Safety and Sustainability in Reuse of Treated Sewage

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CLIMATE CHANGE

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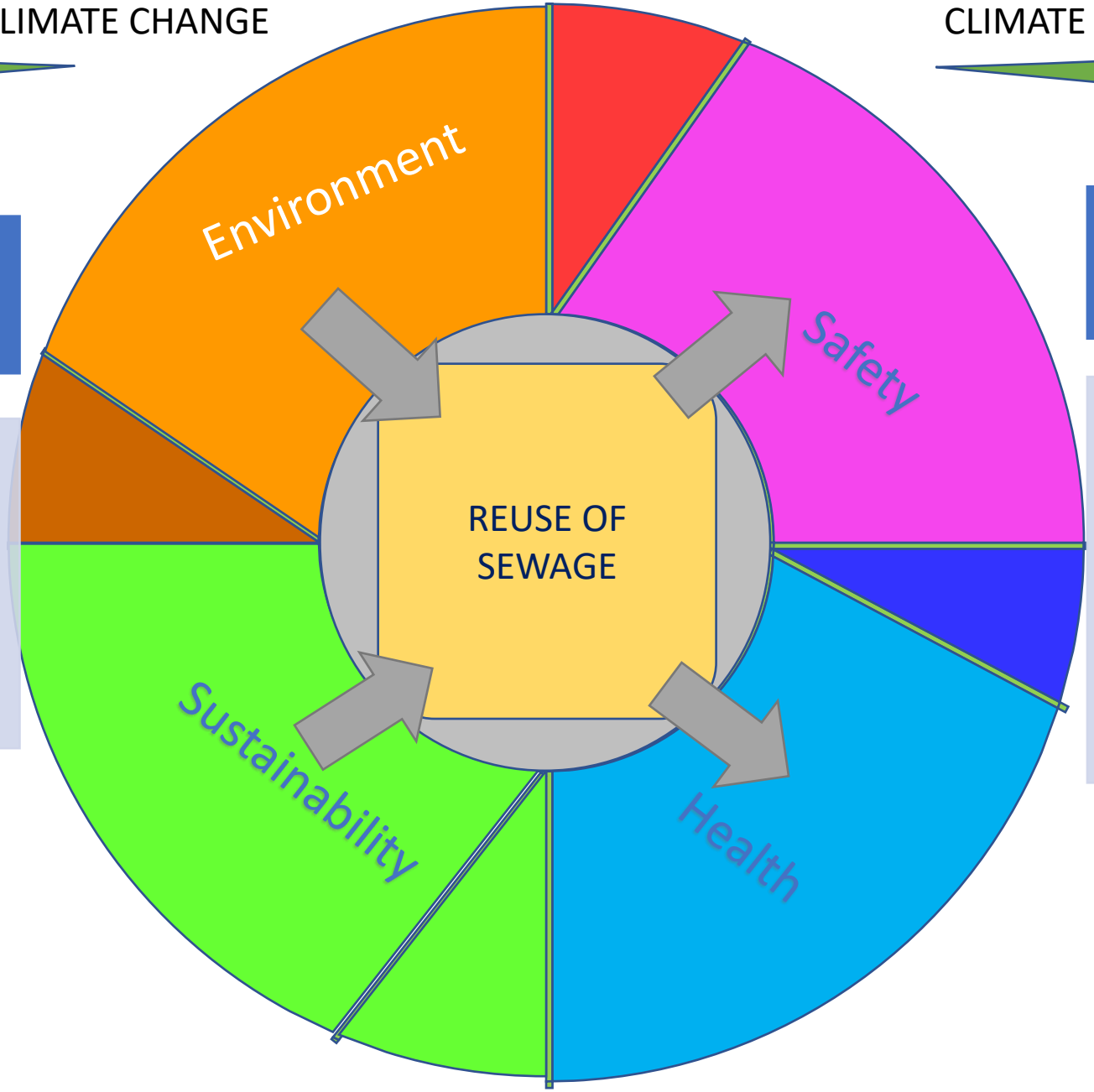
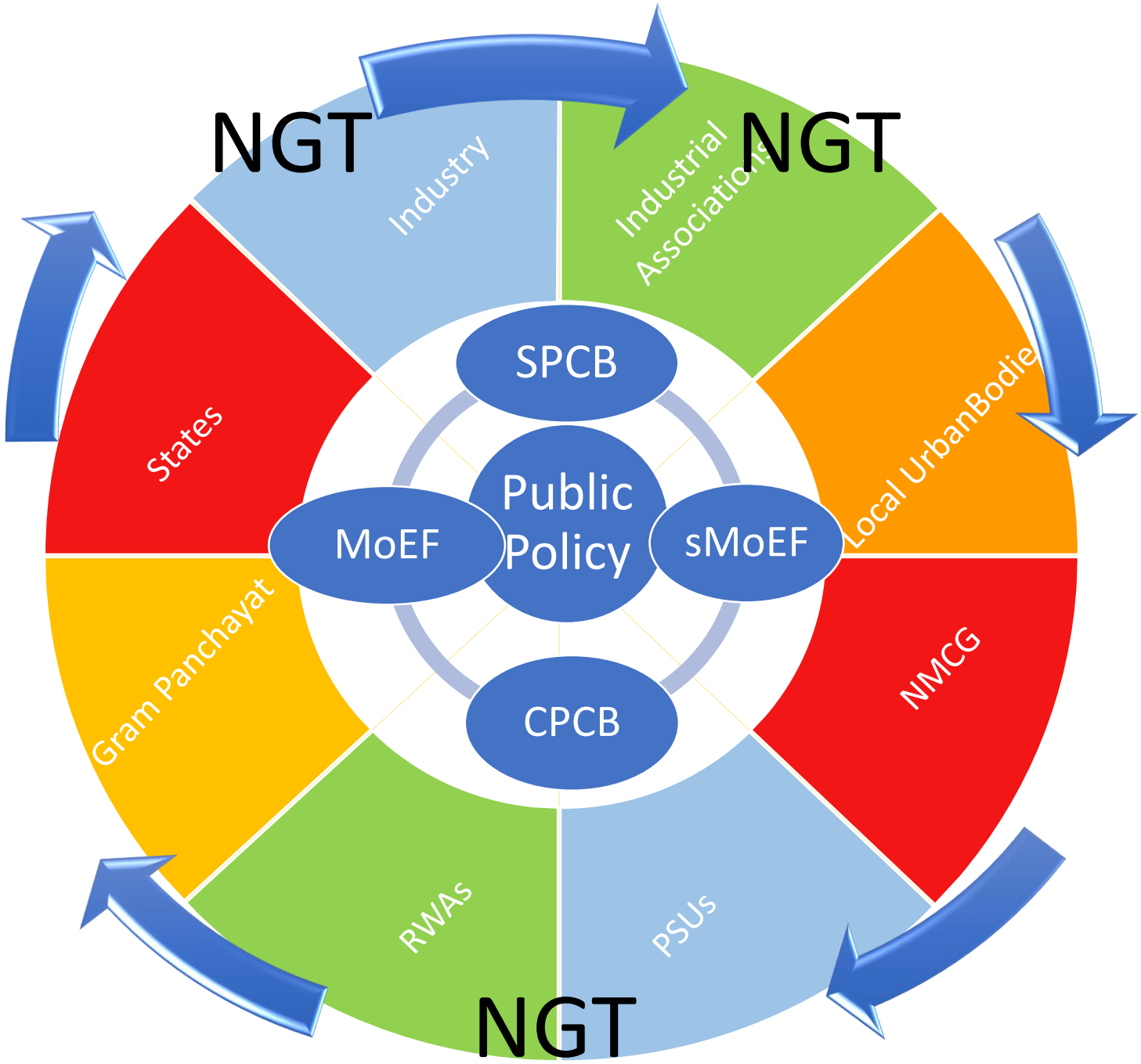
EHS

