Environmental Sciences – CHY1002

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Module-3	**Sustaining Natural Resources and Environmental Quality** Environmental hazards – causes and solutions. Biological hazards – AIDS, Malaria, Chemical hazards- BPA, PCB, Pthalates, Mercury, Nuclear hazards- Risk and evaluation of hazards. Water footprint; virtual water, blue revolution. Water quality management and its conservation. Solid and hazardous waste – types and waste management methods

Water quality management and its conservation

- Effective water quality management is a vital step towards ecologically sustainable development

- Water of adequate quality and quantity is central to the existence of every life form, everywhere.

- Important points
  - Water has two dimensions, quantity and quality, both of which are changeable in time and space.
  - Water is needed for the environment and to support the nation's social and economic structures.
  - The continued availability of water, in terms of both quality and quantity, is open to change, not only through the natural variation, but also through the impacts of water use within the water cycle.

Video- 1 Video-2

- A water quality management process should incorporate:
  - National consistency in methods for setting goals, objectives and standards
  - Clear and explicit administrative processes
  - Clear and explicit assignment of responsibilities for the various phases of administration and operation
  - Accountability, where progress towards the desired water quality goal is monitored and reported
  - Matching of the administrative structures to the physical and social constraints, commonly on a catchment or subcatchment basis
  - Involvement of stakeholders in definitions of goals, development of plans and implementation of strategies
  - Administrative mechanisms responsive to change and development, including changing physical conditions over time, changing public preferences for water quality and resource management, and new technical options
  - Opportunities for harnessing market forces to the water quality management task.

CPCB - Guidelines for Water Quality Management

- Setting Water Quality Goal – designated best use
- Water Quality Monitoring – protocol
- Identification of Nature and Magnitude of Pollution – water quality data
- Source Inventory – point and non-point
- Water Quantity information – data based
- Selection of Technology – Simpler technology
- Financing Waste Management – tax
- Maintenance of sewage treatment plants – under utilized/maintained
- Pollution from industrial sources – control at source, reuse recycle, charges on residual pollution, mixing with sewage
- Pollution from non-point sources – int. pest management
- Some other Important Options for Water Quality Management - Incentives for Water conservation, fine etc.

- Water conservation - the policies, strategies and activities made to manage fresh water as a sustainable resource, to protect the water environment, and to meet current and future human demand

- Goals
  - Ensuring availability of water for future generations - withdrawal of fresh water from an ecosystem does not exceed its natural replacement rate.
  - Energy conservation: Water pumping, delivery and waste water treatment facilities consume a significant amount of energy - 15% of total electricity consumption is devoted to water management.
  - Habitat conservation: Minimizing human water use helps to preserve fresh water habitats - reduces the need to build new dams and other water diversion infrastructures.

- Key activities
  - Any beneficial reduction in water loss, use and waste of resources.
  - Avoiding any damage to water quality.
  - Improving water management practices that reduce the use or enhance the beneficial use of water
- One fundamental conservation goal is universal metering – can reduce consumption by 20 to 40 percent
- Removal of all subsidies to force farmers to grow more water - efficient crops and adopt less wasteful irrigation techniques
- Low-flow shower heads, dual flush, low-flush toilets and composting toilets.
- Faucet aerators, which break water flow into fine droplets to maintain "wetting effectiveness" while using less water.
- Raw water flushing where toilets use sea water or non-purified water
- Waste water reuse or recycling systems, allowing:
  - Reuse of gray water for flushing toilets or watering gardens
  - Recycling of wastewater through purification at a water treatment plant.
- Rainwater harvesting -Tanks or reservoirs above or below ground

