RESEARCH, MONITORING AND REGULATORY STRETEGIES TO DEAL WITH EMERGING CHEMICAL CONTAMINANTS IN DRINKING WATER

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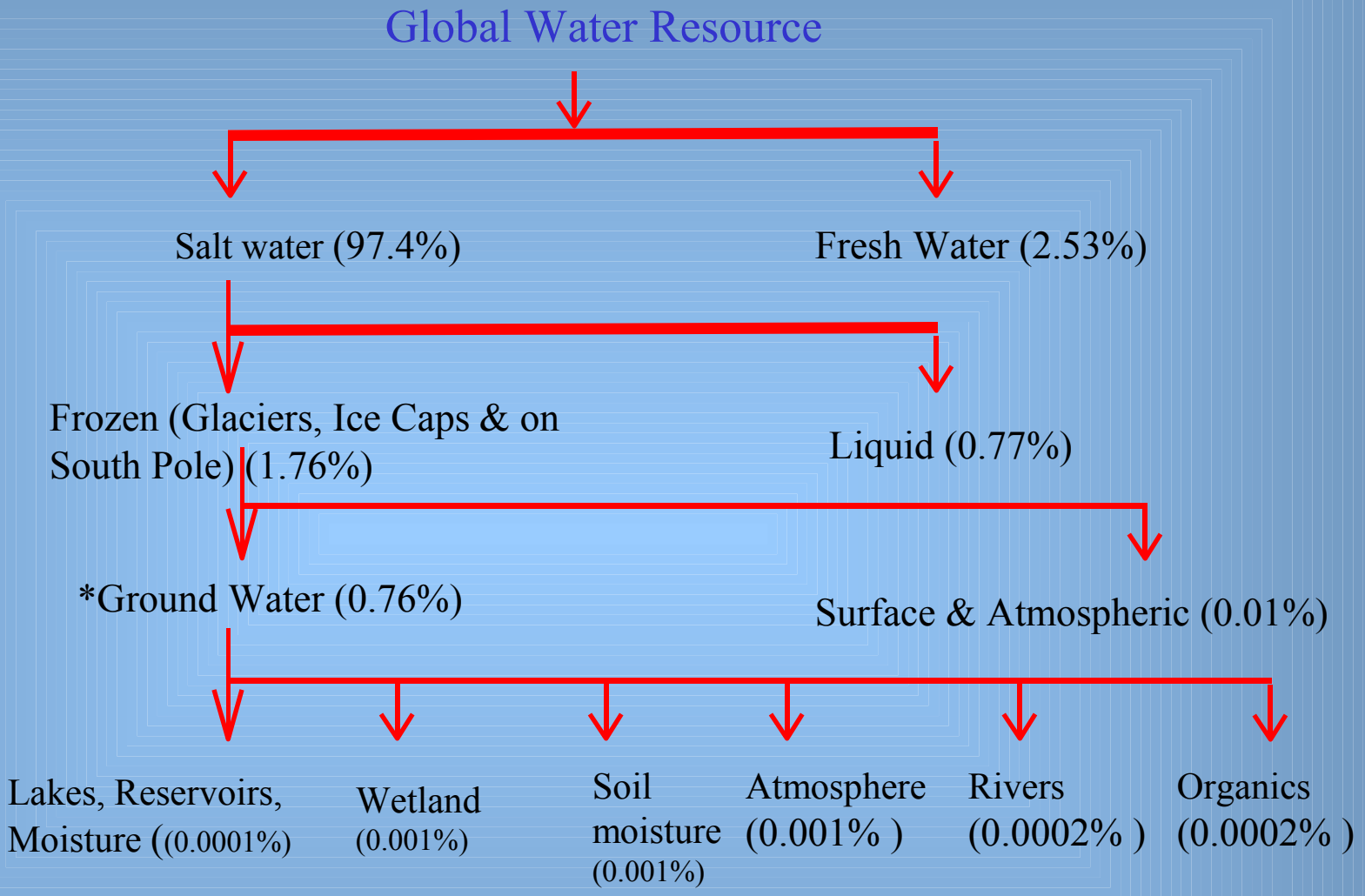
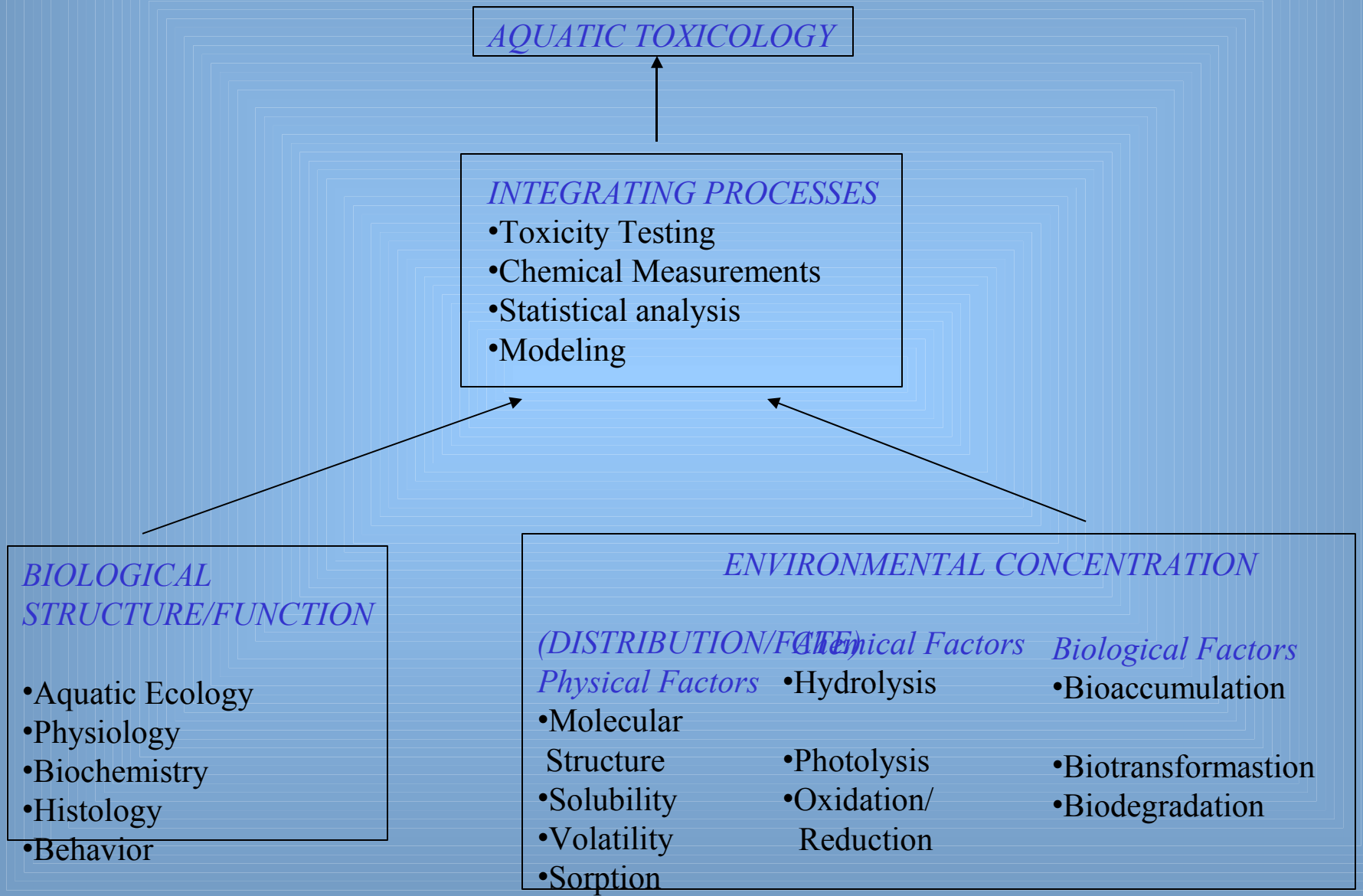
Distribution of World's Water Resources



*Available For Our Use:
Out of Total 0.76% Ground Water Only 0.3%
Out of Total 0.01% Fresh Water Only 0.4%.

Reference:
WQMD & ILEC (1995) Lakes in the World.
Quality Management
Division, Water Quality Bureau.
Environment Agency/International Lake Environment
Committee Foundation, Japan.

