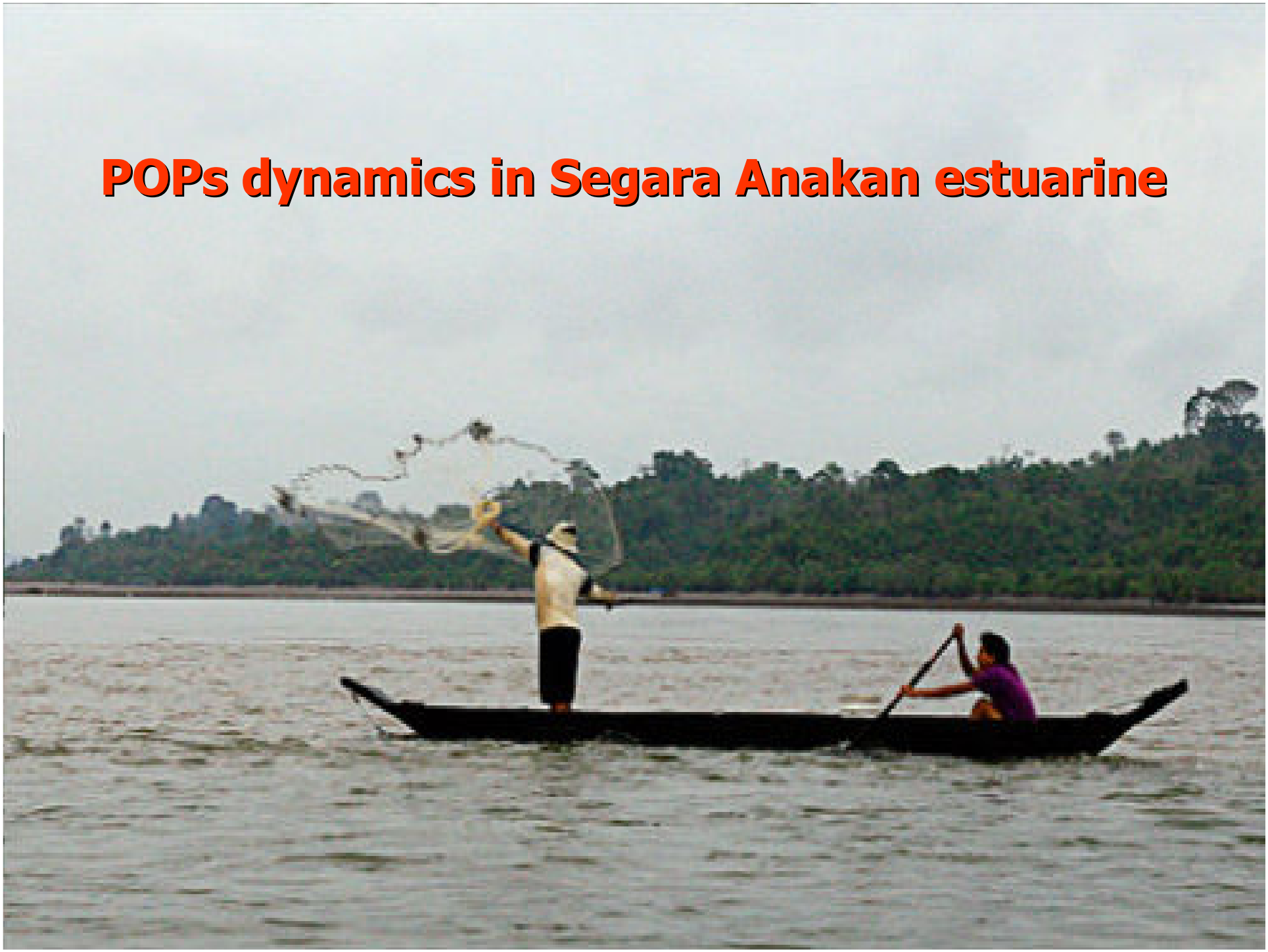
Rainy season: DDT → **DDE**, **DDD**

Dry season: DDT → **DDE**

Some clue

- Under Indonesian tropical climate, the dissipation and degradation of p,p' DDT in rainy season is different than in dry season → important variables
- To evaluate whether the POPs actually were *reduced* or *eliminated* → ΣDDT information is important
- To describe the fresh input of DDT over time → ratio of DDT/(DDE+DDD) should be mentioned