- Environment
- Health
- Safety



EHSS

- Environment
- Health
- Safety
- Sustainability


NGT
NGT
NGT
Industry
Industrial Associations
Local UrbanBodie
NMCG
PSUs
RWAs
Gram Panchayat
States
SPCB
Public Policy
MoEF
sMoEF
CPCB

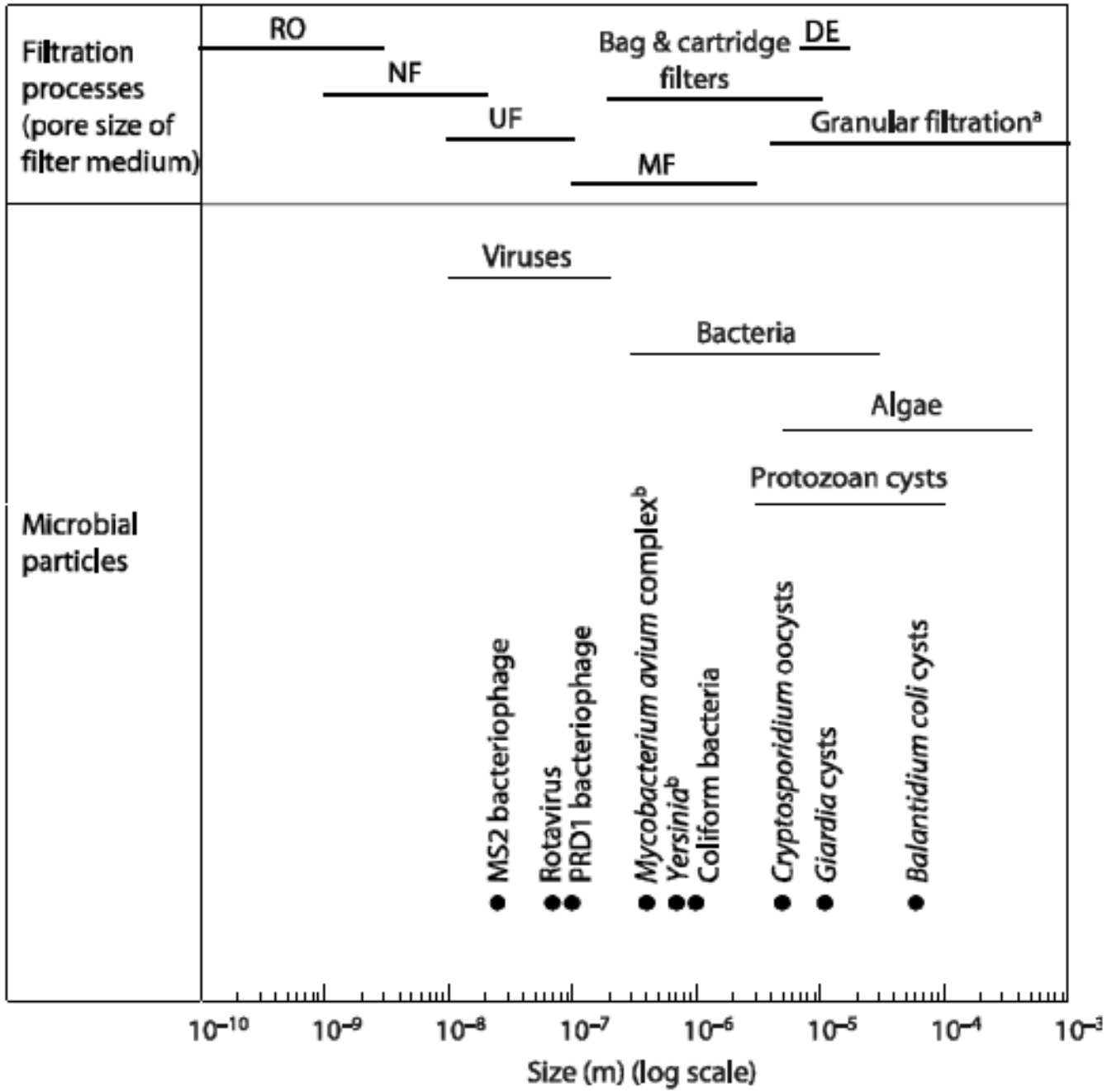
Reuse of Sewage

- Microbial
  - Rivers, Lakes
  - STPs, WWTPs, CETPs
- Chemical
  - Pharmaceuticals
    - Industry
    - Hospitals
    - Drains
    - Sources of Water Supply

Pathogens' leakage routes

- Discharge of air or water from facilities without providing sufficient bacteria elimination
- Taking contaminated used laboratory articles out without sufficient disinfection and sterilization
- Delivery of wastes to waste disposers without providing sufficient disinfection and sterilization
- Laboratory workers having finished experiments and visitors having gone carelessly into a contaminated area come in contact with other people without being aware that they are contaminated
- Escape of animals under infection experiments outside the raising areas.