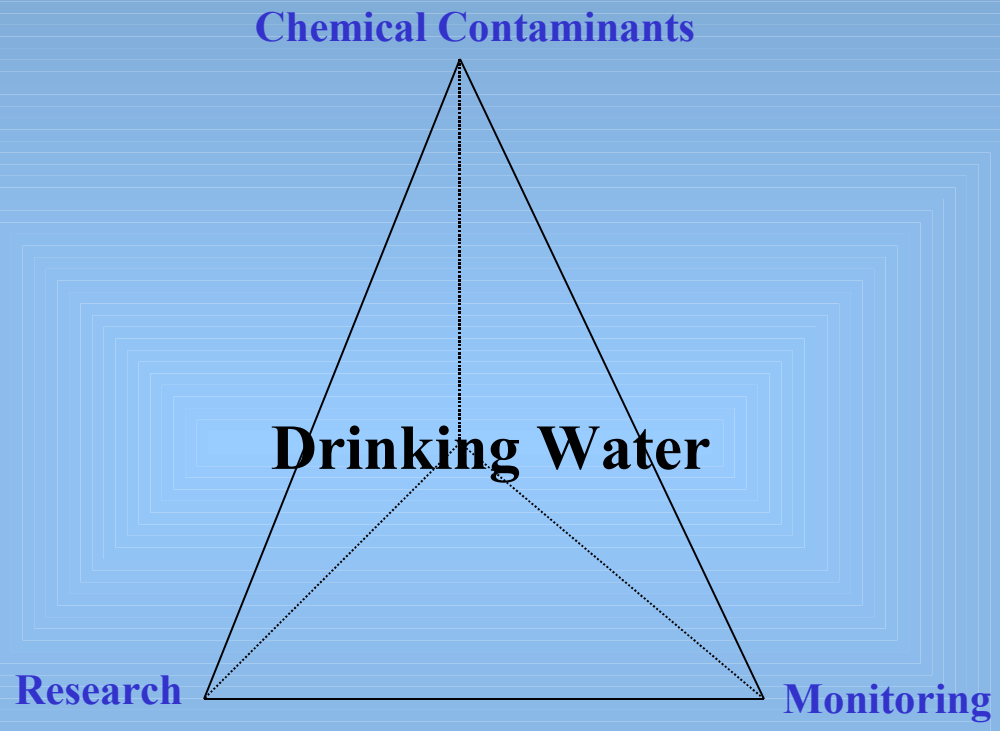
Aquatic Toxicology – A Multidisciplinary Science



Socioeconomic Impact

- An estimated 90% of the country's water resources are polluted with untreated industrial and domestic wastes, pesticides, fertilizers and geogenic chemicals. (www.teriin.org/energy/water.htm).
- Diarrhoel disease kills 6,000 children's every day apart from millions who are debilitated because of water born diseases which hinder their education and impair their ability to a decent livelihood in the future. (*Business India, December, 2003*)
- Socioeconomic impact (losses) due to environmental degradation have been grossly underestimated, sometimes due to lack of adequate data or due to ignoring the Varity of health issues completely.

OUR MOTTO


Chemical Contaminants
Drinking Water
Research
Monitoring

Test characteristics for Drinking Waters is-10500: 1991

S. No.	Substance Characteristic	Requirement	Undesirable effect outside the desirable limit	Permissible limit**
A	**Essential Characteristics**			
1	Colour, Hazen units, Max	5	Above 5, consumer acceptance decreases	25
2	Odour	Unobjectionable	-	-
3	Taste	Agreeable	-	-
4	Turbidity NTU Max	5	Above 5, consumer acceptance decreases	10
5	pH Value	6.5 to 8.5	Beyond this range the water will effect the mucous membrane and /or water supply system	No relaxation
6	Total Hardness (as $CaCO_3$) mg/l, Max	300	Encrustations in water supply structure and adverse effect on domestic use	600
7	Iron (as Fe), mg/l, Max	0.3	Beyond this limit taste /appearance are affected, has adverse affect on domestic uses and were supply structures and promotes iron bacteria	1.0

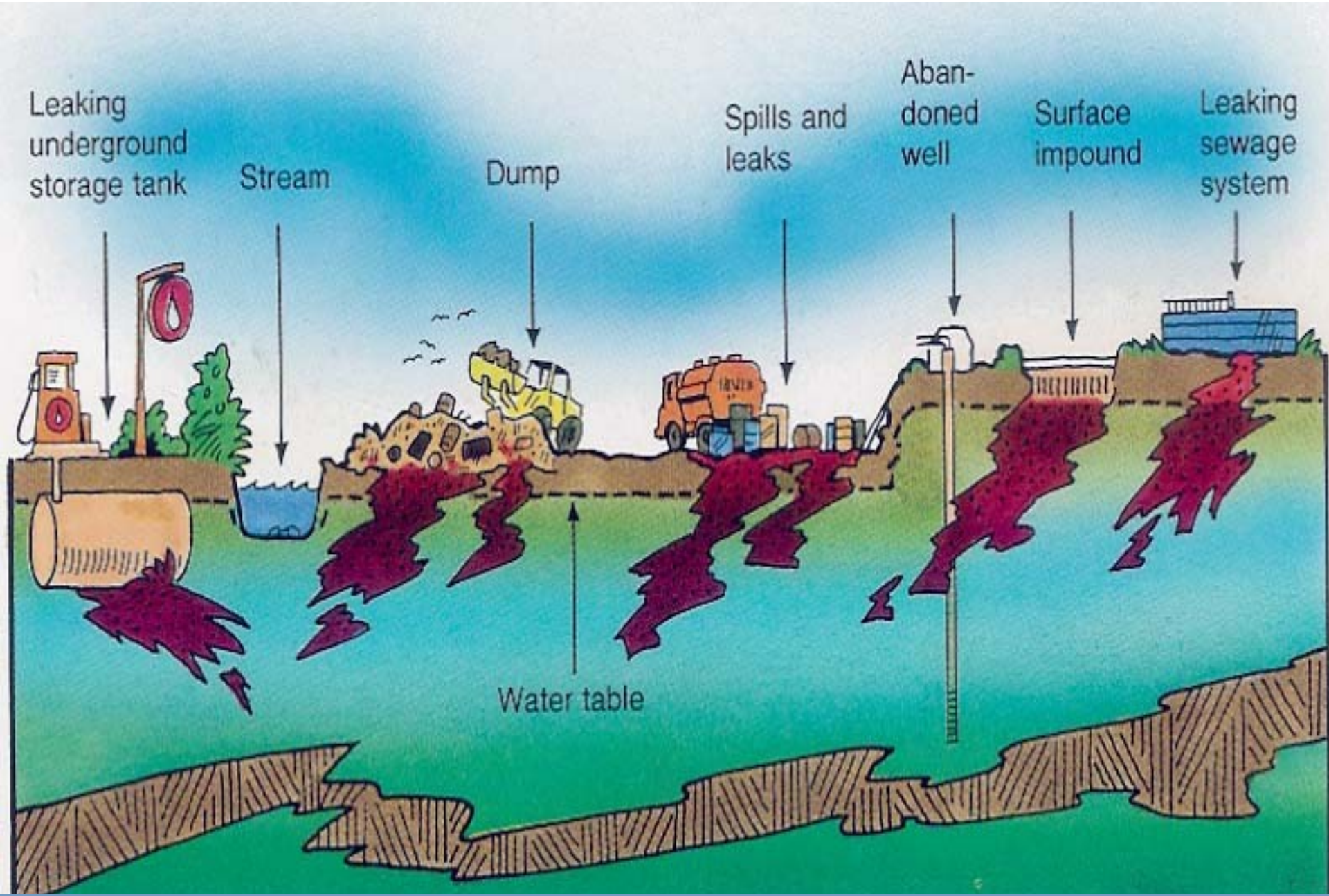
8	Chlorides (as Cl), mg/l, Max	250	Beyond this limit taste, corrosion and palatability are affected	1000
9	Residual free chlorine. Mg/l, Minimum	0.2	-	-
B	**Desirable Characteristics**			
1	Dissolved solids, mg/l, Max	500	Beyond this palatability decreases and may cause Gastrointestinal irritation	2000
2	Calcium (as Ca) mg/l, Max	75	Encrustation's in water supply structure and adverse effect on domestic use	200
3	Copper (as Cu), mg/l, Max	1.5	Astringent taste, discoloration and corrosion of pipes, fitting and utensils will be caused beyond this	1.5
4	Manganese (as Mn) mg/l, Max	0.1	Beyond this limit, taste/appearance are affected, has adverse effect on domestic use and water supply structure	0.3
5	Sulphates (as SO4), mg/1, Max	400	Beyond this causes Gastro intestinal irritation when magnesium or sodium are present	400
6	Fluorides (as F), mg/l, Max	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis	1.5