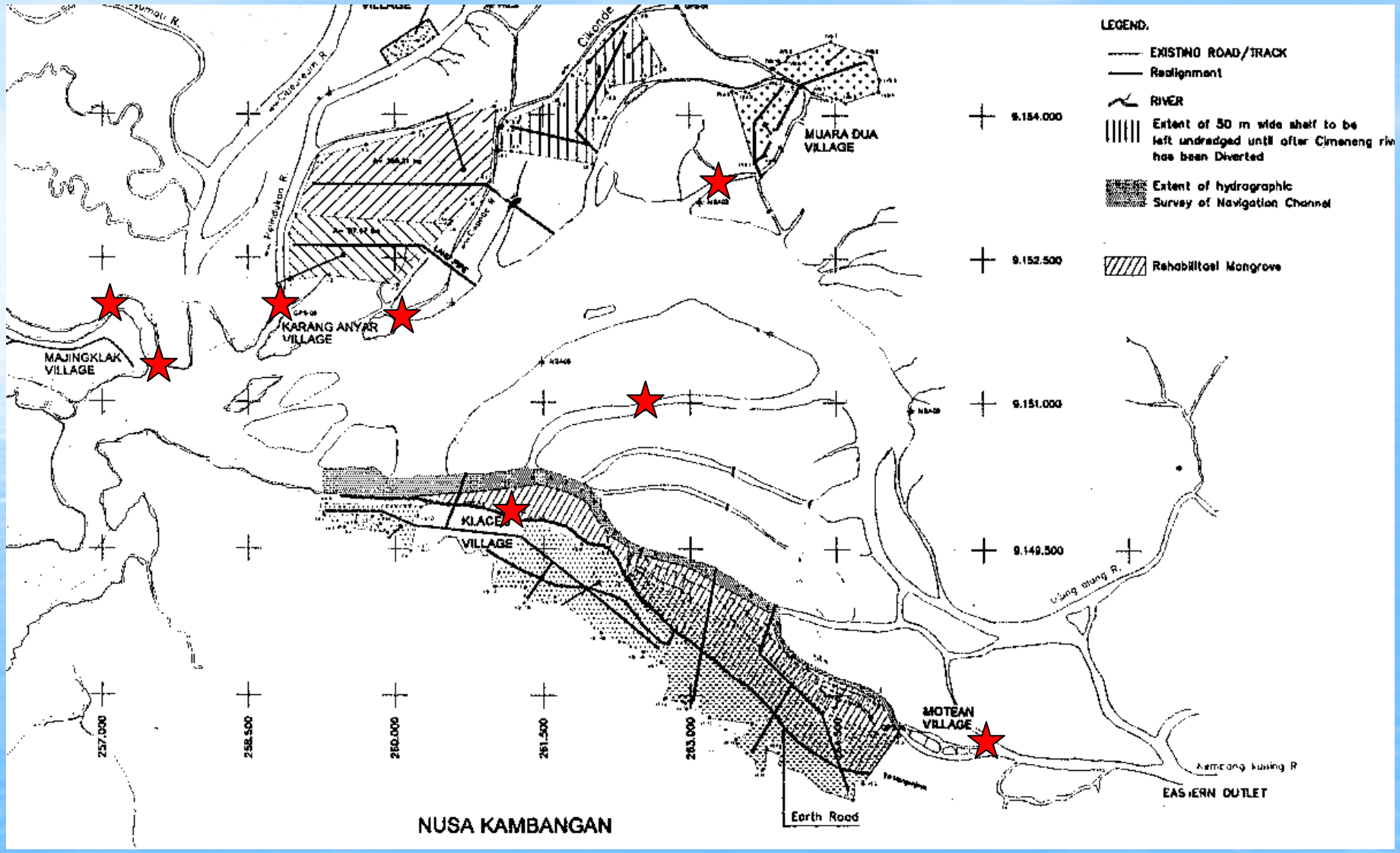
POPs dynamics in Segara Anakan estuarine