Sizes: Filter and Microbial Particles

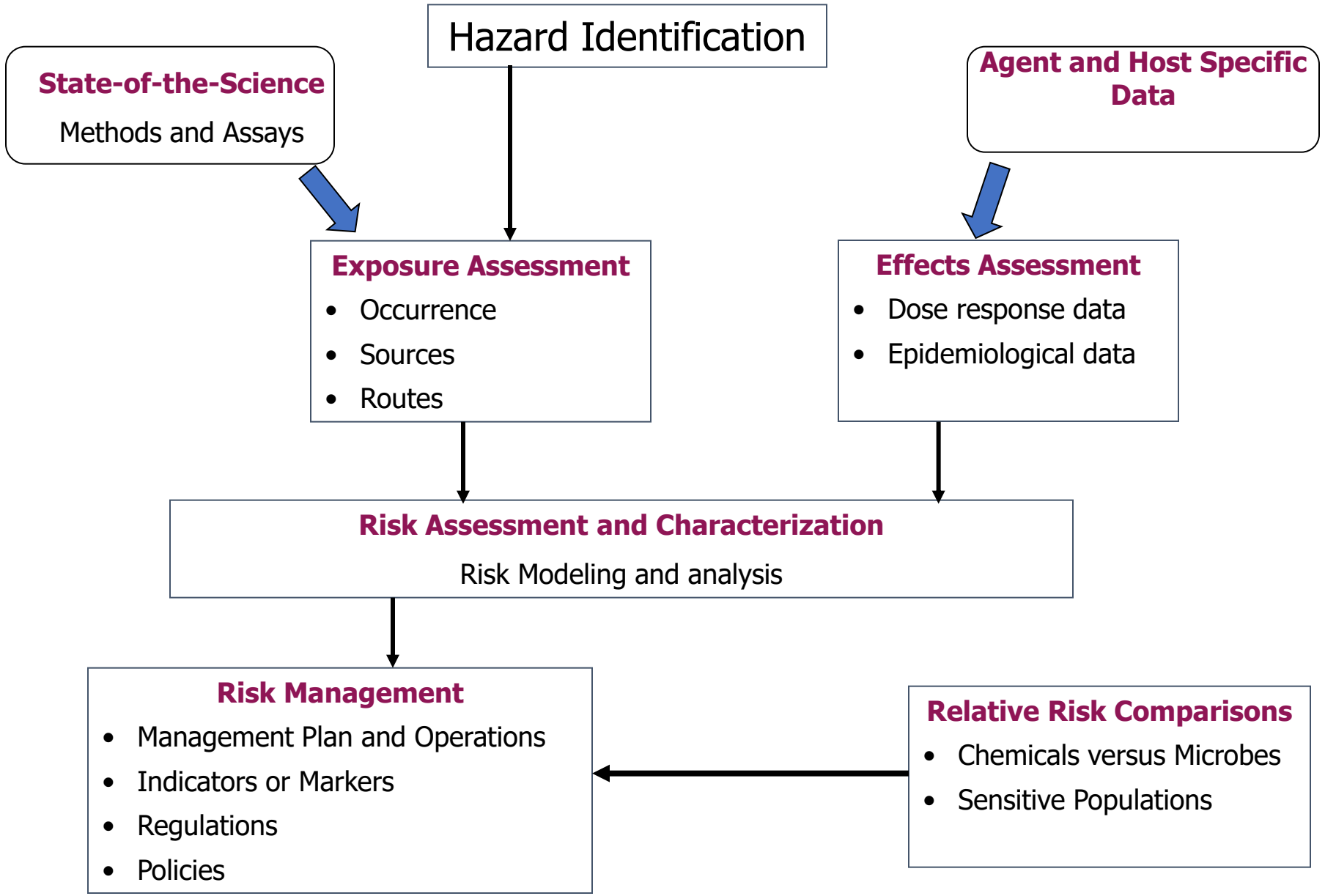


Barriers in the control of pathogens in water

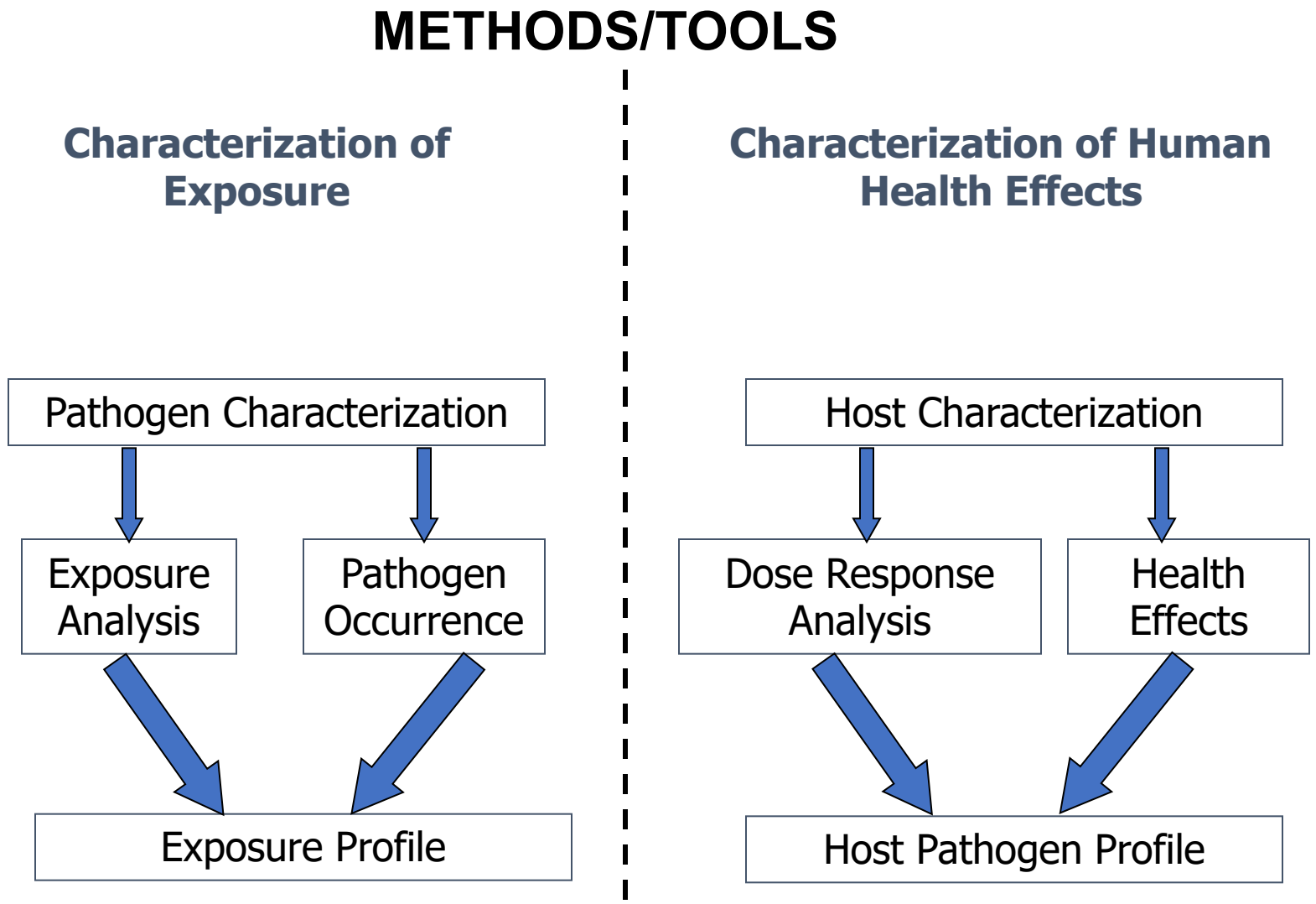
Source		Fecal Coliforms	
Human Coliform Discharges		1 950 000 000 FC/person/day	
Municipal Raw Sewage		Faecal coliforms/100 ml	
		8 260 000 FC Cells/100 mL	
Sewage Treatment Reductions		Cumulative Reductions (percent)	FC surviving
	Primary	50	4 130 000
	Secondary	80	1 652 000
	Tertiary	98	165 200
	Disinfection	99.99	800
Self-purification and effluent dilution 10-15%			
Water Supply Treatment		Cumulative Reductions (percent)	FC surviving
	Raw Water Storage	50	200-350
	Coagulation-sedimentation	60	80-140
	Filtration	99.9	0.8-1.4
	Disinfection	99.9999	0.000 08-0.000 14