7	Phenolic compounds (as C_6H_5OH),mg/l, Max	0.001	Beyond this, the water becomes toxic	.002
8	Mercury (as Hg), mg/l, Max	0.001	Beyond this, the water becomes toxic	No relaxation
9	Cadmium (as Cd), mg/1, Max	0.01	Beyond this, the water becomes toxic	No relaxation
10	Selenium (as Se), mg/l, Max	0.05	Beyond this, the water becomes toxic	No relaxation
11	Arsenic (as As), mg/l, Max	0.2	Beyond this, the water becomes toxic	No relaxation
12	Cyanides (as CN), mg/l, Max	0.05	Beyond this, the water becomes toxic	No relaxation
13	Lead (as Pb), mg/l, Max	0.1	Beyond this, the water becomes toxic	No relaxation
14	Zinc (as Zn), mg/l, Max	5	Beyond this limit, it can cause astringent taste and an opalescence in water	15
15	Anionic detergents (as MBAS), mg/l, Max	0.2	Beyond this limit, it can cause a light froth in water	1.0
16	Chromium (as Cr^{6+}), mg/l, Max	0.05	May be carcinogenic above this limit	No relaxation

17	Polynuclear aromatic hydrocarbons (as PAH), mg/l, Max	-	May be carcinogenic	-
18	Mineral oil, mg/l, Max	0.01	Beyond this limit, undesirable taste and odour after chlorination take place	0.03
19	Pesticide, mg/l, Max	Absent	Toxic	0.001
20	Alpha emitters, µc/mg, Max	-		0.1
21	Beta emitters, µc/ml, Max	-	-	1
22	Alkalinity mg/l, Max	200	Beyond this limit taste becomes unpleasant	600
23	Aluminum (as Al) mg/l, Max	0.03	Cumulative effect is reported to cause dementia	0.2
24	Boron mg/l, Max	1	-	5

* Desirable limit
** In absence of alternate source

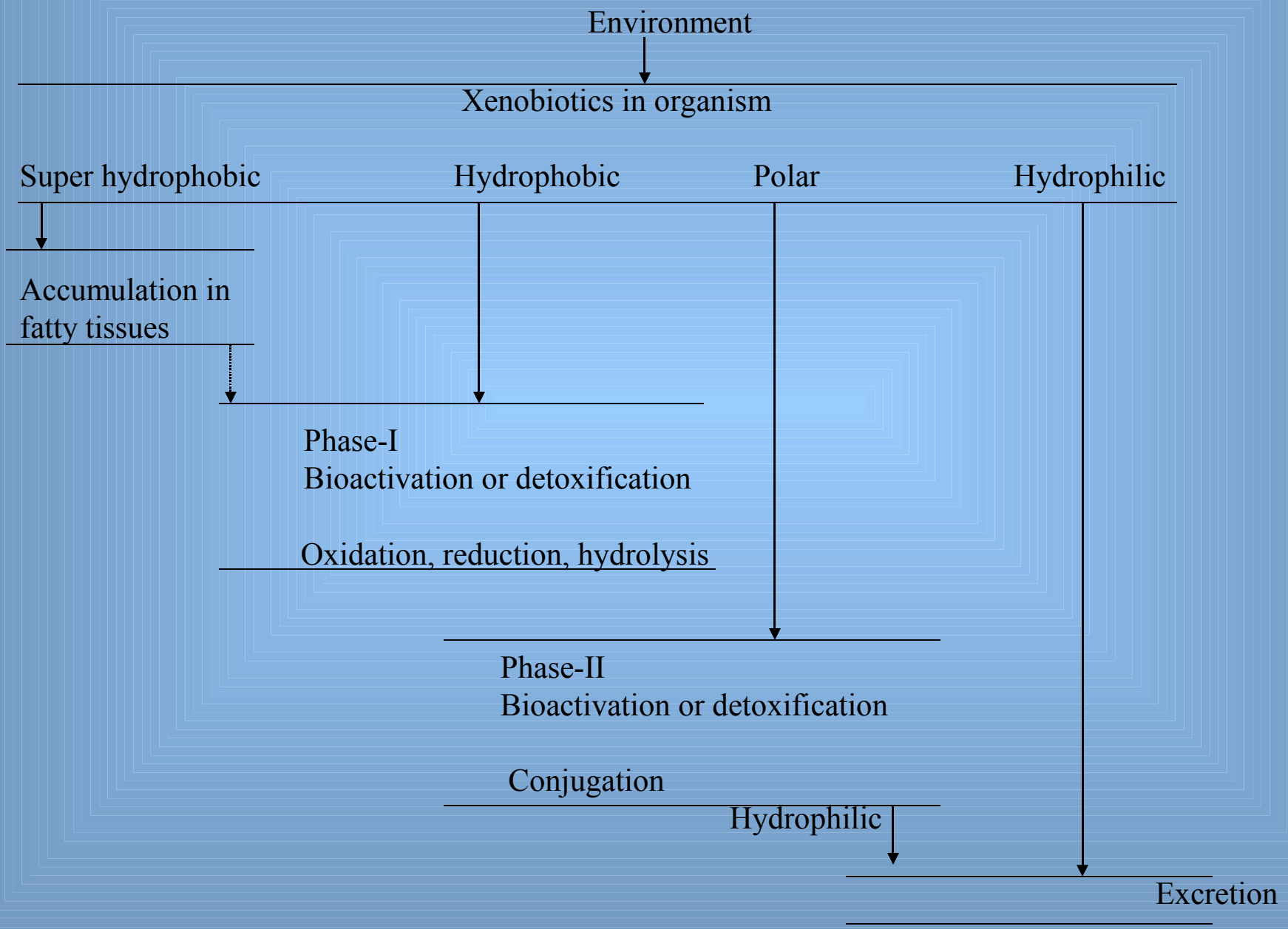
CHEMICAL CONTAMINANTS


Leaking underground storage tank
Stream
Dump
Spills and leaks
Aban-doned well
Surface impound
Leaking sewage system
Water table

Chemical contaminants in water an associated health hazards

1.	Nitrates	Forms nitrosamines which may cause gastric cancer, Methemoglobinemia
2.	Fluorides	fluorosis, skeletal damage
3.	Arsenic	Nervous system disorders, cardiovascular effects, carcinogenicity
4.	Cadmium	Itai-Itai disease, kindly dysfunction, hypertension, nervous system disorders, cancer.
5.	Chromium	Ulceration
6.	Copper	Hepatic and nervous system disorders
7.	Lead	Abdominal colic, anemia, nervous system disorders, teratogenic and fetotoxic effects.
8.	Manganese	Nervous system disorders
9.	Mercury	Nervous system disorders, kidney damage, mutagenicity and teratogenicity
10.	Iron	Hemosiderosis, hemachromatosis skin pigmentation, hepatic disorders
11.	Halogenated By Products	Carcinogenicity

General pathways of biotransformation of xenobiotics in living organisms



Transformation of chemical in the Environment

Transformation of chemicals in the environment can also occur by abiotic processes. The most important abiotic transformation processes can be divided into four separate categories:

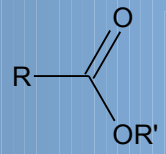
- *Hydrolysis*: Alteration of the chemical structure by direct reaction with water.
- *Oxidation*: A transformation process in which electrons are transferred from the chemical to a species accepting the electrons; the oxidant.
- *Reduction*: The reverse of oxidation; electron transfer takes place from a reductant to t6he chemical to be reduced.
- *Photochemical degradation*: Transformation due to interaction with sunlight.

Transformation and mineralization processes can alter the physicochemical and toxicological properties and reduced exposure concentrations of chemicals which had been released in the environment. Where biotransformation is carried out by higher organism, the formation of polar transformation products (metabolites) can also provide an important method of detoxification.