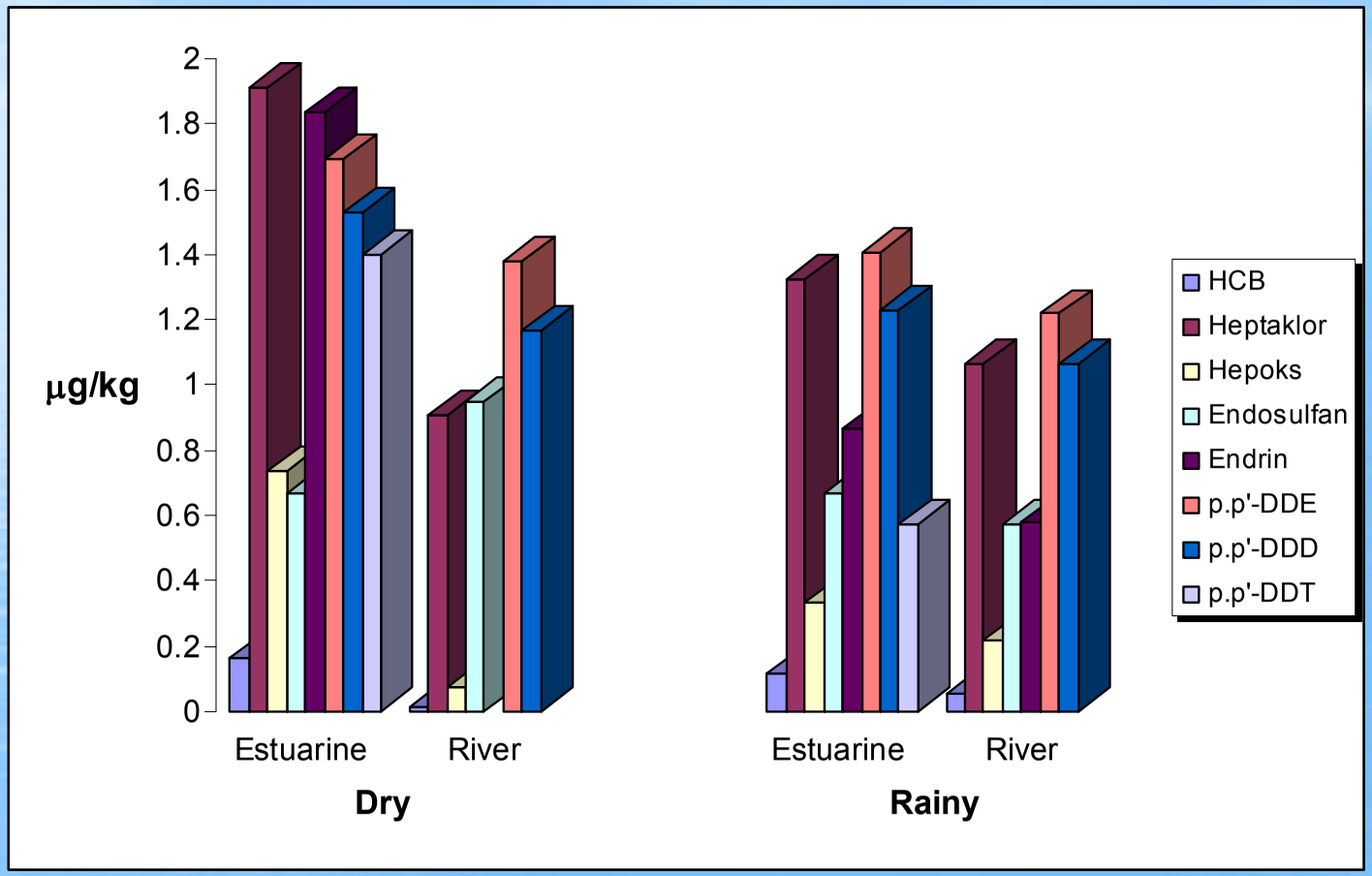
The POPs studied and some of their Physicochemical characteristics