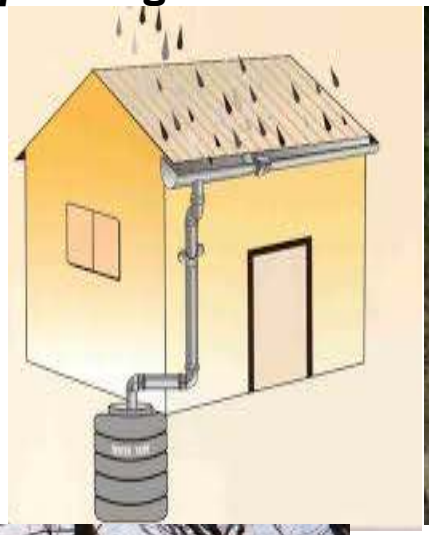
Rain Water Harvesting

- Increases ground water level by capturing and storing rainwater.
- The technique involves water harvesting structure like dug wells, percolation pits, lagoons, check dams etc.
- Capturing rain water and avoiding its pollution – useful for poor and scanty rainfall regions.
- Annual rainfall in India 1200 mm – seasonal (Jun-Sep).
- Cherapunji receives 2nd highest rainfall in the world but still suffers from water scarcity! Due to deforestation
- Rajendra Singh – Water man (Magsaysay Award for harvesting rain water by check dams).

- Objectives
  - To reduce run-off loss
  - To avoid flooding of roads
  - To meet the increasing demands of water
  - To increase ground water level for supply during lean season.
  - To reduce water contamination
- Rain water harvesting methods
  - Tanks or reservoirs above or below ground
  - Pits, dug-well, lagoons, trench or check-dams etc.
  - Recharging ground water.
  - Rain water harvesting – in-situ - Soil characteristics, topography, rainfall pattern and climatic conditions.