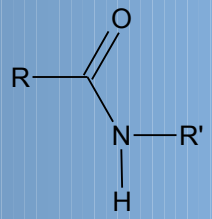
A Biotic Transformation Processes

Reactant

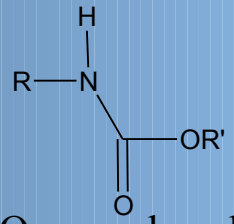
Esters



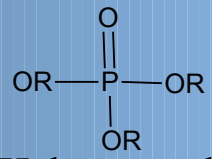
Amides



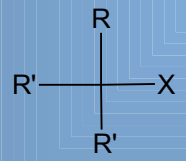
Carbamates



Organophosphates

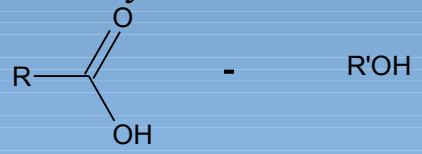


Halogenated Alkanes

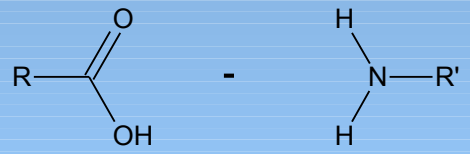


Products

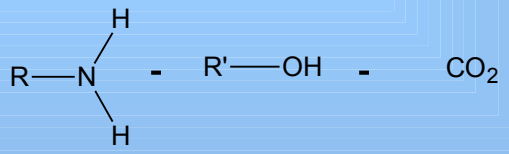
Carboxylic Acid + Alcohol



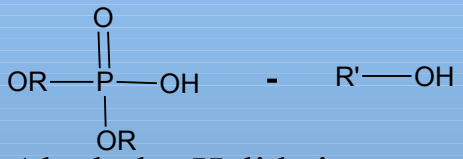
Carboxylic Acid + Amine



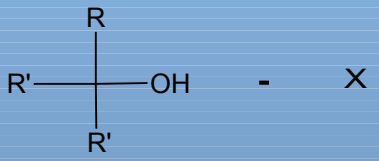
Amine + Alcohol + Carbon dioxide



Phosphate diester + alcohol



Alcohol + Halide ion



Some examples of hydrolytically unstable chemicals and the products formed by hydrolysis (R, R, R " represents an aromatic ring or aliphatic chain and X is a halogen atom)

RESEARCH AND MONITORING STRATEGIES

Salinity (Inland)

Maharashtra	Amravati, Akola
Bihar	Begusarai
Haryana	Karnal
Rajasthan	Barmer, Jaisalmer, Bharatpur, Jaipur, Nagaur, Jalore & Sirohi
U.P.	Mathura

Salinity (Coastal)

Andhra Pradesh	Vishakapatnam
Orissa	Puri, Cuttak, Balasore
West Bengal	Haldai & 24 Pargana
Gujarat	Junagarh, Kachch, Varahi, Banskanta & Surat

Flouride (BIS Desirable Limit is 1.0 mg/L; Max. Permissible Limit is 1.5 mg/L)

Kerala	Palaghat Krishna, Ananipur, Nellor, Chittoor.
Andhra Pradesh	Cuddapah, Guntur and Nalgonda
Gujarat	Banskanta, Kachch & Amreli
Haryana	Hissar, Kaithal & Gurgaon
Orissa	Bolangir, Bijapur, Bhubaneshwar and Kalahandi
Punjab	Amritsar, Bhatinda, Faridkot, Ludhiana & Sangrur
Rajasthan	Nagaur, Pali, Sirohi, Ajmer & Bikaner
Tamil Nadu	Chengalput, Madurai
U.P.	Unnao, Agra, Aligarh, Mathura, Ghaziabad, Meerut & Rai Baraili

Maganese

Orissa	Bhubaneshwar, Athgaon
U.P	Muradabad, Basti, Rampur & Unnao

Iron (BIS Desirable Limit: 0.3 mg/L, Max. Permissible: 1.0 mg/L)

U.P.	Mirjapur
Assam	Darrang, Jorhat, Kamrup
Orissa	***Bhubaneshwar (Max. 49.0 mg/L)***
Bihar	E. Champaran, Muzaffarpur, Gaya, Manger, Deoghar & Madubani
Rajasthan	Bikaner, Alwar, Bharatpur
Tripura	Dharmnagar, Kailasanar, Ambasa, Amarpur, & Agartala
West Bengal	Madnipur, Howrah, Hoogly and Bankura

Zinc

Andhra Pradesh	Hyderabad, Osmania University campus
Delhi	R.K. Puram
Rajasthan	Udaipur

Arsenic (BIS limit is 0.05 mg/L with no relaxation)

West Bengal	Malda, Murshidabad, Nadia, ***Pargana (Max. 2.95mg/L)***
Bihar	Bhojpur
Chhattisgarh	Rajanangaon
Uttar Predesh	Ballia, Lakhimpur Khiri

Nitrate (BIS Desirable Limit is < 45 mg/L; Max. Permissible is 100 mg/L)

Bihar	Patna, East Champaran, Palamu, Gaya, Nalanda, Nawada and Banka
Andhra Pradesh	Vishakapatnam, East Godvari, Krishna, Prakasam, Nellor, Chittoor, Anantpur, Cuddapah & Kurnool
Delhi	Naraina, Shehadr (Blocks)
Haryana	Ambala, Sonepat, Jind, Gurgaon,Faridabad & Hissar
Himachal Pradesh	Kulu, Solan, Una
Karnataka	Bidar, Gulbarge and Bijapur
Madhya Pradesh	***Sehore (Maximum 2100 mg/L)*****,** Bhopal & (West & Central Part of state)
Maharashtra	Jalna, Beed Nanded, Latur, Osmanabad, Solapur Satara, Sangli and Kolhapur
Punjab	Patiala, Faridkot, Firozpur, Sangrur & Bhatinda
Rajasthan	Jaipur, Churu, Ganganagar, Bikaner, Jalore, Barmer, Bundi and Sawaimadhopur
Tamil Nadu	Coimbatore, Penyar and Salem
West Bengal	Uttar Dinajpur, Malda, Birbhum, Murshidabad, Nadia, Bankura and Purulia.

Sulphide

Orissa	Balasore, Cuttak & Puri

Chromium

Punjab	Ludhiana
Uttar Pradesh	Kanpur

Summarized information of the occurrence of *Heavy Metals* in ground water in India

State	District	Heavy Metals
Assam	Digbai	Fe, Mn, Ni, Zn, Cd, Cr, Pb
Andhra Pradesh	Anantpur, Prakasam, Mahaboobnagar, Cuddapah, Nalagonda	Mo, Zn, Pb, As, Cd, Fe, Cu, Hg, Mn
Bihar	Dhanbad, Kosi, Burhi-Gandak	Fe, Mn, Cr, Zn, Cu, Hg, Cd
Haryana	Faridabad	Cu, Pb, Zn, Cr, Cd, Fe, Mn, Ni
HP	Purwanoo, Kala Amb	Cd, Pb, Fe, Mn
Karnataka	Bhadravathi	Zn, Mn
Madhya Pradesh	Bastar, Karba, Ratlam, Nagda	Fe, Ce, Cr, Cu, Pb, Hg
Orissa	Angul, Talchur	Cu, Cr, Fe, Cd, Pb
Punjab	Ludhiana, Mandi, Gobindgarh	Cu, Cr, Zn, Fe, Pb, Cd
Rajasthan	Pali, Udaipur	Pb, Zn, Fe, Mn, Cd, Co, Mo, Ag, Cu
Tamil Nadu	Manali, North Arcot	Hg, Ni, Cd, Cu, Zn, Pb, Fe, Mn
Uttar Pradesh	Basti , Varanasi, Kanpur, Allahabad, Aligarh, Jaunpur	Pb, Cd, Cu, Zn, Cr, Fe, Mn, Hg
West Bangal	Durgapur, Howrah, Nadia, Murshidabad	Fe, Mn, Ni, Zn, Cd, Cr, Pb