Quantitative Risk Assessment for Agents from Environmental Sources: Conceptual Framework

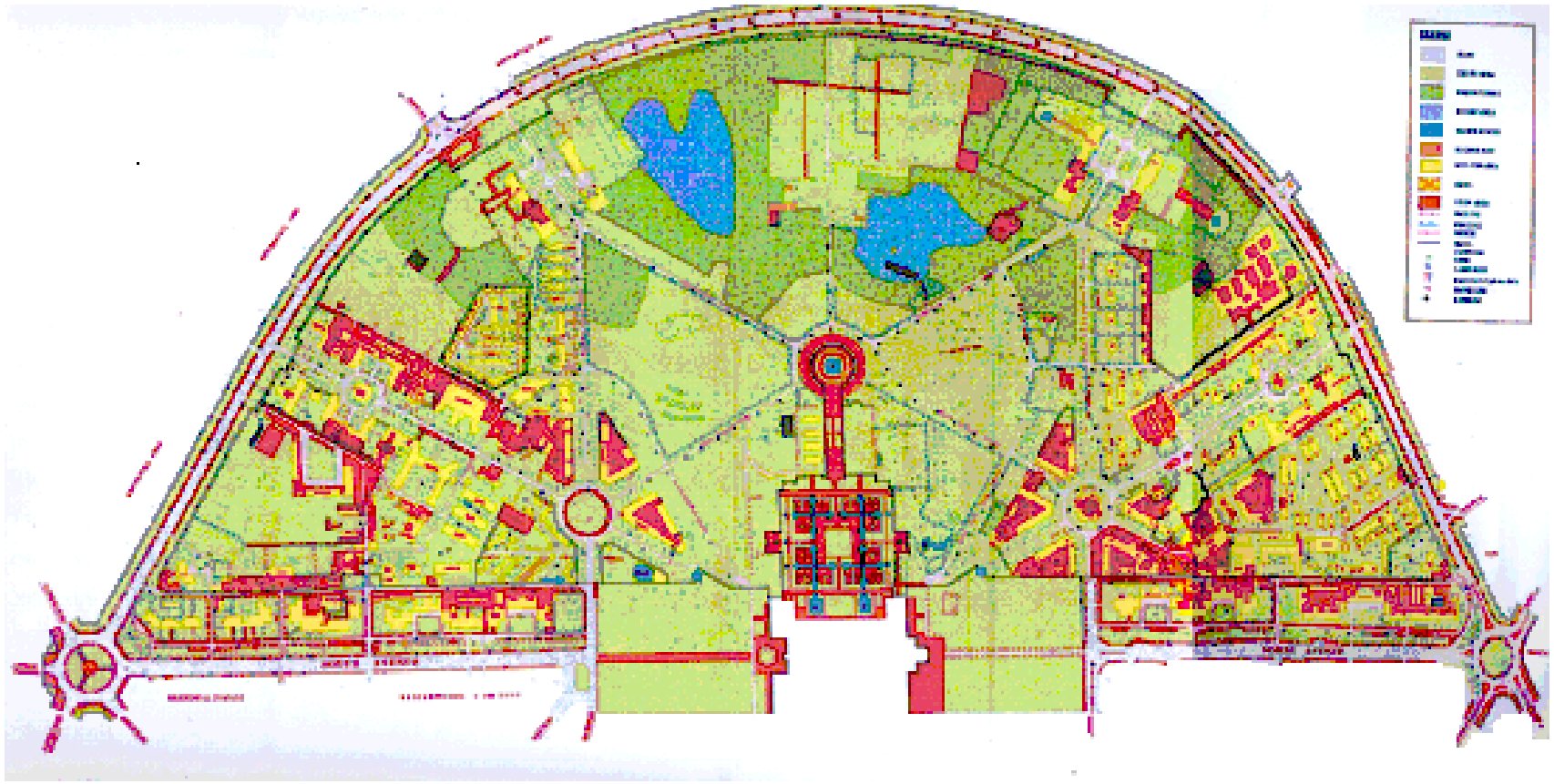
(Adapted from: National Academy of Sciences - National Research Council framework)



ILSI/EPA Risk Assessment System: Analysis Phase



Layout of the President's Estate



PRESIDENT'S ESTATE

- **Spread over an area of 360 acres of Raisina Hills**
- **Total Population of 10,000**
- **Designed flow of 800 m^3/day**
- **Raw water source:**
  NDMC + Yamuna + Wells & Tube Wells
- **Comprises of**
  - **894 Type I quarters**
  - **89 Type II quarters**
  - **39 Type III quarters**
  - **56 Type IV quarters**
  - **37 Type V quarters**
  - **7 Type VI quarters**