Traditional Rain Water Harvesting

Roof-top storage tanks

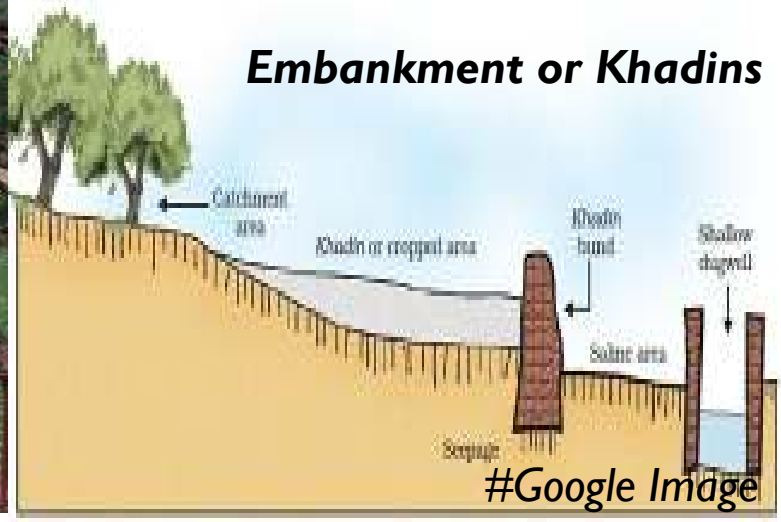


Bamboos as pipeline

Johads

Hauz

Embankment or Khadins



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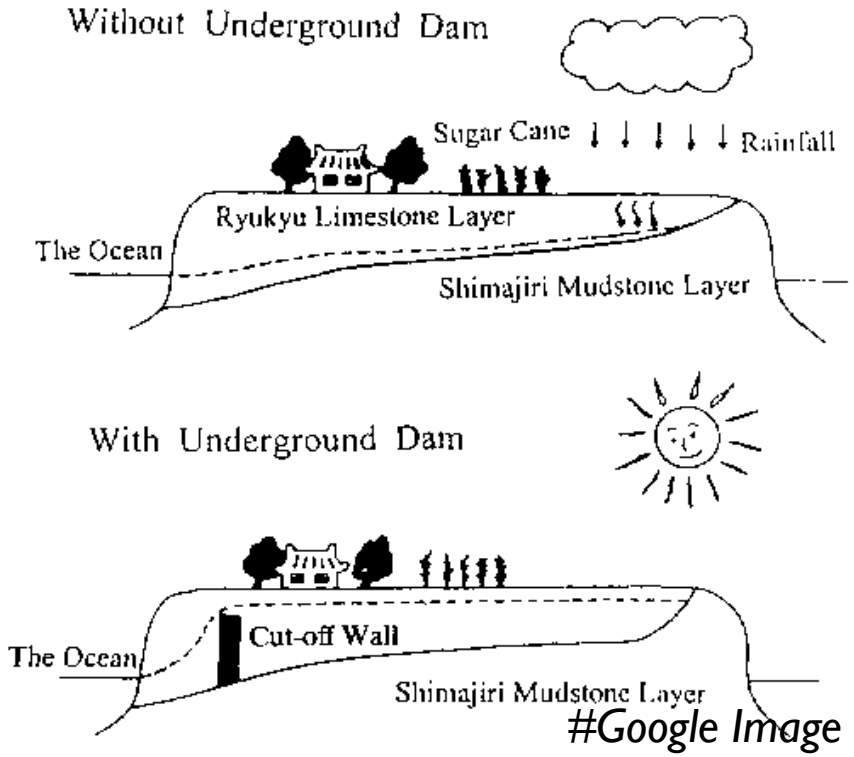
- Modern Techniques of Rain Water Harvesting
  - Run-off from large catchment areas
  - Shallow percolation tanks/ponds
  - Check dams (made from rocks, plants, loose rocks, stones, slabs etc.)
  - Ground water dams
    - Less evaporation and contamination



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Water footprint and virtual water

- A measure of humanity's appropriation of fresh water in volumes of water consumed and/or polluted.
  - Measured in cubic metres per tonne of production, per hectare of cropland, per unit of currency and in other functional units

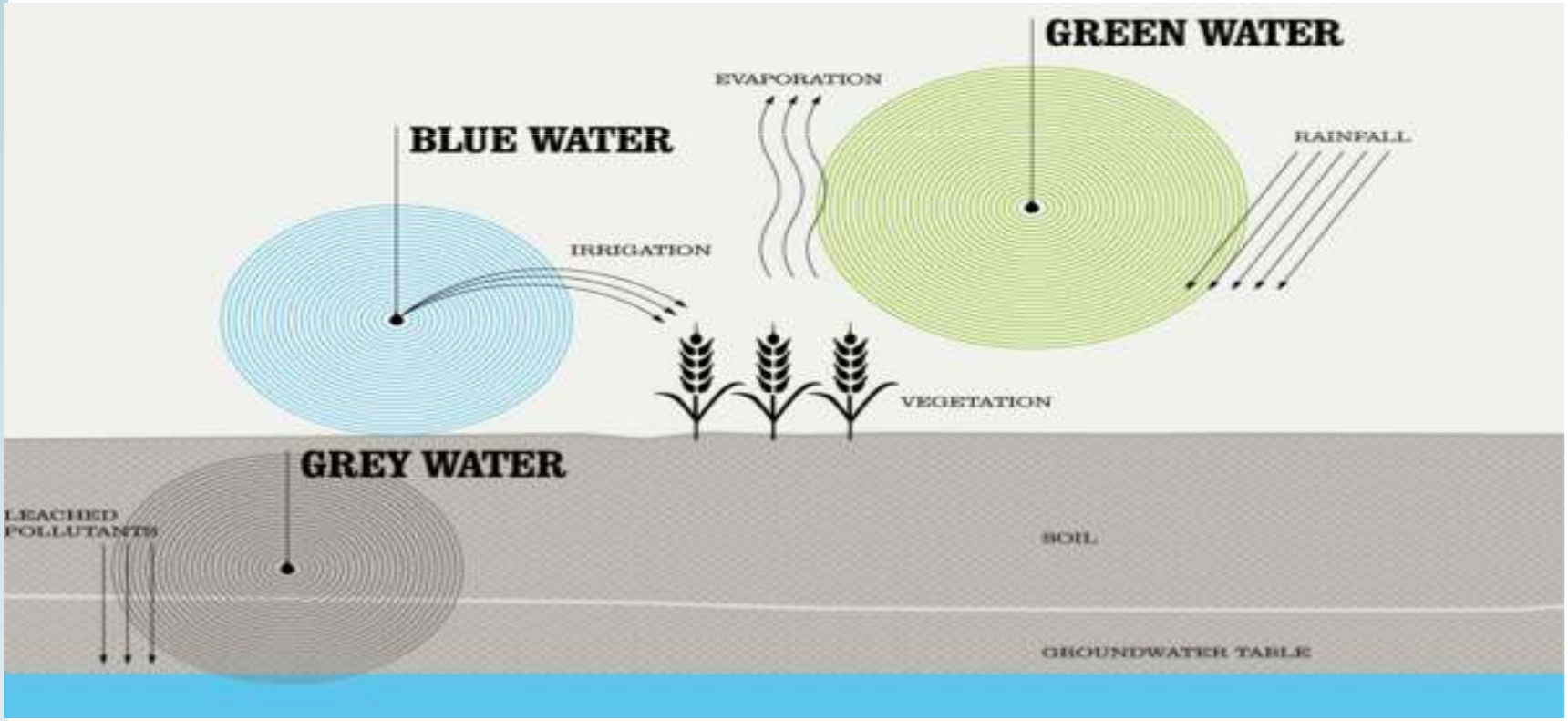
- Provide a comprehensive picture of water use by delineating the source of water consumed, either as rainfall/soil moisture or surface/groundwater, and the volume of fresh water required for assimilation of pollutants