Summarized information of the occurrence of *fluoride* in ground water in India

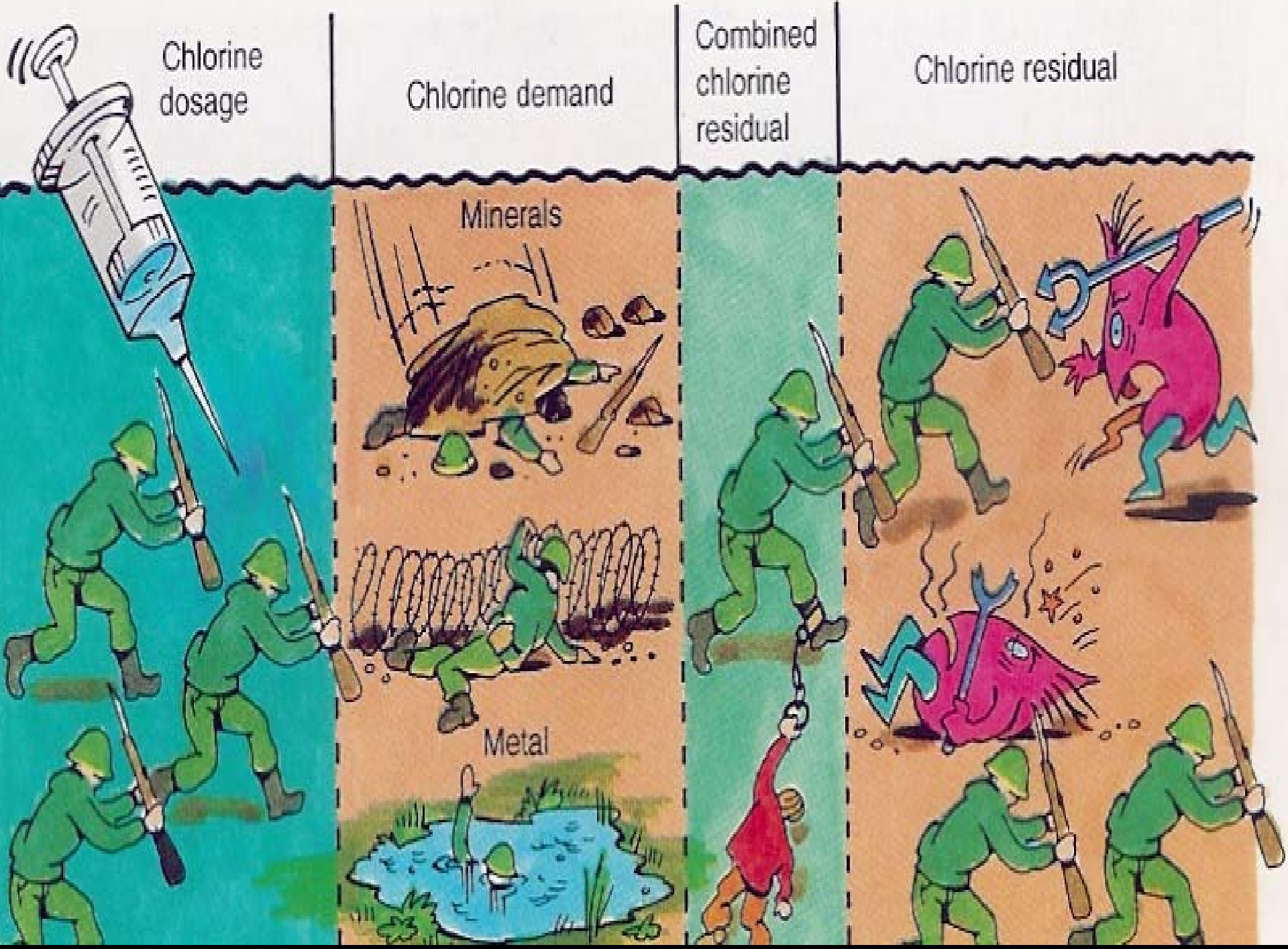
State	Name of District	Number of villages surveyed	Range of fluoride (mg/l)
Gujarat	Mehsana	127	1.58-9.9
Jammu & Kashmir	Doda	7	0.05-4.21
Maharasthra	Jalgaon	10	0.11-30
Maharashtra	Bhandara	7	1.5-10.2
Uttar Pradesh	Unnao	10	0.12-19.0
Karnataka	Dharwad	44	0.40-18.0
Karnataka	Gulbarga	33	0.2-5.6
Karnataka	Raichur	147	0.4-8.5
Haryana	Gurgaon	26	0.17-24.2
Madhya Pradesh	Shivpuri & Jabua	11	1.5-4.2

Summarized information of the occurrence of *nitrate* in ground water in India

State	Max. Nitrate, mg/L	District
Andhra Pradesh	1490	Parkasam
Assam	22	Lakhimpur
Bihar	440	Gaya
Delhi	1600	Shadra
Gujrat	560	Gujrat
Haryana	1310	Sirsa
Himachal Pradesh	176	Una
Jammu & Kashmir	460	Jammu
Karnataka	900	Mandya
Kerala	200	Palghat
Madhya Pradesh	2100	Sehore
Maharashtra	948	Nagpur
Orissa	800	Ganjam
Punjab	900	Sangrur
Rajasthan	1910	Jaipur
Tamil Nadu	1600	Salem
UP	840	Hamirpur
West Bengal	331	Purlia

Arsenic crisis in India and Bangladesh

Location	Years of exposure	Estimated Nos. People exposed (millions)	% Percent with skinlesion	Arsenic Concn. In water µg/L
Bangladesh	1970-present	18-22	33.6	10-2000
India				
West Bengal	1978-1996	>1	20	10-3700
Uttar Pradesh	Understudy	-	-	> permissible limit
Standard Limits:	Current USEPA and World Health Organisation limits are 10 and 50 µg/l for drinking water respectively in case of ARSENIC.			


Chlorine dosage
Chlorine demand
Combined chlorine residual
Chlorine residual
Minerals
Metal

Halogenated by products formed by chlorination[a]

Oxidation by products	Concentrations b , µg/liter	
	Median	Maximum
Trihalomethane		
Chloroform	25	240
Bromodichloromethane	9.5	90
Chlorodibrommethane	1.6	36
Bromoform	<0.2	7.1
Haloacetic acids		
Dichloroacetic acid	15	74
Trichloroaceitic acid	11	85
Bromochloroacetic acid	3.2	49
Monochloroacetic acid	1.3	5.8
Dibromoacetic acid	<0.5	7.4
Monobromoacetic acid	<05	1.7
Tribromoacetic acid	-	-
Bromodichloroacetic acid	-	-
Chlorodibromoacetic acid	-	-

[a]Studies have primarily focused on surface water systems where high DBPS would be expected. Median and [b]maximum concentrations vary widely depending on the chemical/time/source of sampling.

Chlorination byproducts and its health effects

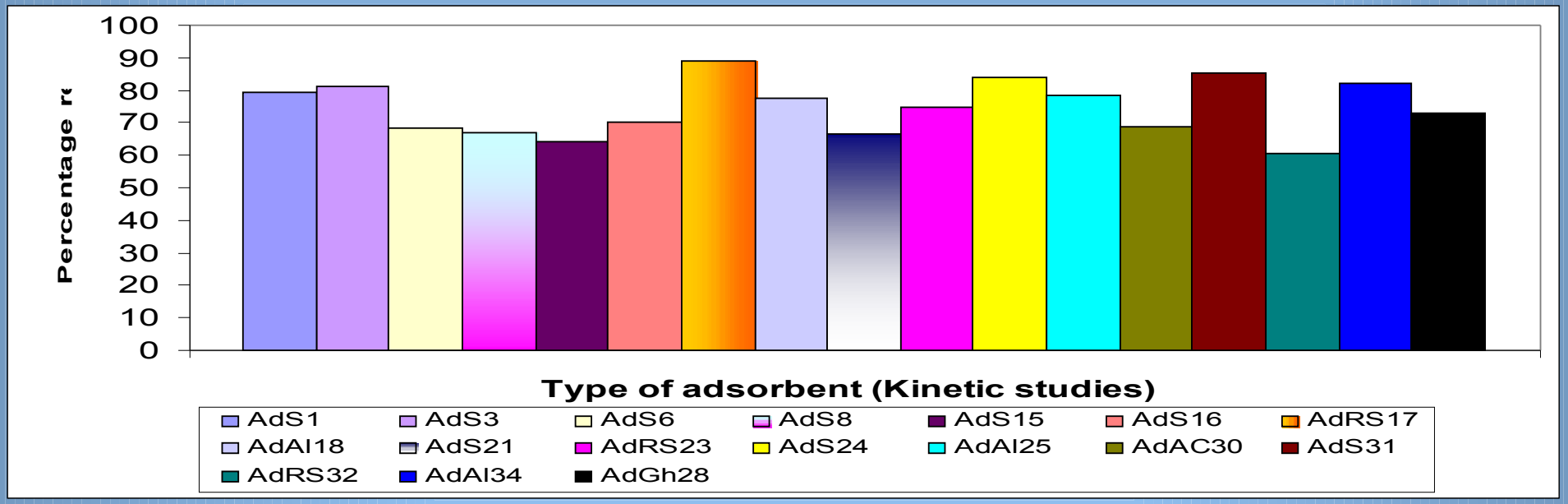
Class of DBPs	Compounds	Health effects
Trihalomethanes (THM)	Chloroform	Cancer, liver, kidney and reproductive effects
	Dibromochloromethane	Nervous system, liver, kidney and reproductive effects
	Bromodichloromethane	Cancer, liver, kidney and reproductive effects
	Bromoform	Cancer, liver, kidney and reproductive effects
Haloacetonitrile (HAN)	Trichloroacetonitrile	Cancer, mutagenic and clastogenic effects
Halogenated aldehydes and Ketones	Formaldehyde	Mutagenic
Halophenol	2-Chlorophenol	Cancer, tumor promoter
Haloacetic acids (HAA)	Dichloroacetic acid	Cancer, reproductive and developmental effects