Water for Public Gardens in Delhi

- Reservoirs at Lodhi Garden, Chankyapuri, Rajghat, and India Gate

- Microbial quality in terms of total coliforms and fecal coliforms were observed
- Total Coliform: 3×10^3 to 1×10^5 MPN/100 mL; fecal coliforms: 1×10^3 to 7×10^4 MPN/100 mL) for irrigating urban garden

Location	BOD		COD		Turbidity	
	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
Lodhi Garden	93	21	118	29	137	68
Chanykapuri	59	7	100	30	29	13
Indiagate	76	17	131	26	84	16
Rajghat	38	5	85	30	63	25
Okhla STP	52	10	92	25	40	18

Microbial Quality

Microbes	Min	Median	Average	Max	Standard deviation
Lodhi Garden					
TC	3.25×10^5	4.1×10^6	8.03×10^6	2.95×10^7	1.21×10^7
FC	2.0×10^5	4.1×10^6	6.9×10^6	2.4×10^7	9.72×10^6
Chankyapuri					
TC	4.0×10^5	4.4×10^5	4.59×10^5	5.65×10^5	6.23×10^4
FC	4.0×10^5	4.4×10^5	4.59×10^5	5.65×10^5	6.23×10^4
India Gate					
TC	4.0×10^6	9.4×10^6	9.54×10^6	1.3×10^7	3.92×10^6
FC	4.0×10^6	5.65×10^6	7.32×10^6	1.35×10^7	3.71×10^6
Rajghat					
TC	4.0×10^5	1.8×10^6	2.27×10^6	6.4×10^6	2.46×10^6
FC	1.8×10^5	1.8×10^6	2.52×10^6	7.9×10^6	3.14×10^6