POPs	Vapor Pressure in 10^{-6} mmHg at 20 °C	Water Solubility in µg/L	log KOC
HCB	11	5	-
Heptachlor	300	50	5.01
Hepox	-	350	4.77
Endosulfan	10	530	4.44
p,p' DDE	6.5	14	5.11
Endrin	0.2	260	4.43
p,p' DDD	1.0	20	5.04
p,p' DDT	0.7	5.5	5.34

Sampling sites



The influence of dry and rainy season to POPs level in Estuarine and river sediment



Saline water → sediment act as POPs scavenger

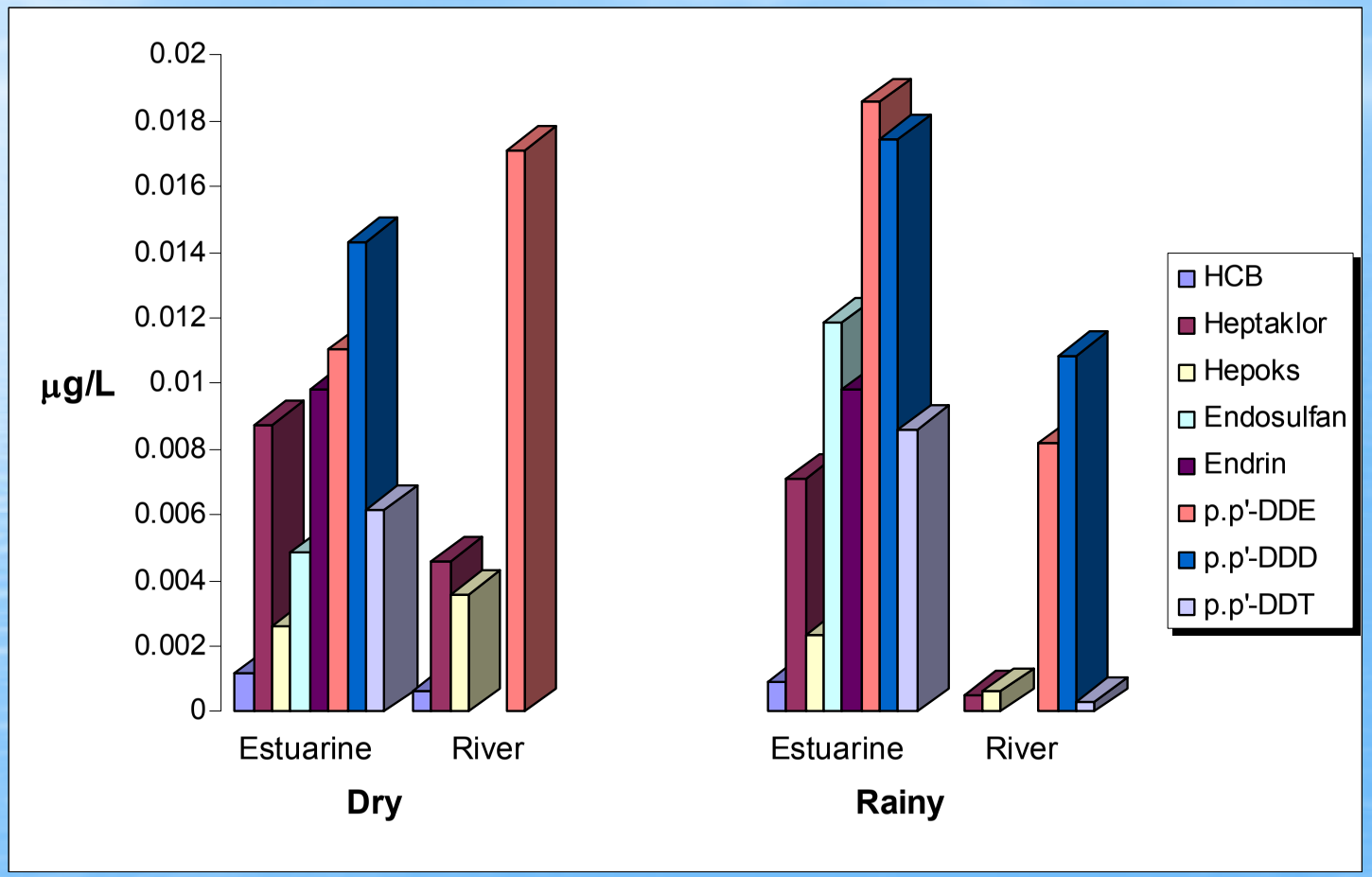
POPs entering the estuary by solid particles transportation