- The water footprint has three components
  - Green – rain water stored in soil, transpired or used by plants – relevant to agricultural, horticulture and forestry products

- Blue –Surface or ground water either evaporated, used in a product or taken from one place to another. Irrigated agriculture, industry and domestic water use.

- Grey - Amount of fresh water required to assimilate pollutants - considers point-source pollution discharged to a freshwater resource directly through a pipe or indirectly through runoff or leaching from the soil.

Video



http://www.gracelinks.org/1336/water-footprint-concepts-and-definitions

- **Facts :** The production of one kilogramme of beef requires approximately 15 thousand litres of water (93% green, 4% blue, 3% grey water footprint).
- The water footprint of Chinese consumption is about 1070 cubic metres per year per capita. About 10% of the Chinese water footprint falls outside China.
- Japan with a footprint of 1380 cubic metres per year per capita, has about 77% of its total water footprint outside the borders of the country.
- The water footprint of US citizens is 2840 cubic meter per year per capita. About 20% of this water footprint is external. The largest external water footprint of US consumption lies in the Yangtze River Basin, China.
- The global water footprint of humanity in the period 1996-2005 was 9087 billions of cubic meters per year (74% green, 11% blue, 15% grey). Agricultural production contributes 92% to this total footprint.
- Water scarcity affects over 2.7 billion people for at least one month each year.

- **Virtual water - Hoekstra and Chapagain definition -** The volume of freshwater used to produce the product, measured at the place where the product was actually produced

- The water is said to be virtual because once the wheat is grown, the real water used to grow it is no longer actually contained in the wheat. The concept of virtual water helps us realize how much water is needed to produce different goods and services.

- In semi-arid and arid areas, knowing the virtual water value of a good or service can be useful towards determining how best to use the scarce water available

- Virtual water trade - refers to the hidden flow of water if food or other commodities are traded from one place to another.