Conventional Water Pollutants

Carbon → COD

BOD

Industrial Activities

Solids → TSS

TS

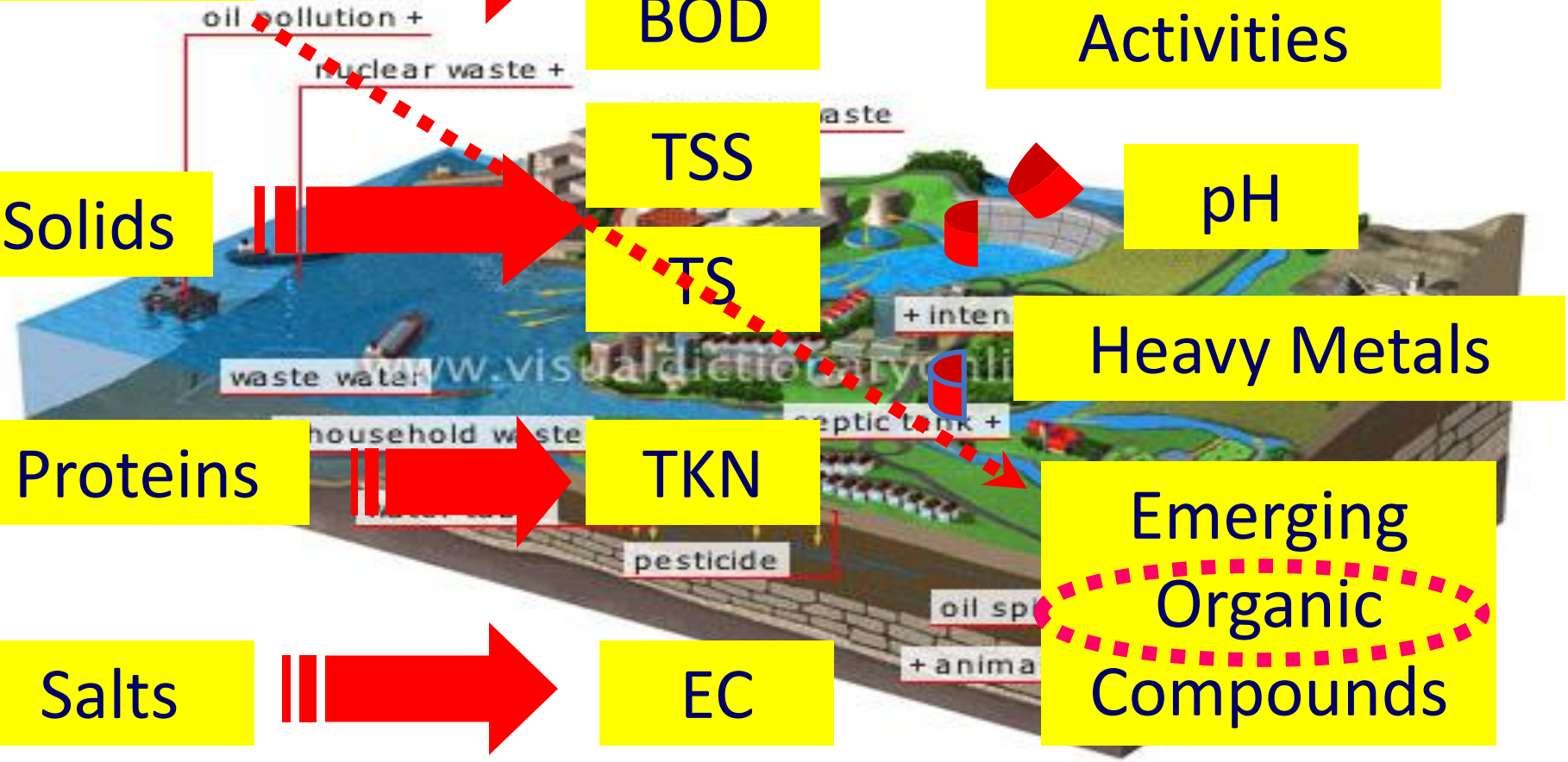
pH

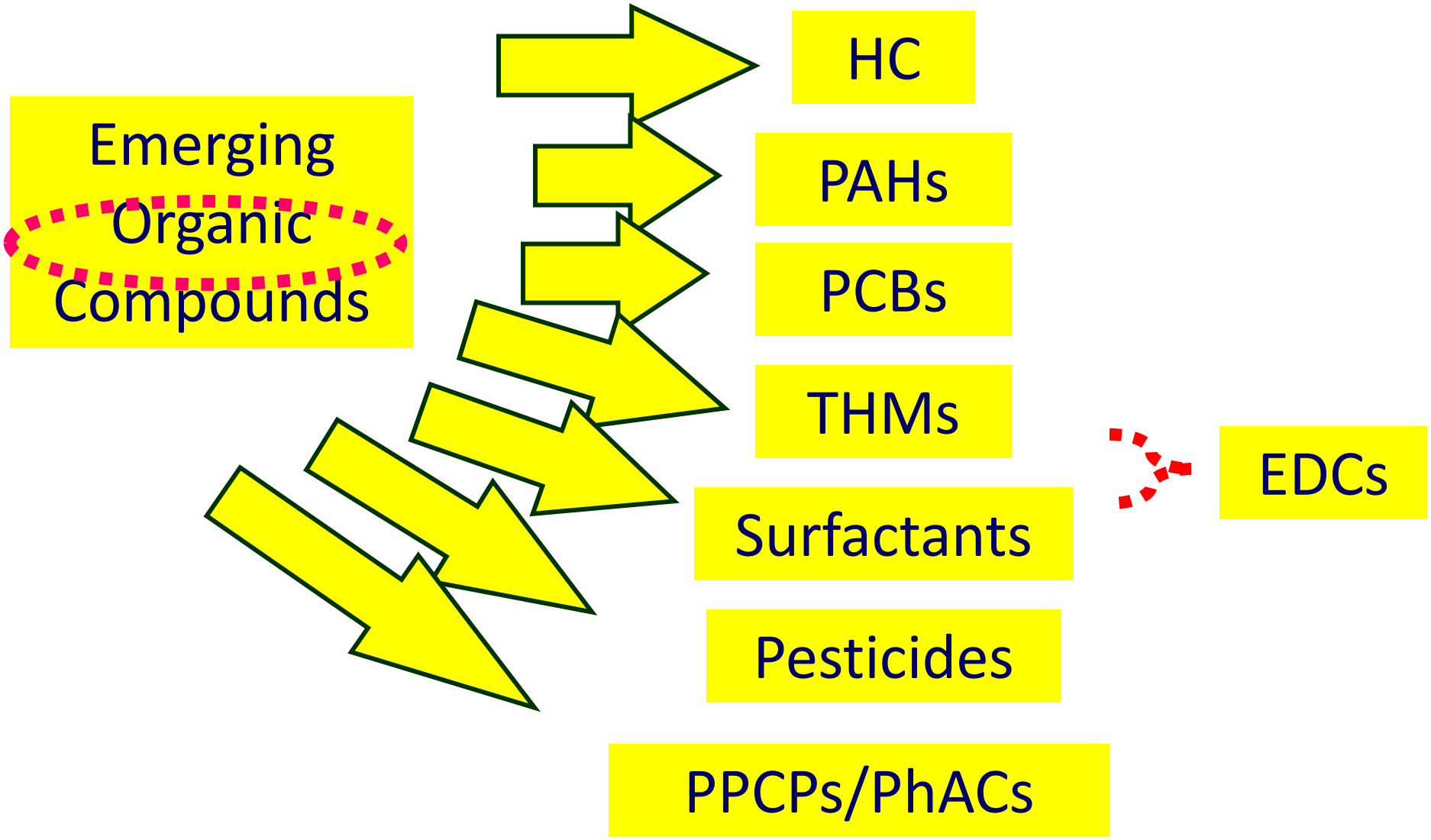
Heavy Metals

Proteins → TKN

Emerging Organic Compounds

Salts → EC




Emerging Organic Compounds
HC
PAHs
PCBs
THMs
Surfactants
Pesticides
PPCPs/PhACs
EDCs

WHATS ARE THE EDCs?

- The chemicals that interfere with the synthesis, transport, and/or action of natural hormones responsible for the reproduction, development, and/or behavior of an organism .

- Soya products
- Detergents
- Pesticides
- Plasticizers
- Polyaromatic-hydrocarbons
- Pharmaceutical residues
- Oral contraceptives
- Personal care products
- Hormone-replacement treatments

Selected EDCs Categories

- Pesticide Residues

Include

- Organochlorine Pesticides
- Organophosphorous Pesticides

- Pharmaceutical and Personal Care Products (PPCPs)

include

- NSAIDs
- Antibiotics
- Antiepileptic drugs
- Other Compounds

Sources of EDCs in Water and Wastewater

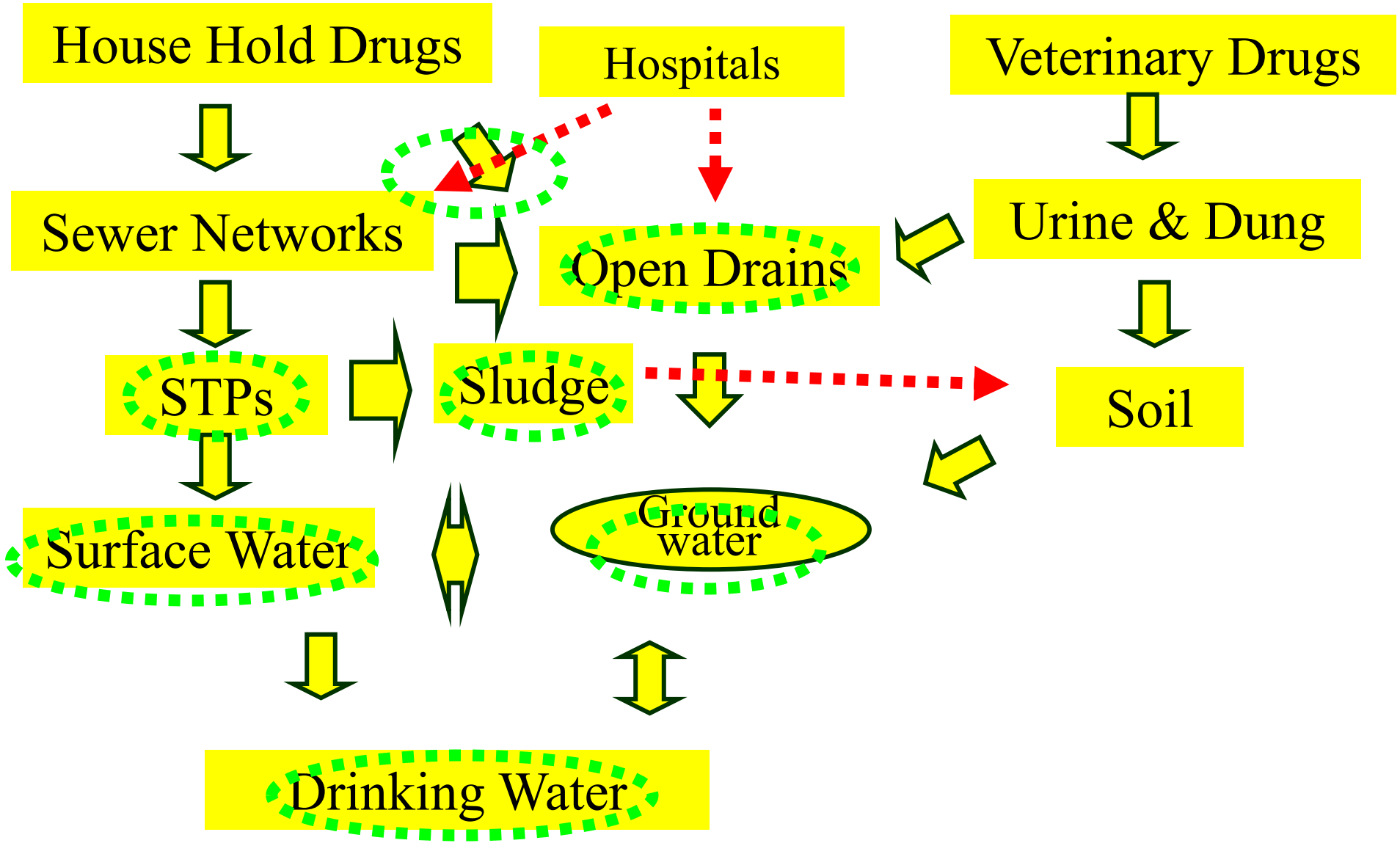
- Modern Agricultural Practices
- Household Pest Control Programme
- Personal hygiene
- Human urine and excreta
- Disposal of discarded medicines

