

ES 200 ENVIRONMENTAL STUDIES

Module-C

Anthropogenic effects on ecosystem, water quality & health, water & wastewater treatment



Lecture-3

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Learning Objectives

Water Quality & Pollution Sources

- Concept of water quality and human health
- Major water pollutants & their effects
- Toxicity and risk assessment
- Point & non-point sources of pollution

Water Quality



<https://i1.wp.com/www.siasat.com/wp-content/uploads/2016/07/Dirty-water.jpg?fit=550%2C320>

Water Quality

Water quality can be thought of as a **measure of the suitability of water for a particular use** based on selected physical, chemical, and biological characteristics.

- What is present?
- How much is present?
- When is it present?
- Where is it present?

Difference between an Impurity and a Pollutant in Water

- ✓ Natural water is never pure!
- ✓ Lot of impurities are already present, e.g. dissolved CO₂ and O₂, minerals etc.
- ✓ The fact that some impurity is desirable or not in a particular concentration at a particular place for a particular use decides if it is a **pollutant in that context**.
- ✓ For example, minerals are desirable in drinking water, but may not be desirable in water during a lab experiment.

Major Pollutants in Water

- Inorganic Pollutants (e.g. Nutrients: N, P; Heavy Metals, Fluoride etc.)
- Organic Pollutants (e.g. Pesticides, PPCPs etc.)
- Biological Pollutants (e.g. Pathogens)

Major Pollutants in Water

Inorganic Pollutants

Nutrients: N & P

Nitrogen

- Present as $\text{NH}_3/\text{NH}_4^+$, NO_2^- , NO_3^-
- Essential for protein and amino acid synthesis
- Higher concentrations are toxic
- Blue baby syndrome (or Methemoglobinemia)

Phosphorus

- Present as orthophosphate (PO_4^{3-}) and polyphosphate
- Essential for forming DNA, RNA, and energy transfer in the cells
- Higher concentrations are problematic and result in Eutrophication

Major Pollutants in Water

Inorganic Pollutants

Fluoride: F⁻

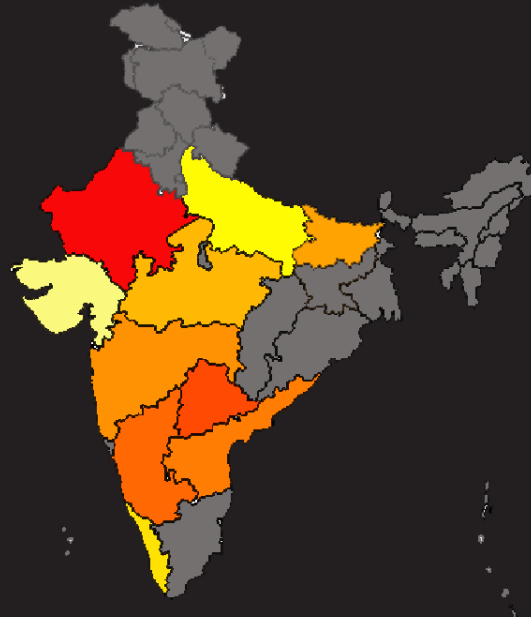
Design by **PANTHEO**

FLUOROSIS

Fluorosis is a crippling and painful disease caused by intake of fluoride. Fluoride can enter the body through drinking water, food, toothpaste, mouth rinses and other dental products; drugs, and fluoride dust and fumes from industries using fluoride containing salt and or hydrofluoric acid.



IN LAST 5 YEARS - **4157 Lakhs** released under
National Programme for Prevention & Control of Fluorosis (NPPCF)
1076 Lakhs utilized
~75% funds not utilized



TOP 10 INDIAN STATES WITH MOST NUMBER OF PEOPLE AFFECTED WITH FLUOROSIS

STATE	No. of People Affected
RAJASTHAN	40,04,613
TELANGANA	19,22,783
KARNATAKA	13,29,602
ANDHRA PRADESH	10,91,394
MAHARASHTRA	6,72,939
BIHAR	4,91,923
MADHYA PRADESH	4,54,054
KERALA	2,75,557
UTTAR PRADESH	1,43,967
GUJARAT	90,704

TOTAL in 19 STATES -
117 Lakh people affected

<https://factly.in/wp-content/uploads/2015/03/fluorosis-in-India-top-10-indian-states-most-number-of-people-affected-Infographic.png>