m^3/ton

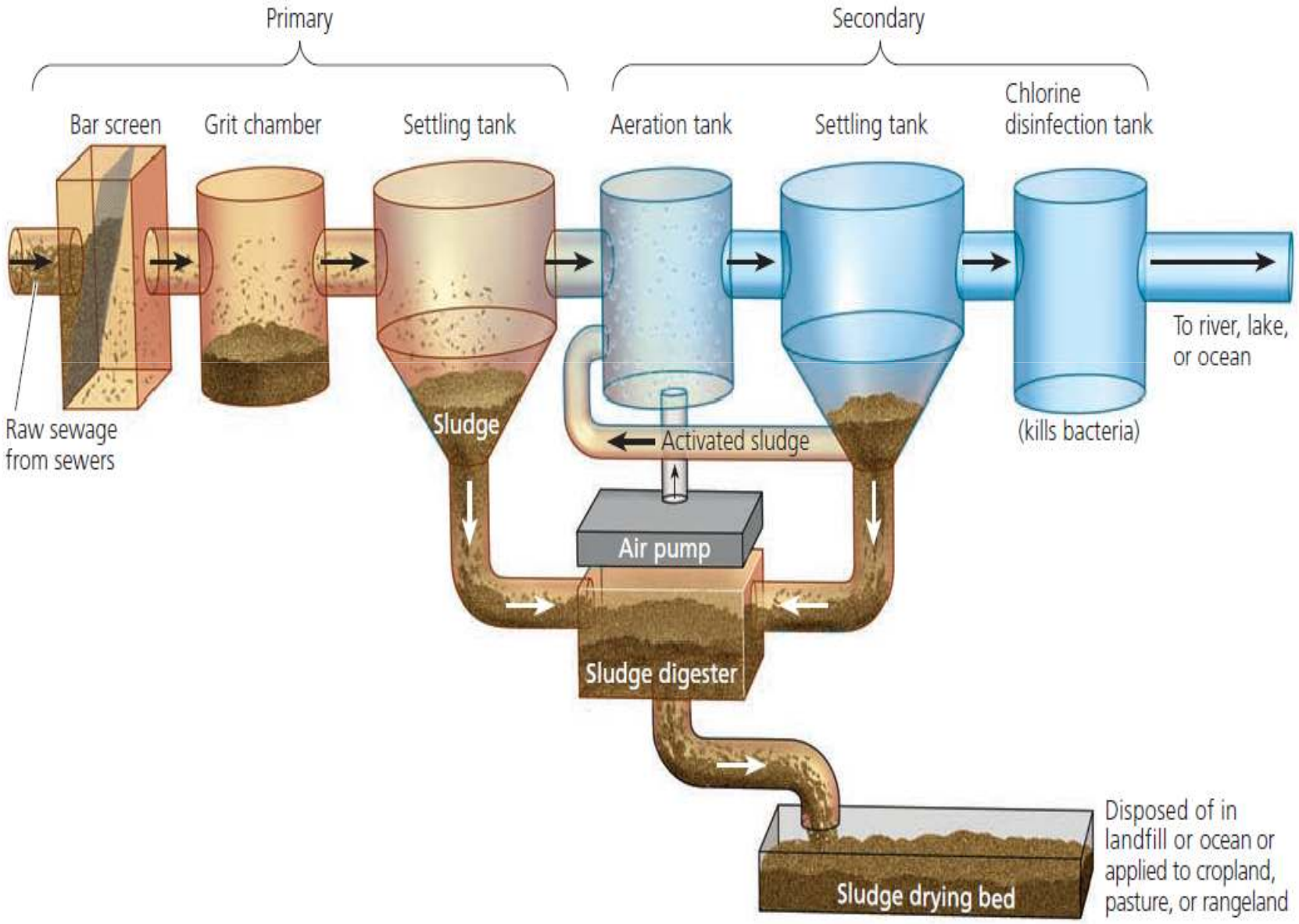
wiki

Product	USA	China	India	Russia	Indonesia	Australia	Brazil	Japan	Mexico	Italy	Netherlands	World average
Cotton lint	5,733	3,210	18,694		10,072	4,268	6,261		4,812			8,242
Leather (bovine)	14,190	13,513	17,710	22,575	15,929	18,384	18,222	11,864	40,482	22,724	12,572	16,656
Beef	13,193	12,560	16,482	21,028	14,818	17,112	16,961	11,019	37,762	21,167	11,681	15,497
Coffee (roasted)	5,790	7,488	14,500		21,030		16,633		33,475			20,682
Coffee (green)	4,864	6,290	12,180		17,665		13,972		28,119			17,373
Cotton seed	2,535	1,419	8,264		4,453	1,887	2,777		2,127			3,644
Chicken meat	2,389	3,652	7,736	5,763	5,549	2,914	3,913	2,977	5,013	2,198	2,222	3,918
Eggs	1,510	3,550	7,531	4,919	5,400	1,844	3,337	1,844	4,277	1,389	1,404	3,340
Tea (made)		11,110	7,002	3,002	9,474		6,592	4,940				9,205
Cheese	3,457	4,968	6,793	6,671	5,675	4,544	4,969	4,032	11,805	4,278	3,190	4,914
Sheep meat	5,977	5,202	6,692	7,621	5,956	6,947	6,267	3,571	16,878	7,572	5,298	6,143
Milk powder	3,234	4,648	6,368	6,253	5,317	4,255	4,654	3,774	11,077	4,005	2,982	4,602
Goat meat	3,082	3,994	5,187	5,290	4,543	3,839	4,175	2,560	10,252	4,180	2,791	4,043