Average consumption of *Pesticides* in Selected Countries of World

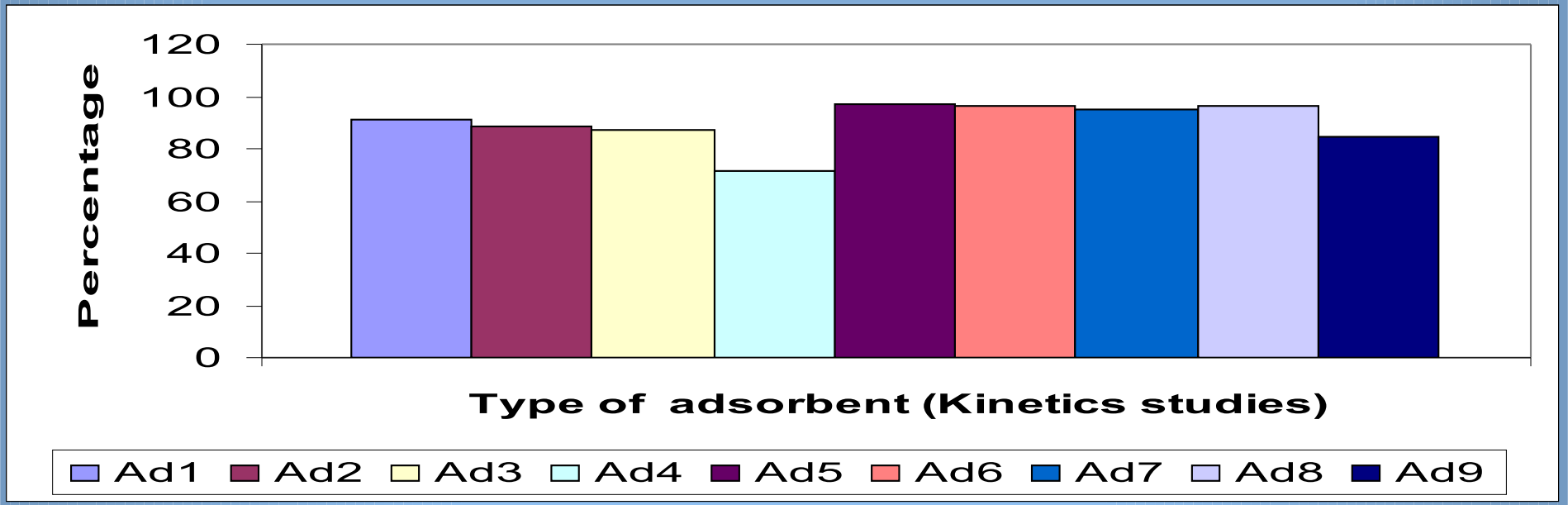
Country	Consumption in g/ha
Taiwan	17,000
Japan	12,000
Europe	3,000
USA	2,500
Argentina	960
Mexico	750
India	570
Africa	127

Ref: Bami,H.L. Pesticide risk an overview of Indian Sceen:Pesticide Information 18(3): 4-7, 1992.