Major Pollutants in Water

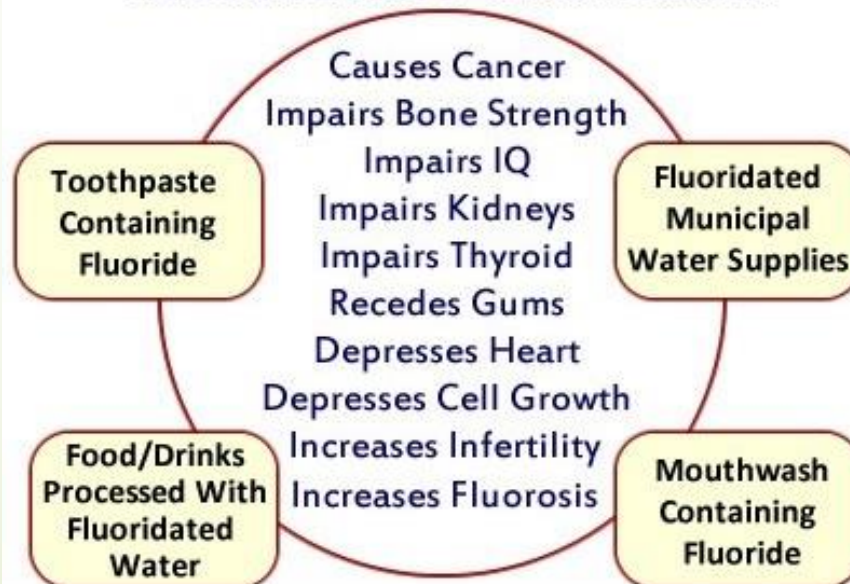
Inorganic Pollutants

Fluoride

Most developed nations, including all of Japan and 97% of western Europe DO NOT Fluoridate

Fluoride

BIOLOGICAL EFFECTS OF SODIUM FLUORIDE:



www.preventdisease.com/fluoride

<http://fluoridefree.org.nz/wp-content/uploads/2014/05/Body-Effects-of-F.jpg>

Major Pollutants in Water

Inorganic Pollutants

Fluoride

Skeletal Fluorosis



<http://www.inrem.in/fluorosis/images/leg.jpg>

Dental Fluorosis



http://www.noforcedfluoride.org/images/420_Fluorosisbig.gif

Major Pollutants in Water

Inorganic Pollutants

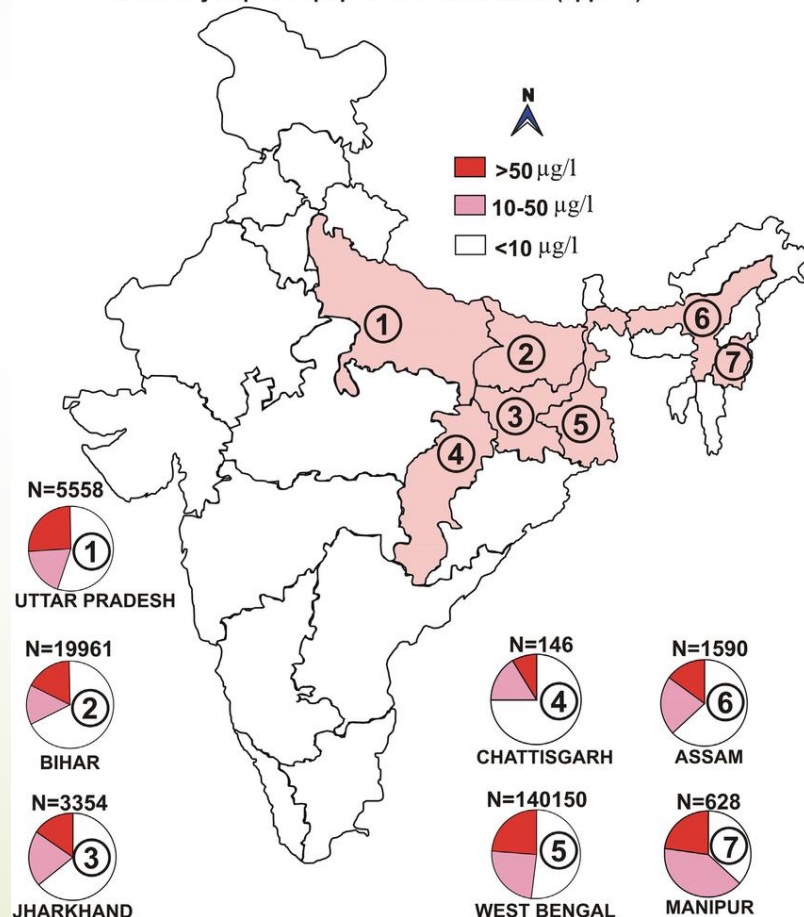
Arsenic



https://www.researchgate.net/profile/B_Das6/publication/302982351/figure/fig2/AS:372885651771393@1465914275666/Fig-2-The-locations-of-arsenic-affected-states-in-India-number-of-samples-analyzed-and.jpg

List of arsenic endemic states in India

Area of endemic states = **529674 sq km** (approx)
 Population of endemic states = **359 million** (approx)
 Potentially exposed population = **50 million** (approx)



Major Pollutants in Water

Inorganic Pollutants

Arsenic

ARSENIC POISONING

Inorganic arsenic has been declared a known human carcinogen by the International Agency for Research on Cancer, the U.S. Environmental Protection Agency, and the Department of Health & Human Services.