Pork	3,946	2,211	4,397	6,947	3,938	5,909	4,818	4,962	6,559	6,377	3,790	4,856
Rice (broken)	1,903	1,972	4,254	3,584	3,209	1,525	4,600	1,822	3,257	2,506		3,419
Soybeans	1,869	2,617	4,124	3,933	2,030	2,106	1,076	2,326	3,177	1,506		1,789
Sorghum	782	863	4,053	2,382		1,081	1,609		1,212	582		2,853
Rice (husked)	1,656	1,716	3,702	3,118	2,793	1,327	4,003	1,586	2,834	2,180		2,975
Millet	2,143	1,863	3,269	2,892		1,951		3,100	4,534			4,596
Rice (paddy)	1,275	1,321	2,850	2,401	2,150	1,022	3,082	1,221	2,182	1,679		2,291
Coconuts		749	2,255		2,071		1,590		1,954			2,545
Barley	702	848	1,966	2,359		1,425	1,373	697	2,120	1,822	718	1,388

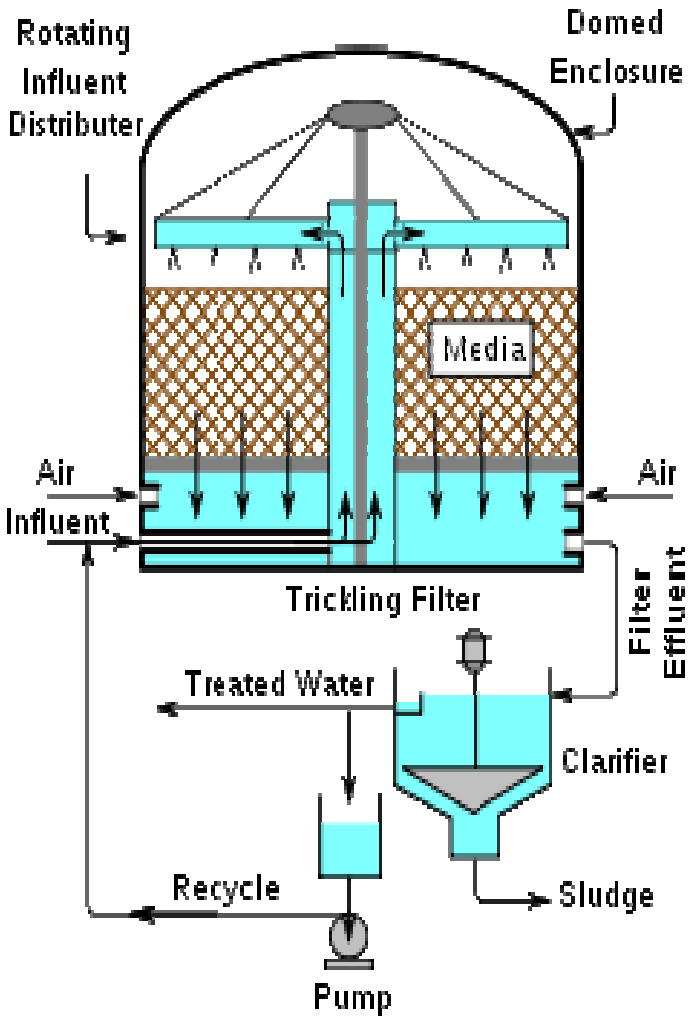
Waste water treatment

- To reduce solids, BOD, COD, nitrates and phosphates to permissible levels
- To reduce organic/inorganic substance, nutrients, toxic substances, kill pathogens etc.
- Primary treatment
  - Large particles removal with a screen.
  - Grit chamber treatment – sand settle down
  - Sedimentation tank – suspended solids settle by gravity, chemically treated polymers
  - 35% BOD and 60% suspended solids removed