Arsenic Removal

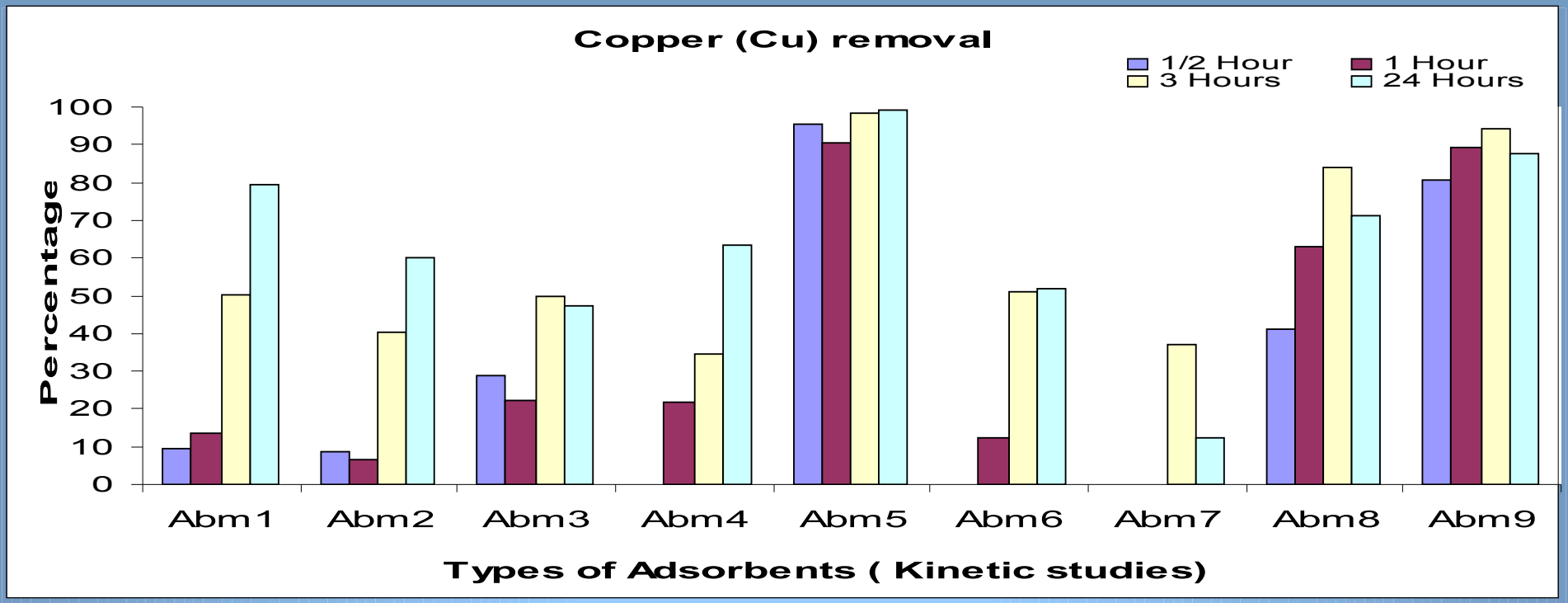


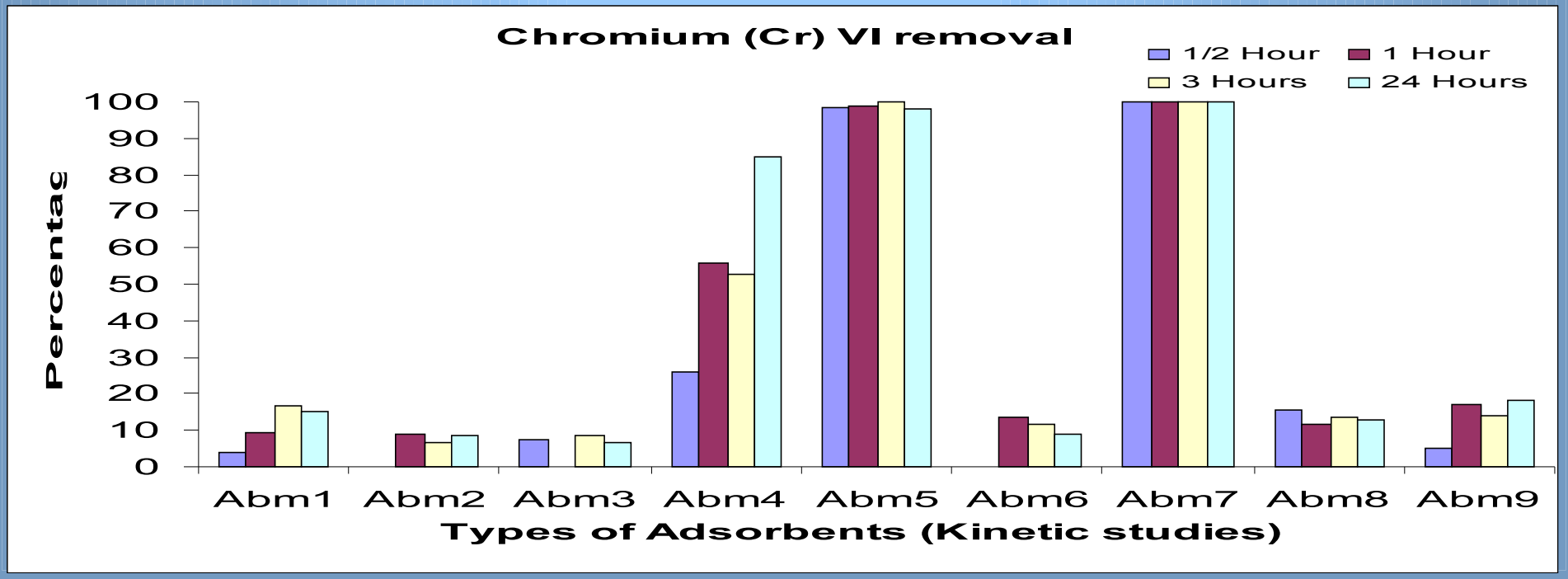
Fluoride Removal

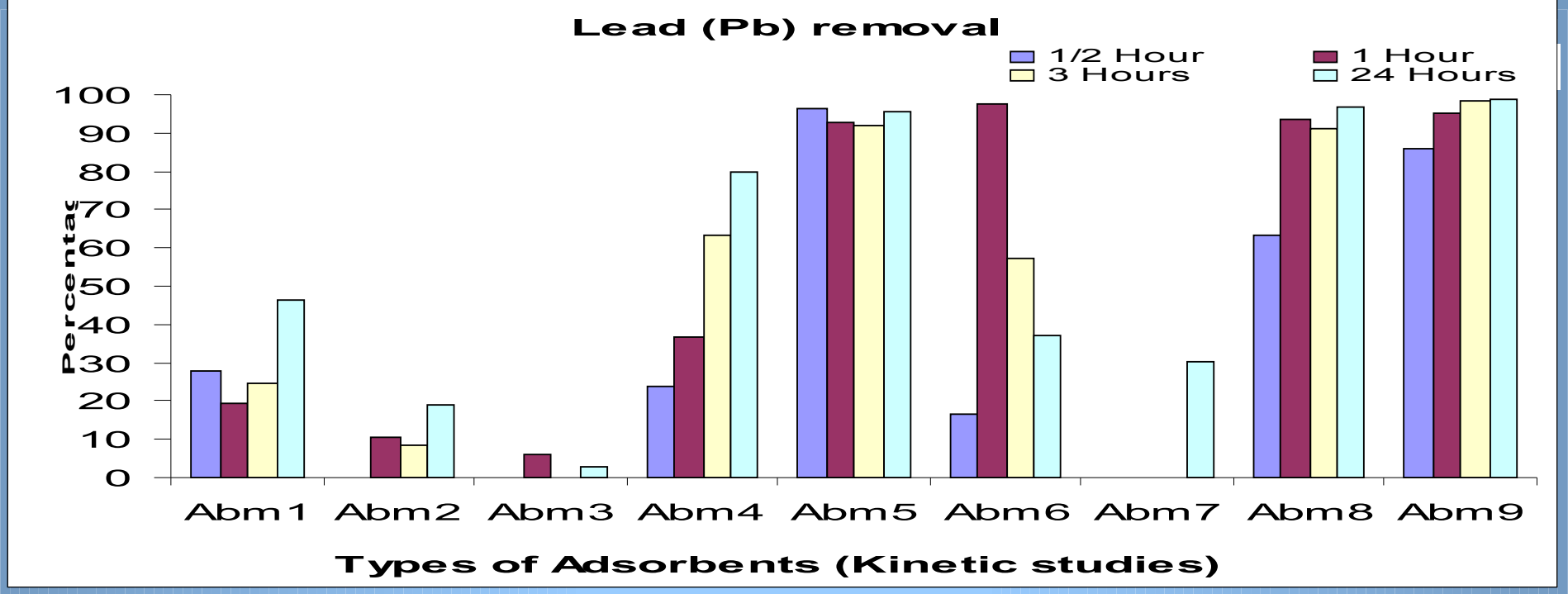


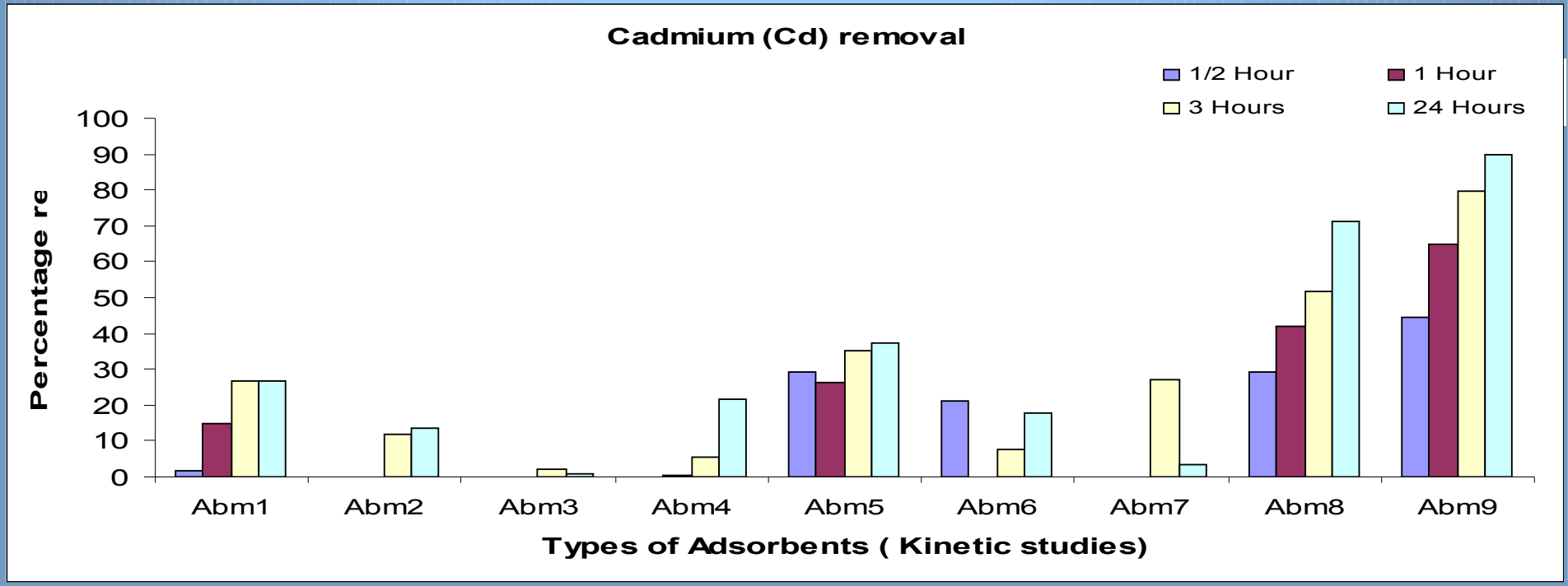
Sorbents for the removal of Arsenic and Fluoride

(Ad1)
(Ad5)
(Ad6)
(Ad7)
(Ad8)
(AdRS17)
(AdS24)
(AdS31)
(AdAl34)


Copper (Cu) removal
1/2 Hour
1 Hour
3 Hours
24 Hours
Percentage
100
90
80
70
60
50
40
30
20
10
0
Abm1
Abm2
Abm3
Abm4
Abm5
Abm6
Abm7
Abm8
Abm9
Types of Adsorbents (Kinetic studies)


Chromium (Cr) VI removal
1/2 Hour
1 Hour
3 Hours
24 Hours
Percentag
100
90
80
70
60
50
40
30
20
10
0
Abm1
Abm2
Abm3
Abm4
Abm5
Abm6
Abm7
Abm8
Abm9
Types of Adsorbents (Kinetic studies)


Lead (Pb) removal
1/2 Hour
1 Hour
3 Hours
24 Hours
100
90
80
70
60
50
40
30
20
10
0
Abm1
Abm2
Abm3
Abm4
Abm5
Abm6
Abm7
Abm8
Abm9
Types of Adsorbents (Kinetic studies)


Cadmium (Cd) removal
1/2 Hour
1 Hour
3 Hours
24 Hours
100
90
80
70
60
50
40
30
20
10
0
Abm1
Abm2
Abm3
Abm4
Abm5
Abm6
Abm7
Abm8
Abm9
Types of Adsorbents (Kinetic studies)

Sorbents for the removal of heavy metal

(Abm1)

(Abm4)

(Abm5)

(Abm6)

(Abm7)

(Abm8)

(Abm9)

Sorbents for the removal of Nitrate

(AbN1)

(AbN2)

(AbN3)