Early Symptoms:

- Skin discoloration
- Skin lesions
- Nausea
- Vomiting
- Diarrhea

Increased Risk:

- Kidney disease
- Heart disease
- Liver disease
- Lung cancer
- Skin cancer
- Bladder cancer
- Diabetes
- Paralysis



<https://static1.squarespace.com/static/5171eee1e4b08db7106e5bbb/t/5181e49ee4b04f94760ca925/1367467166663/Arsenic+Poisoning.jpg>

Arsenicosis



<http://pubs.acs.org/cen/hotarticles/cenar/991206/7749wil10x.ce.jpg>

Major Pollutants in Water

Inorganic Pollutants

Reading Assignment

Read about the occurrences and health effects of Cr, Pb, and Hg.

Major Pollutants in Water

Organic Pollutants

Pesticides



<http://quitmarijuana.org/wp-content/uploads/2017/03/Pesticide-Sign.gif>

Organochlorine Pesticide

<http://www.scielo.br/img/revistas/jbchs/v20n5/a17fig01.gif>

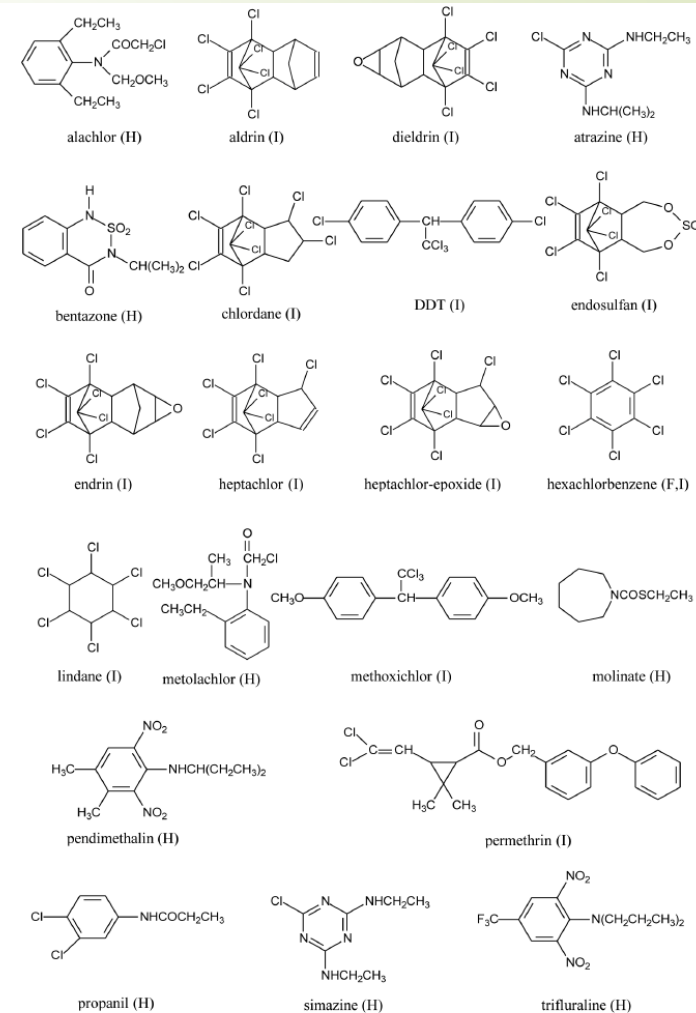


Figure 1. Structure of selected pesticides (H = Herbicides; I = Insecticides; F = Fungicides).

Major Pollutants in Water

Organic Pollutants

Pesticides



<http://quitmarijuana.org/wp-content/uploads/2017/03/Pesticide-Sign.gif>

Pesticides such as Endosulfan have been detected in Arctic! How did it reach there?

Organophosphate Pesticide

Pesticide	Molecular formula
Methyl parathion	$\text{CH}_3\text{O}-\text{P}(=\text{S})(\text{OCH}_3)-\text{O}-\text{C}_6\text{H}_4-\text{NO}_2$
Endosulfan	$\text{C}_{10}\text{H}_{16}\text{Cl}_2\text{N}_2\text{O}_6\text{P}_2\text{S}_2$
Malathion	$\text{CH}_3\text{O}-\text{P}(=\text{S})(\text{CH}_3)-\text{S}-\text{CH}(\text{CH}_2\text{C}(=\text{O})\text{OC}_2\text{H}_5)_2$
Dichlorvos	$(\text{CH}_3\text{O})_2\text{P}(=\text{O})-\text{O}-\text{CH}=\text{CCl}_2$