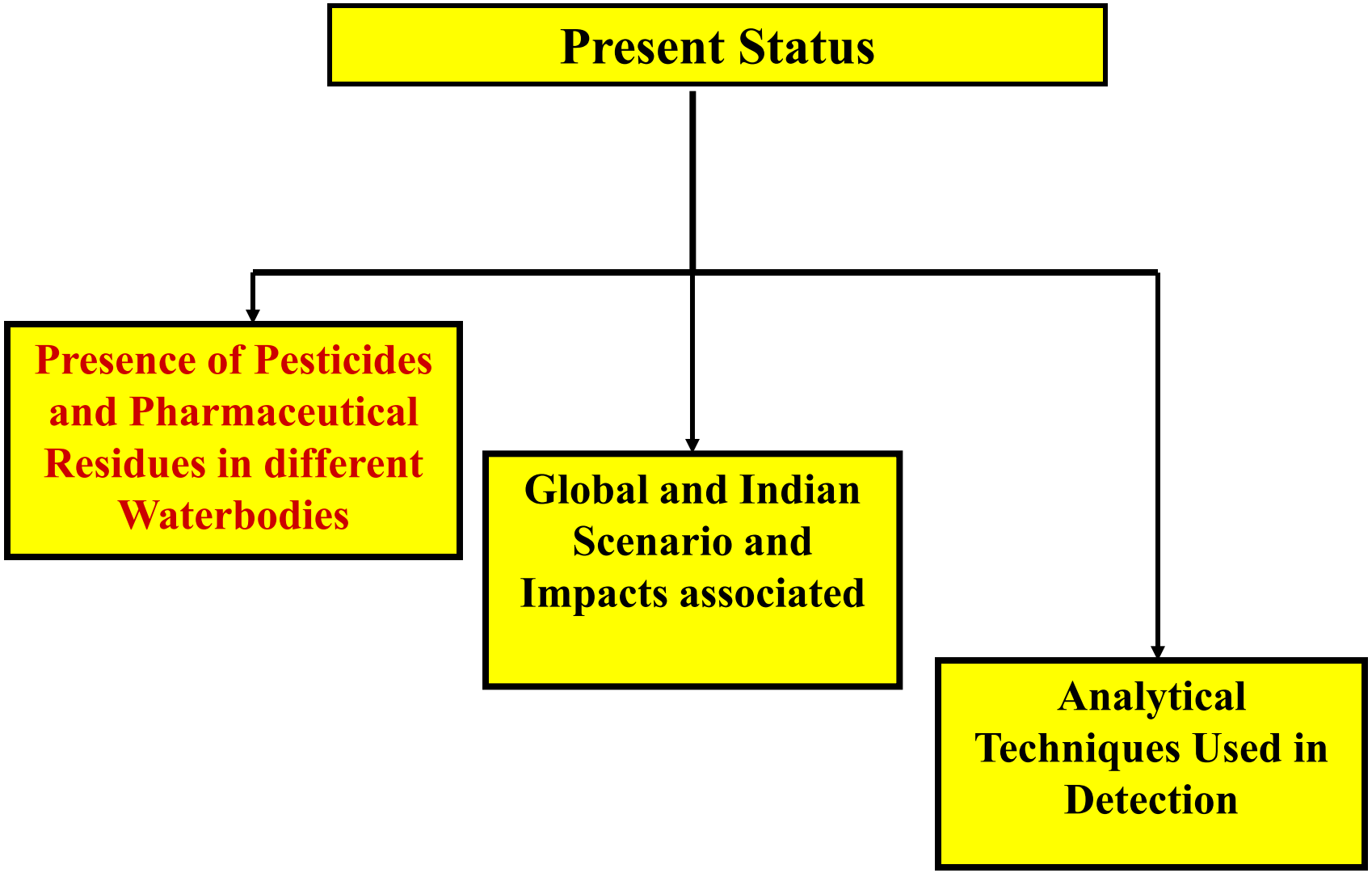
Contd.

Sources……

- Emission from Medical Care Units
- Industrial effluents from Pharmaceutical Industry
- Leaching and run off from Fish farms
- Animal dung and urine
- Feed additives for animals

Entry root for PhACs/PPCPs




Present Status
Presence of Pesticides and Pharmaceutical Residues in different Waterbodies
Global and Indian Scenario and Impacts associated
Analytical Techniques Used in Detection

Pesticides and PPCPs: Global scenario

Pesticide Residues in water

- Presence – Around the Global

In PPB

River Water

China	0.1-3.8	Zhang et al, 2004
Brazil	0.02-1.0	Rissato et al, 2006
Spain	<0.1	R-Mozaz et al., 2004
Ghana	0.12-0.60	Darco et al, 2008
Pakistan	BDL-17	Tariq et al, 2007

Pesticide Residues in water

- Presence – Around the Global

		In PPB	
Lakes	Yunnan, China	1.22-14.3	Yang et al, 2007
	Sariyar, Turkey	27-70	Oezmen et al, 2008
	Rawal, Pakistan	5.82	Tariq et al, 2007
Ground Water	Punjab, Pakistan	40-60	Tariq et al, 2007
	Australia	0.3-8.5	Mitchell et al, 2005
Industrial Waste Water	Cyprus	0.03-1.59	Fatta et al, 2007

Presence of Pharmaceutical Residues in different water segments

Sr No	Type	Compound	Reference & Country Reported
1.	Drinking Water	Diclofenac	Wasik et al, 2006 (Poland)
		Ibuprofen	Araujo et al, 2008 (Venezuela)
		Naproxen	
2.	Surface Waters	Diclofenac	Heberer 2002 (Germany)
		Ibuprofen	
		Diazepam	Terens, 2001 (Germany)
		Caffeine	
		Estrol	Kolpin et al, 2002 (USA)
		Clofibric acid	Wasik et al, 2006 (Poland)
		Naproxen	Rederson et al, 2002 (Germany)

Cont.