DDT in estuarine sediment

- ΣDDT
  - rainy season 3.2 μg/kg, indicating of washing out by fresh water influx into the sea → DDT pollution level should be decreasing with time
  - dry season 4.2 μg/kg, indicating of salting out effect → scavenging
- Ratio of DDT/(DDE+DDD)
  - rainy season 0.2
  - dry season 0.4

} **No fresh input of DDT**

The influence of dry and rainy season to POPs level in Estuarine and river water

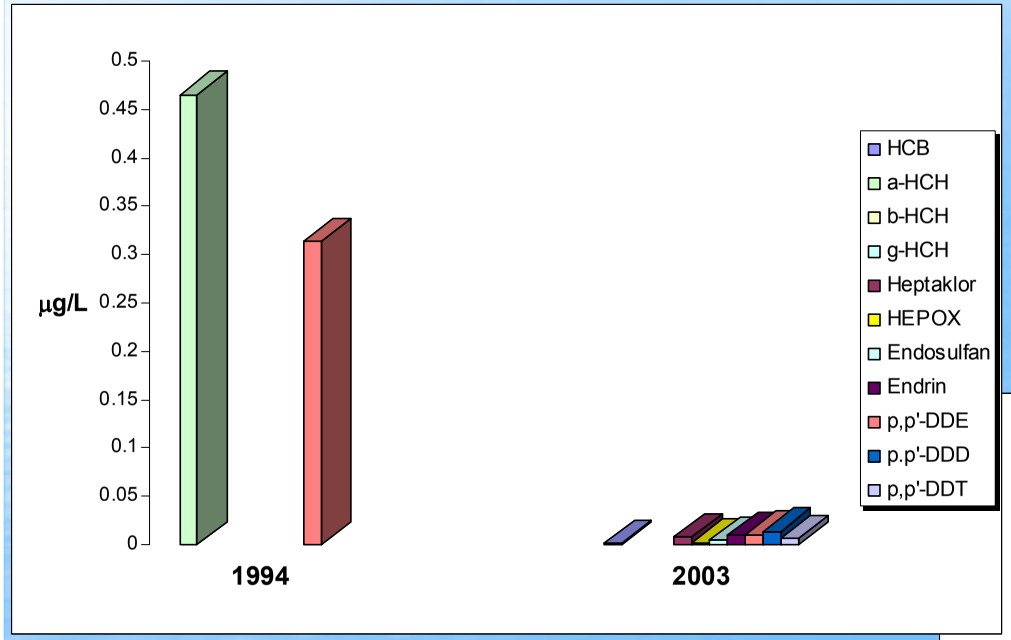


Salting out effect prevails:
Estuarine > River; and Rainy season > Dry season

Estuarine Sediment-Water Equilibrium

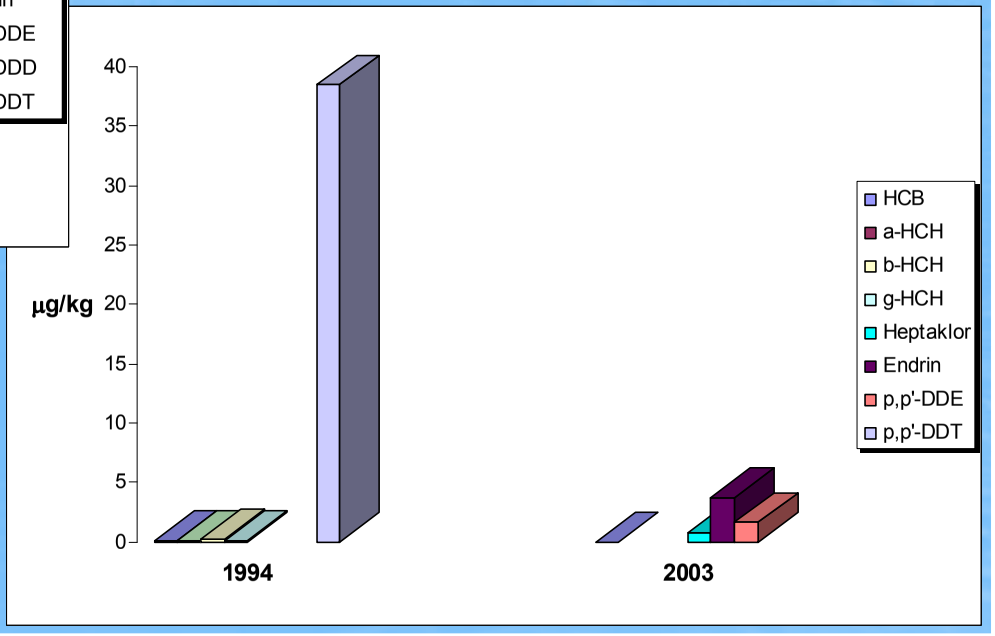
- For POPs mostly transported through waterways → sorption desorption prevails
- The $C_{sediment}/C_{water}$ ratios for Hepox, Endrin, DDTs and Endosulfan (the "swimmer") in dry season were 2.0 to 3.4 times of those in rainy season → salting out effect to the sorption-desorption equilibrium.
- The $C_{sediment}/C_{wate}$ ratios of HCB and HCH (the "flyer") were 1.1 to 1.2 times of those in rainy season, indicating of more input from precipitation due to their volatility