<http://www.scielo.br/img/revistas/jbchs/v26n3/0103-5053-jbchs-26-03-0484-gf03.jpg>

Major Pollutants in Water

Organic Pollutants



https://cunhaenvirosci.wikispaces.com/file/view/leaflet_Eng-1.jpg/48049615/274x187/leaflet_Eng-1.jpg

Major Pollutants in Water

Organic Pollutants

Persistent Organic Pollutants (POPs)

Polycyclic Aromatic Hydrocarbons (PAHs)

Pharmaceutical and Personal Care Products (PPCPs)

Emerging Contaminants

Major Pollutants in Water

Biological Pollutants

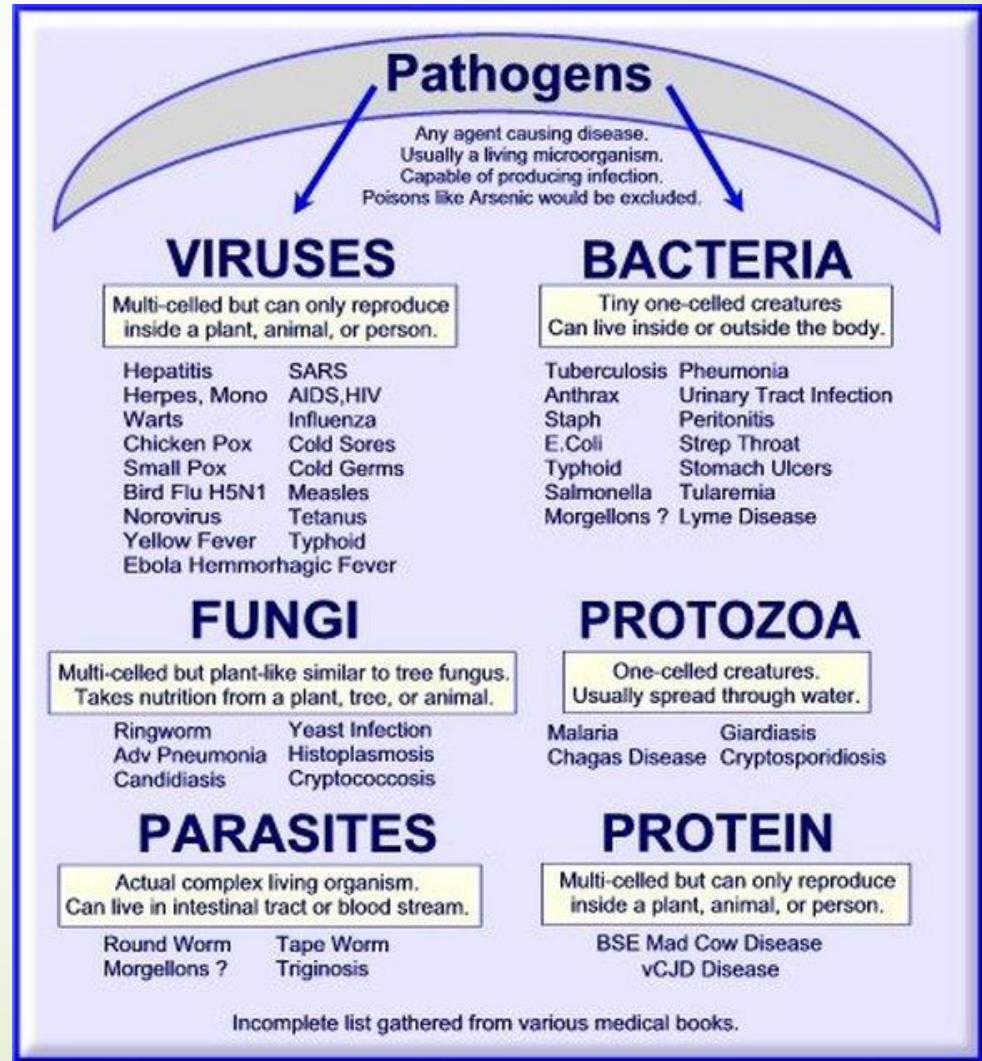
Pathogens



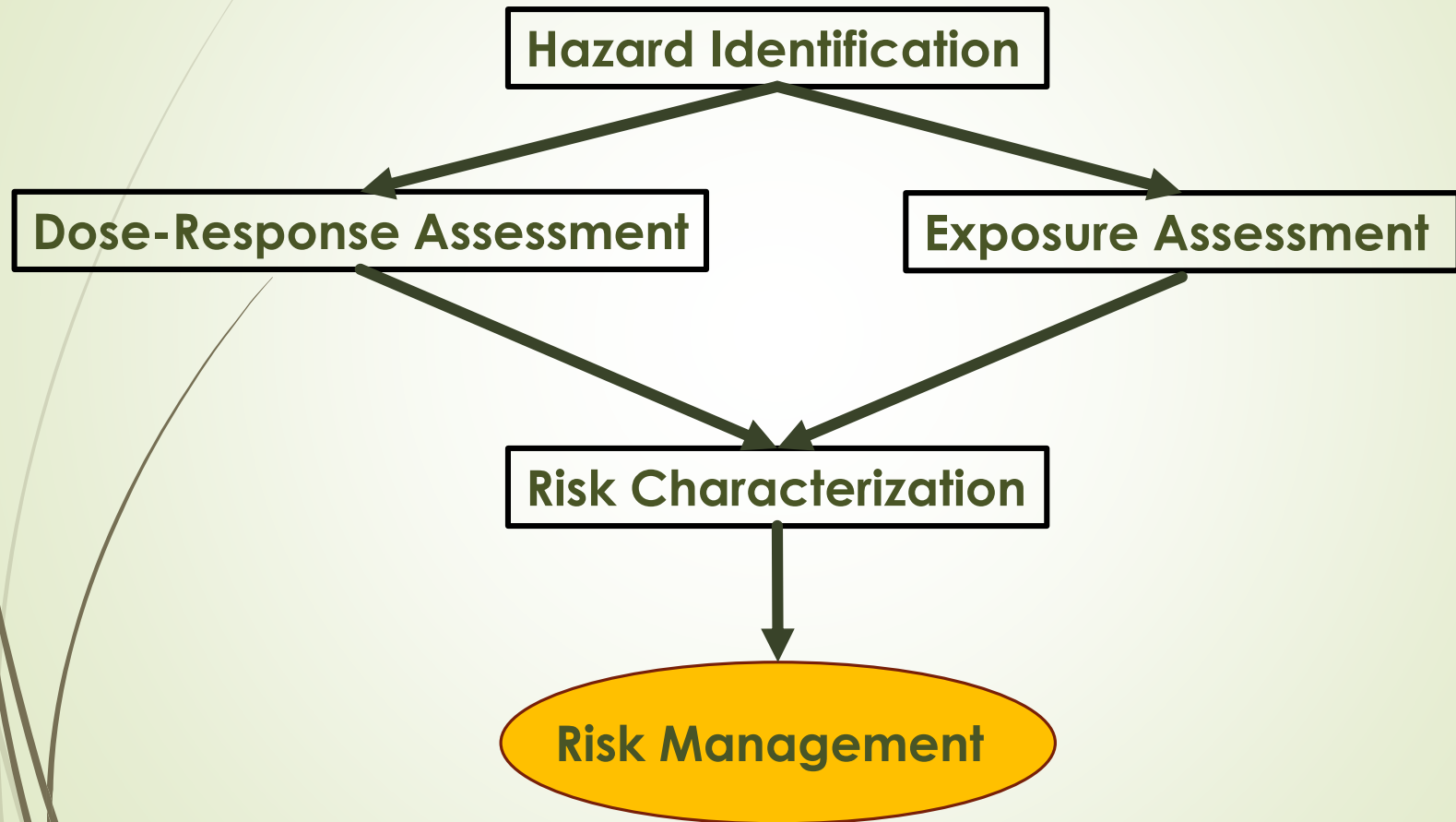
International
Biohazard
Symbol

https://upload.wikimedia.org/wikipedia/commons/0/00/Biohazard_symbol_black_and_yellow.png