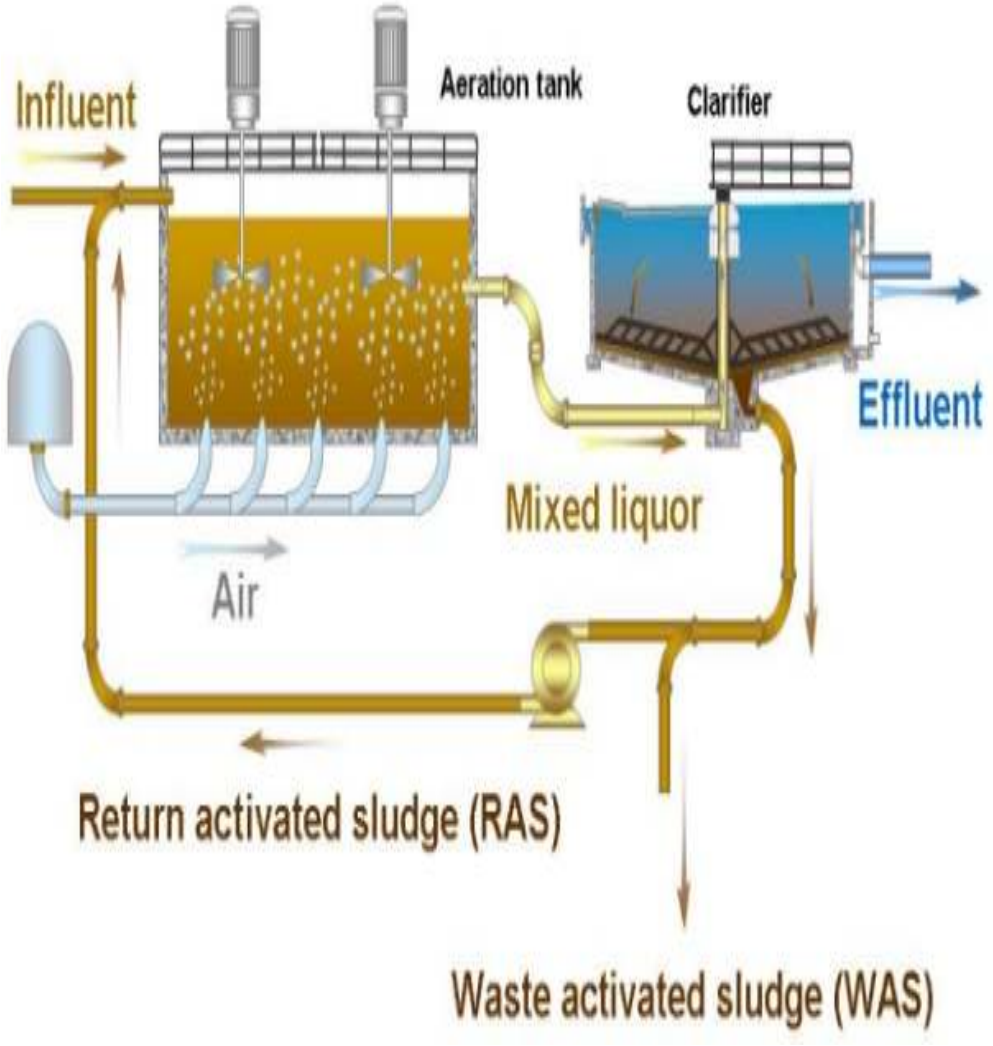
Flow Chart


Primary
Secondary
Bar screen
Grit chamber
Settling tank
Aeration tank
Settling tank
Chlorine disinfection tank
To river, lake, or ocean
Raw sewage from sewers
Sludge
Activated sludge
(kills bacteria)
Air pump
Sludge digester
Sludge drying bed
Disposed of in landfill or ocean or applied to cropland, pasture, or rangeland