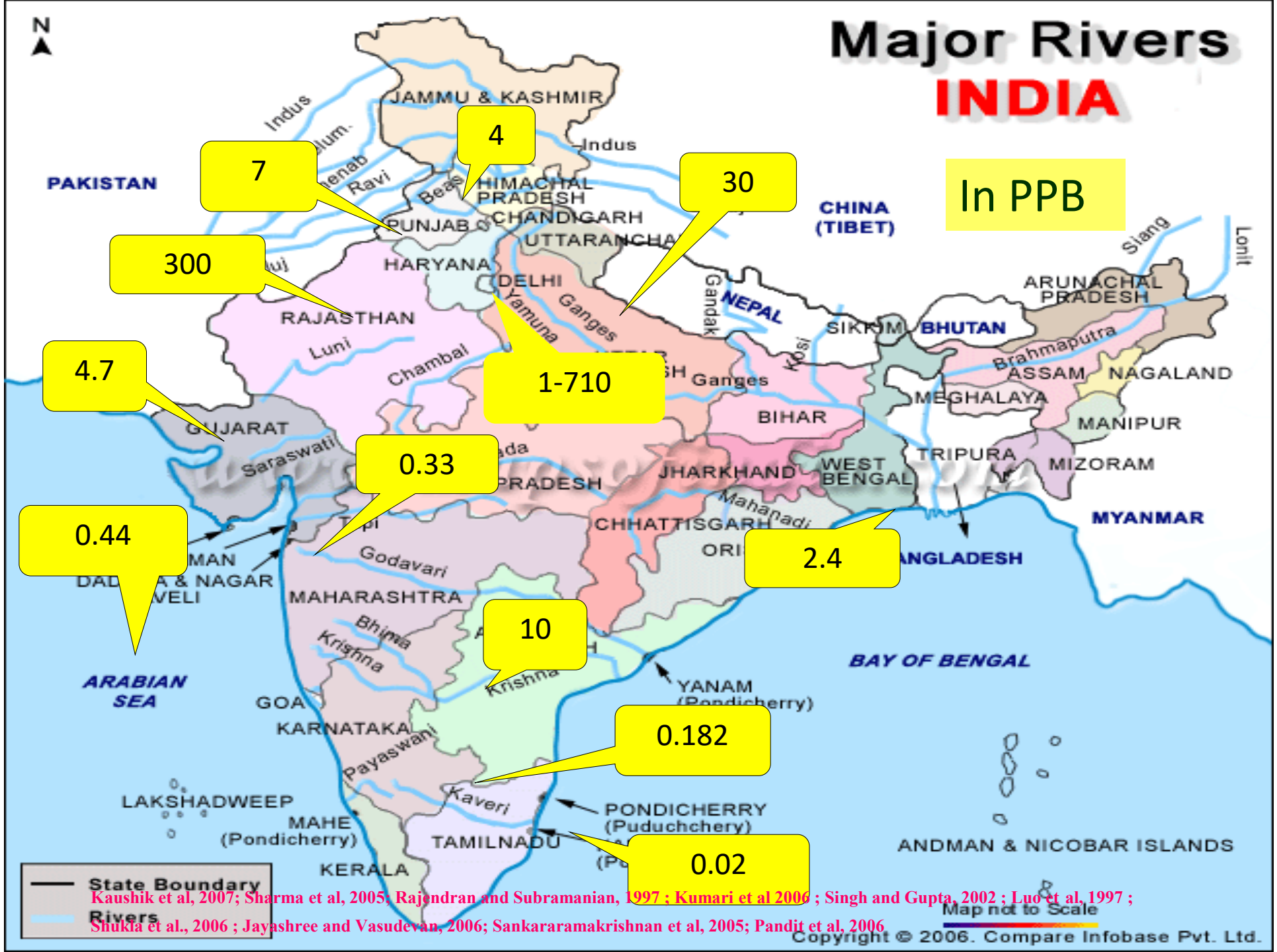
3.	Sewage effluents	Diazepam	Suchara et al, 2008 (Brazil)
		Diclofenac	
4.	Biosolids	Estrone	Ternes et al, 2001 (Germany)
		17B-estradiol	
5.	Sea Water	Diclofenac	
6.	Wastewater	Acetylsalicylic acid	Ternes et al, 2001 (Germany)
		Diazepam	
		Chloramphenicol	

Cont.

Sr No	Type	Compound	Reference
6.	Wastewater	Diclofenac	Stackelberg et al, 2007 (USA)
		Ibuprofen	
		17B-estradiol	Jurgensen and Surensen, 2000 (Germany)
		17A-estradiol	
		Estrol	
		Caffeine	Gomez et al, 2007 (Spain)
		Carbamazepine	
		Acetaminophen	
		Nonylphenol	Kolpin et al, 2002 (Germany)

Indian scenario
Pesticides Residues in Water

- Total pesticide consumption is 41350 MT (NCIPM, 2006)
- Present in all the major rivers, open wells, sea water, estuaries, lakes and ponds.
- Concentration is much higher than the prescribed safe limit of 1PPB.
- Ground Water also severely affected in some areas under intensive agriculture practices and the areas under severe water scarcity
- 300 times more than safe limit in Ground Water in Rajasthan, where ground water is a major source for drinking water
- Yamuna River, pesticide is present all along its length and the concentration varies from PPB level to PPM level.



Kaushik et al, 2007; Sharma et al, 2005; Rajendran and Subramanian, 1997 ; Kumari et al 2006 ; Singh and Gupta, 2002 ; Luo et al, 1997 ; Shukla et al., 2006 ; Jayashree and Vasudevan, 2006; Sankararamakrishnan et al, 2005; Pandit et al, 2006