<http://kmbiology.weebly.com/uploads/6/0/1/1/6011704/552362.jpg?585>



Risk Assessment of a Pollutant

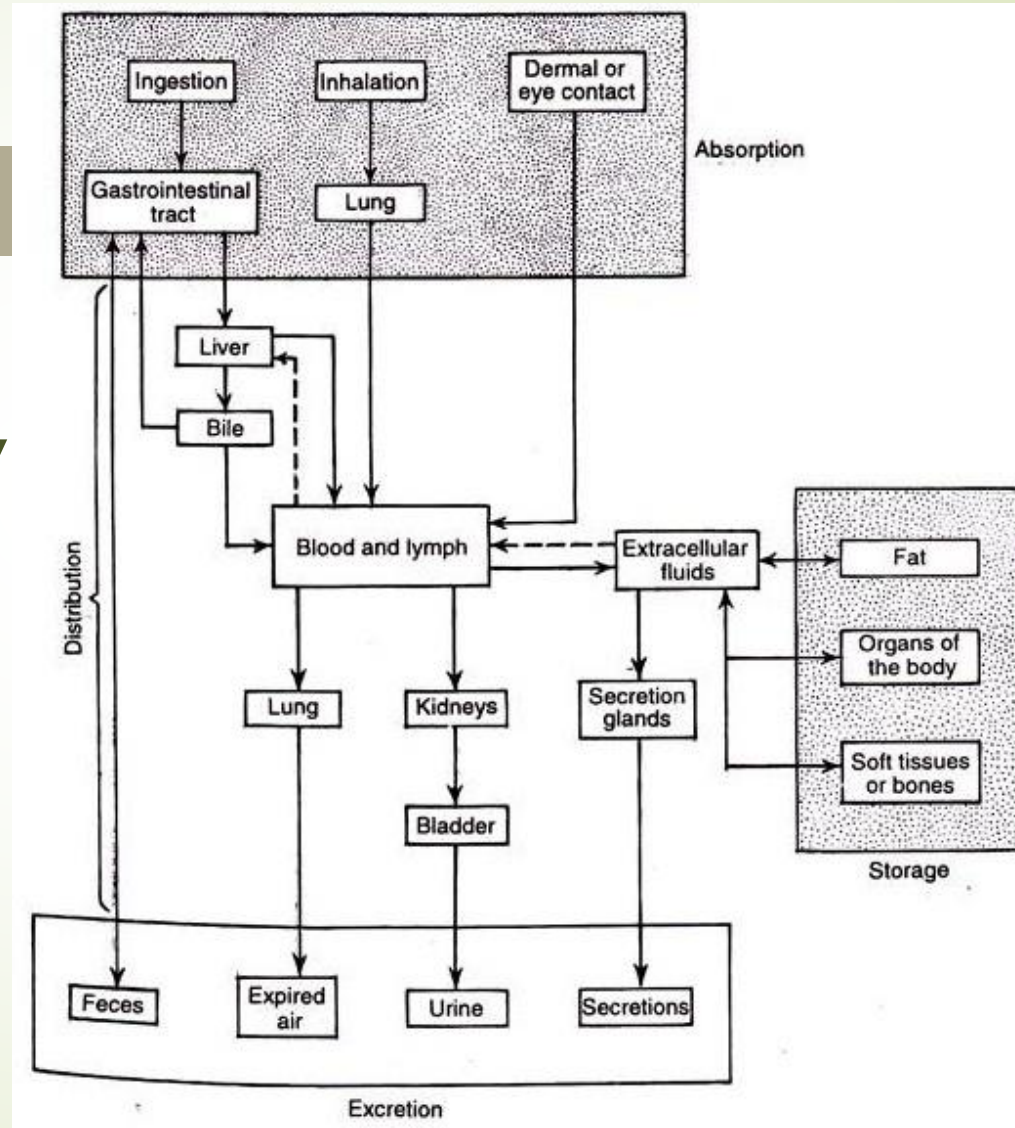


Risk Assessment of a Pollutant

Hazard Identification

Fate of chemical toxicants in the body

http://www.environmentalpollution.in/wp-content/uploads/2017/02/clip_image008-14.jpg



Risk Assessment of a Pollutant

Hazard Identification

Acute Toxicity

Adverse effects of a substance that result either from a single exposure or multiple exposures in a short space of time (usually less than 24 hours)