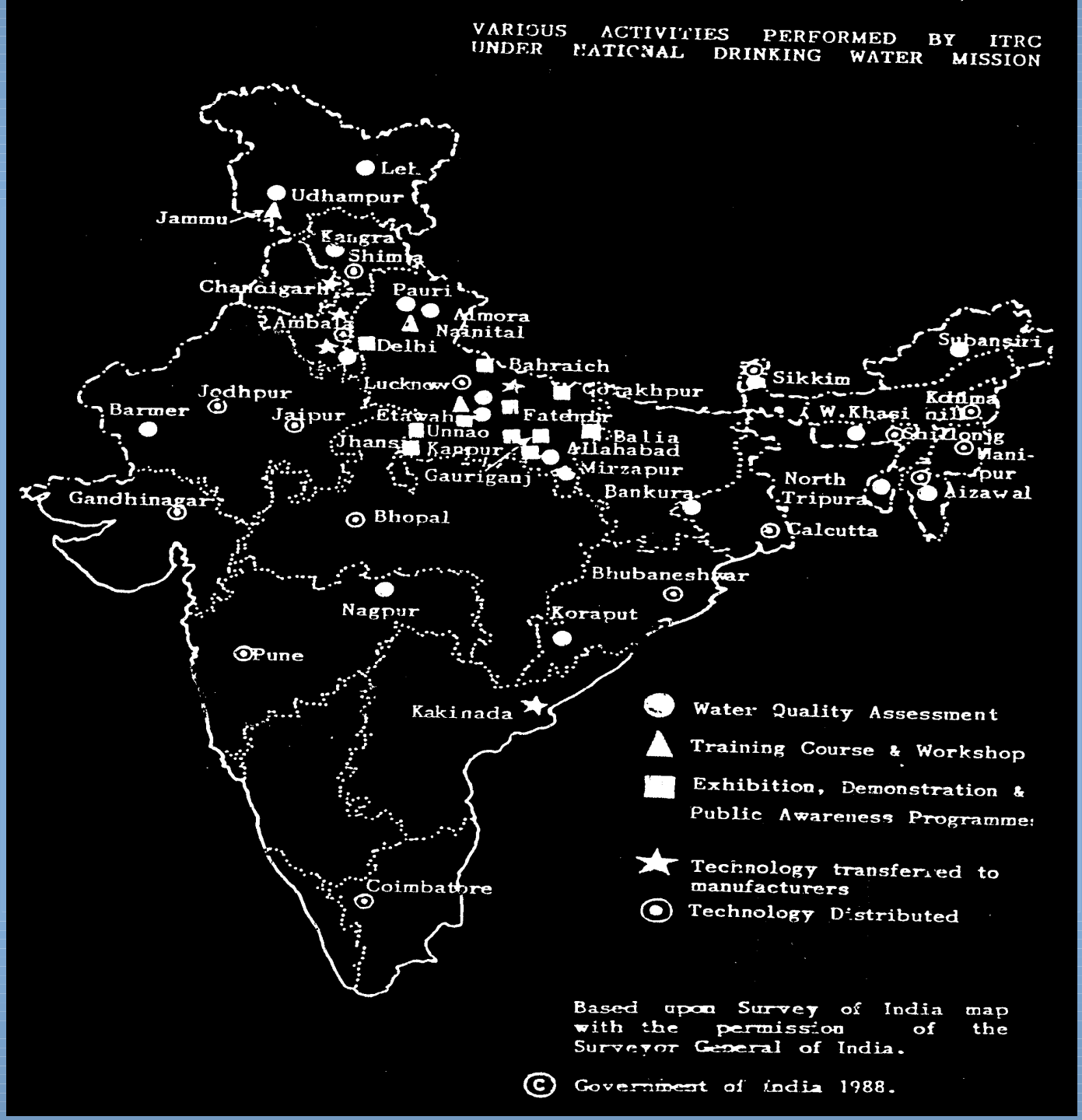
(AbN4)

A comparison of silver ionization vis a vis other conventional water disinfection methods

Parameters	Silver Ionization	Chlorination
Harmful to eyes?	No	Yes
Irritating to skin?	No	Yes
Bleaches hair?	No	Yes
Explosive, unsafe?	No	Yes
Dangerous to store?	No	Yes
Corrosive to pipelines?	No	Yes
Evaporates?	No	Yes
Toxic to landscaping?	No	Yes
Unpleasant smell?	No	Yes
Linked to cancer ?	No	Yes
Toxic to lungs?	No	Yes
Requires maintenance?	No	Yes
Forms trihalomethanes	No	Yes
Forms chloramines?	No	Yes

Centre of Excellence

National Advanced Centre for Water Quality Assurance &Training


VARIOUS ACTIVITIES PERFORMED BY ITRC
UNDER NATIONAL DRINKING WATER MISSION
Leh
Udhampur
Jammu
Kangra
Shimla
Chandigarh
Pauri
Almora
Nainital
Ambala
Delhi
Bahraich
Lucknow
Gorakhpur
Jodhpur
Barmer
Jaipur
Etawah
Fatehpur
Unnao
Jhansi
Kanpur
Balia
Allahabad
Mirzapur
Gauriganj
Gandhinagar
Bhopal
Bankura
Sikkim
Subansiri
Kohima
W.Khasi hill
Shillong
Mani-
pur
North
Tripura
Aizawal
Calcutta
Bhubaneshwar
Nagpur
Koraput
Pune
Kakinada
Coimbatore
Water Quality Assessment
Training Course & Workshop
Exhibition, Demonstration &
Public Awareness Programme
Technology transferred to
manufacturers
Technology Distributed
Based upon Survey of India map
with the permission of the
Surveyor General of India.
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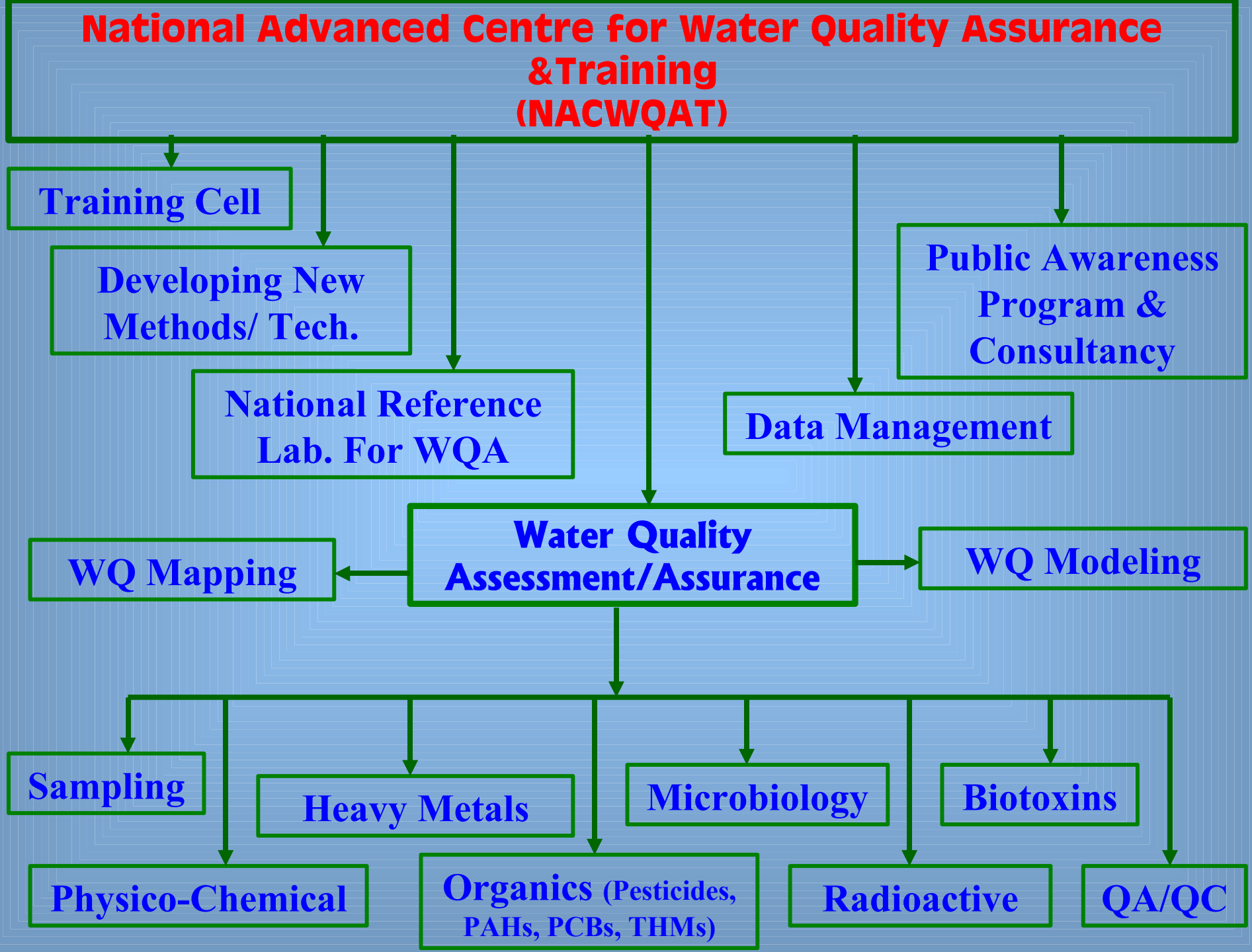
National Advanced Centre for Water Quality Assurance &Training (NACWQAT)
Training Cell
Developing New Methods/ Tech.
National Reference Lab. For WQA
Public Awareness Program & Consultancy
Data Management
WQ Mapping
Water Quality Assessment/Assurance
WQ Modeling
Sampling
Heavy Metals
Microbiology
Biotoxins
Physico-Chemical
Organics (Pesticides, PAHs, PCBs, THMs)
Radioactive
QA/QC


THANKS