POPs Washing out of estuarine ecosystem



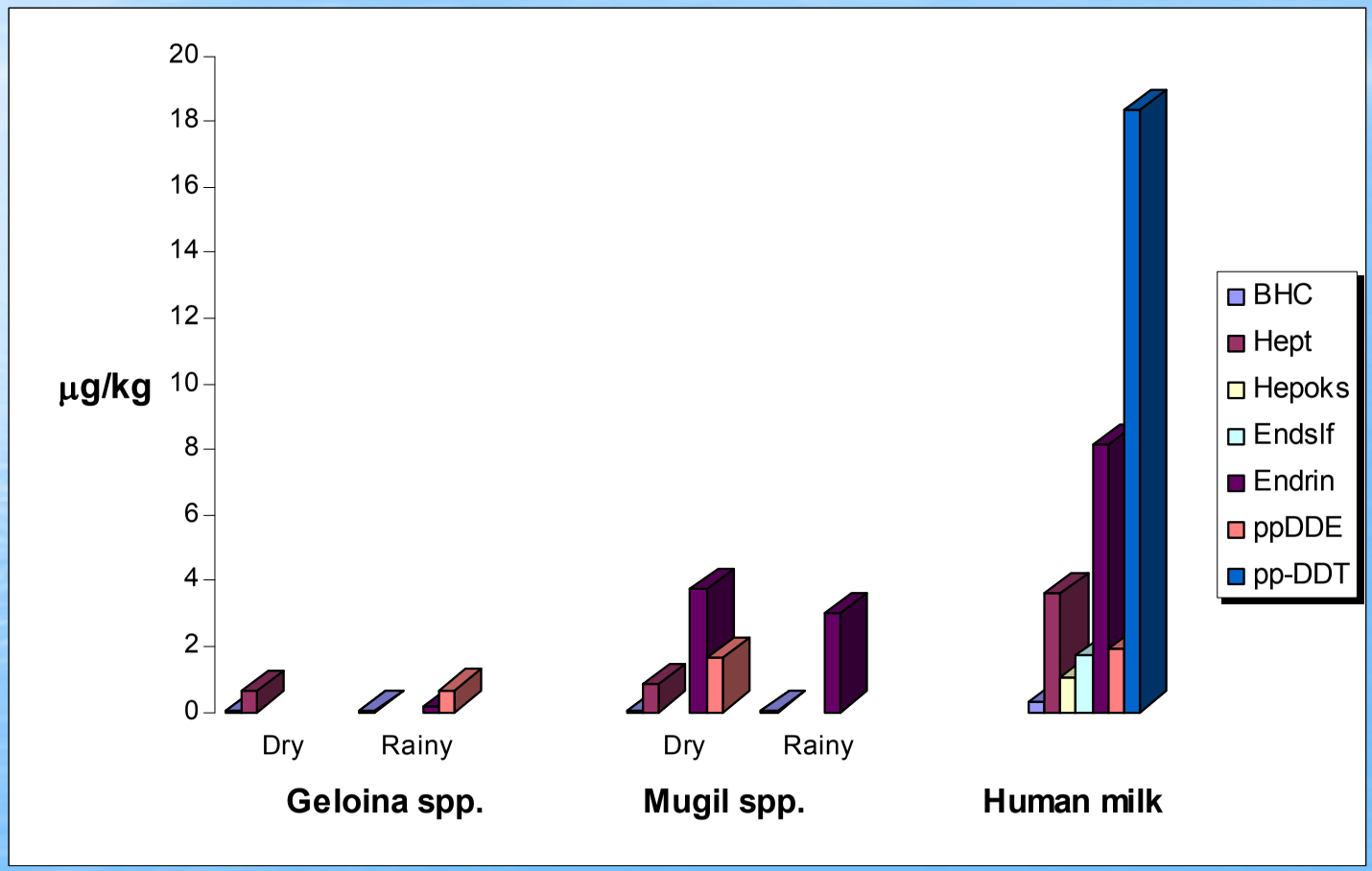
POPs level in estuarine water

POPs level in *Mugil* spp.




Bioaccumulation

POPs Concentrations in local mussels, seawater spawning fishes and human milk



Ratio to estuarine water:

4 to 75 **15 to 350** **175 to 2976**

Risk evaluation for fish meal consumers and breast milk fed babies area

- The daily consumption rate limit (CR_{lim}), kg/d (EPA) is calculated as follows

$$CR_{lim} = \frac{ARL \bullet BW}{CSF \bullet C_m}$$

  - maximum acceptable individual lifetime risk level of 1 in 100,000, ARL10-5
  - cancer slope factors (70-yr lifetime exposure, upper 95 percent confidence limit), CSF is 0.34.
- calculation based on DDT carcinogenicity
  - fish meal consumers is 0.9 kg/day
  - breast fed babies is 0.015 L/day

Risk management on POPs is still required, especially for p,p'-DDT

Conclusion

- The dynamics of POPs in estuarine environment under Indonesian tropical climate were influenced by rainy and dry season
- Salinity influences the sorption-desorption equilibrium of "swimmer" POPs more than "flyer" POPs
- Sediment act as scavenger and source of POPs for the estuarine ecosystem
- Bioaccumulation of POPs in mussel (*Geloina* spp.) < seawater spawner (*Mugil* spp.)< Human Milk
- The risk evaluation for DDT in human milk indicate that risk management on p,p'-DDT is still required


Thank you for your atention