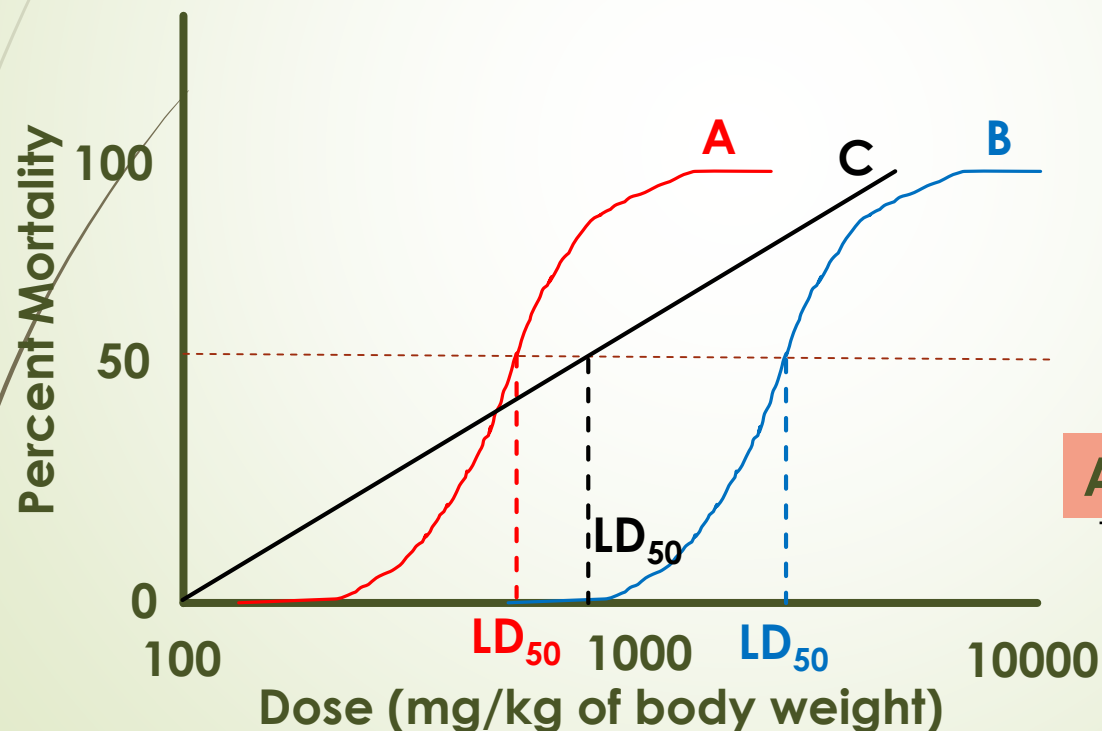
Chronic Toxicity

Delayed adverse effects of a substance following repeated long duration exposures (usually months or years)

Doses required for acute toxicity are generally much higher than for chronic toxicity

Risk Assessment of a Pollutant

Acute Toxicity



LD₅₀: Lethal Dose at which 50% of the exposed population dies

A is more toxic than B

A is less toxic than C at low doses

lesser the amt req to kill 50% population more toxic is the cpd

Risk Assessment of a Pollutant

A Conventional Rating System for the Acute Toxicity of Chemicals in Humans

Toxicity Rating	Oral Dose LD ₅₀ (mg/kg)
Practically nontoxic	> 15000
Slightly toxic	5000 - 15000
Moderately toxic	500 - 5000
Very toxic	50 - 500
Extremely toxic	5 - 50
Super toxic	< 5

TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin):
Most toxic compound known to science

LD₅₀ = 0.0006 mg/kg for Guinea Pigs; 0.022-0.045 mg/kg for Rats

Risk Assessment of a Pollutant

Chronic Toxicity

Carcinogenesis: Initiation and promotion of cancer

Mutagenesis: Mutations due to the alteration of DNA

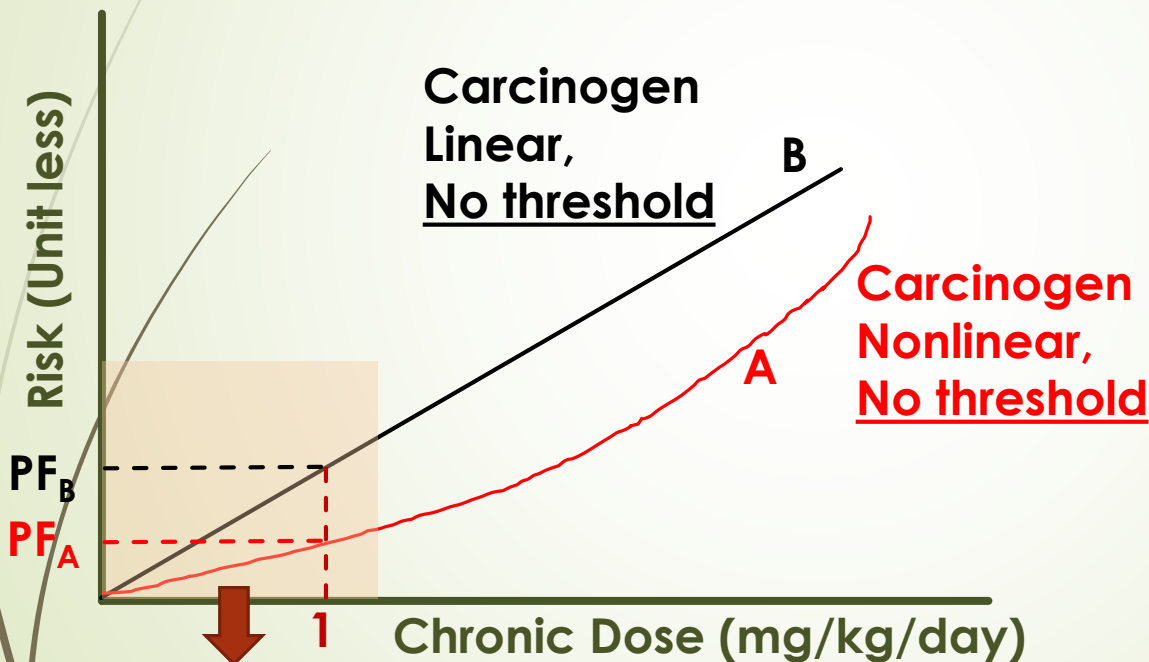
Teratogenesis: Malformation during development of the fetus

Risk Assessment of a Pollutant

Chronic Toxicity: Carcinogens

Chronic Dose or Chronic Daily Intake (CDI) is an exposure averaged over an entire lifetime (assumed to be 70 years for humans)

Potency Factor (PF) is the slope of the Dose-Response curve during its linear stage

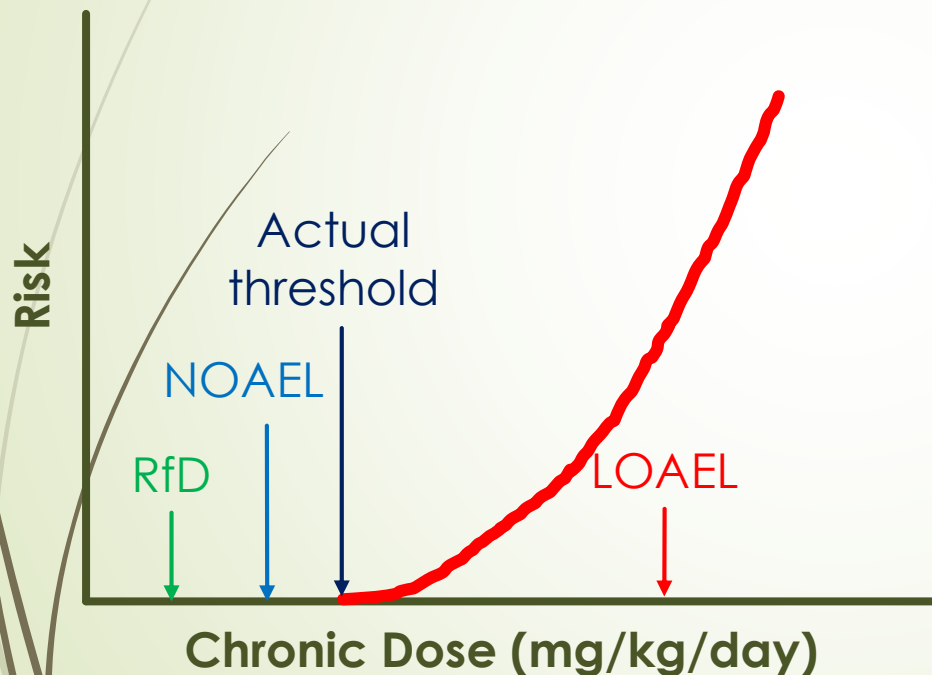


At low dose levels, effect can be assumed to be linear

Incremental Lifetime Cancer Risk = $CDI \times PF$
If Risk $< 10^{-6}$; Safe

Risk Assessment of a Pollutant

Chronic Toxicity: Non Carcinogens



LOAEL: Lowest Observed Adverse Effect Level

NOAEL: No Observed Adverse Effect Level

RfD: Reference Dose

$RfD = NOAEL / \text{Safety Factor}$

Risk Assessment of a Pollutant

Chronic Toxicity: Non Carcinogens

$$\text{Hazard Quotient}(HQ) = \frac{\text{Average daily dose during exposure period (mg/kg-day)}}{RfD}$$

If $HQ < 1.0$; No significant risk of systematic toxicity

When exposure involves more than one chemical

Hazard Index (HI) = Sum of the individual Hazard Quotient

Risk Assessment of a Pollutant

Human Exposure Assessment

What is the amount of exposure to some substance?

Unless individuals are exposed to the toxicants, there is no human risk.

1. Evaluate the pathways that allow toxic agents to be transported from the source to the point of contact with people.
2. Make an estimate of contact that is likely to occur between people and those contaminants.

Risk Assessment of a Pollutant

Human Exposure Assessment

Bioconcentration or Bioaccumulation

Accumulation of a chemical in or on an organism when the source of chemical is solely water

$$\text{Bioconcentration Factor (BCF)} = \frac{\text{Concentration within the organism}}{\text{Concentration in the water}}$$

Biomagnification

Increasing concentration of a chemical in organisms of higher trophic levels

Contaminant Degradation

Risk Assessment of a Pollutant

Risk Characterization

- What are the uncertainties (statistical and biological)?
- Which dose-response assessment and exposure assessments are to be used?
- Which population groups should be the primary targets for protection?
- What is the most meaningful expression of the health risk?

Point vs Non-Point Sources of Pollutants

Point Source



<http://theglobalwatergroup.com/images/process2.jpg>

Line Source



<https://upload.wikimedia.org/wikipedia/commons/thumb/c/ca/NorthSouth-Expressway.jpg/300px-NorthSouth-Expressway.jpg>

Area Source



http://s3.amazonaws.com/kidzworld_photo/images/201064/61d08863-3586-479f-8896-2854787e8913/oil1.jpg

What is a Volume Source?

Next Lecture:

Parameters for Water Quality Characteristics, and Water Quality Standards

QUIZ