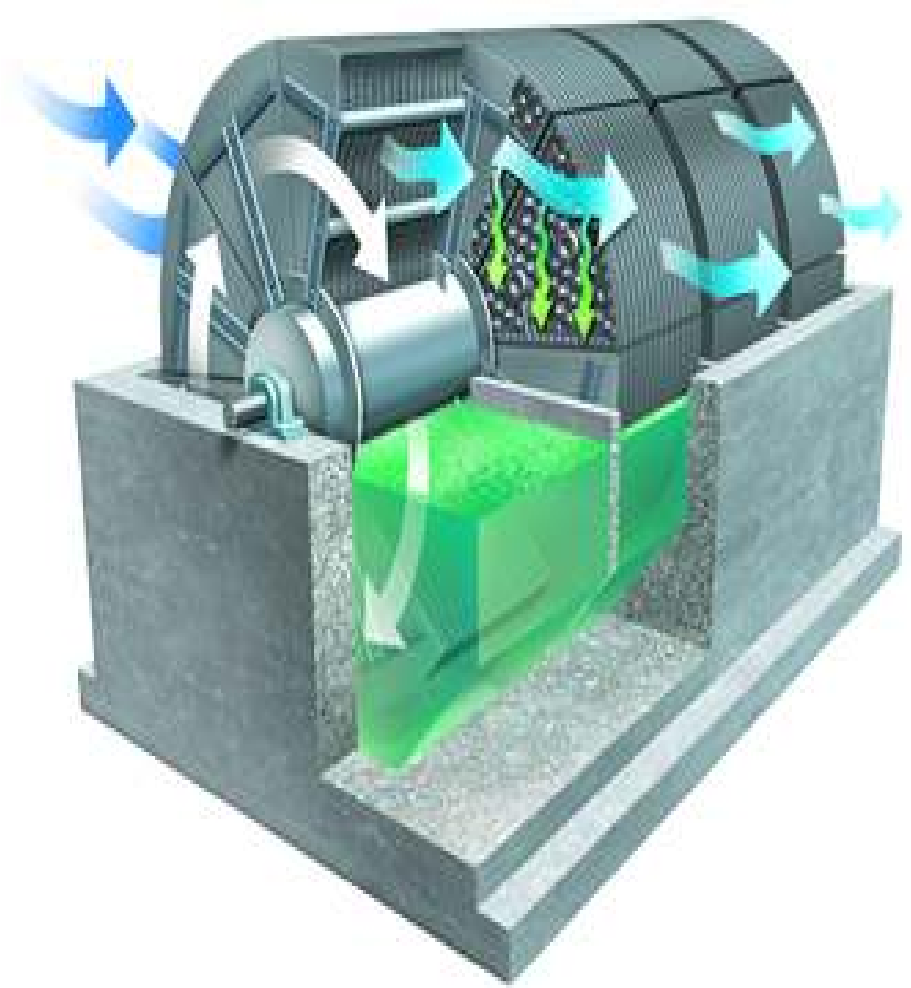
- Secondary treatment – biological process involving micro organisms – 90% BOD, suspended solids removed
  - Trickling filters
    - Bed of crushed stones (with slime) + aerobic bacteria, protozoa, algae, fungi, worms etc. – degraded sewage collected at the bottom – better organic matter removal



- Activated sludge process
  - Aeration and micro organisms (bacteria and protozoa) — oxygen pumped – few hours agitation – waste to settle in bottom in secondary settling tank – sludge produced, dewatered and disposed off – used for landfills, croplands, pastures, etc.



- Rotating Biological Contactor (RBC)
  - Circular plastic discs with microorganism growth – 40% disc area submerged wastewater tank – absorb organic water when in and oxygen when out – high degree of organic matter removal achieved

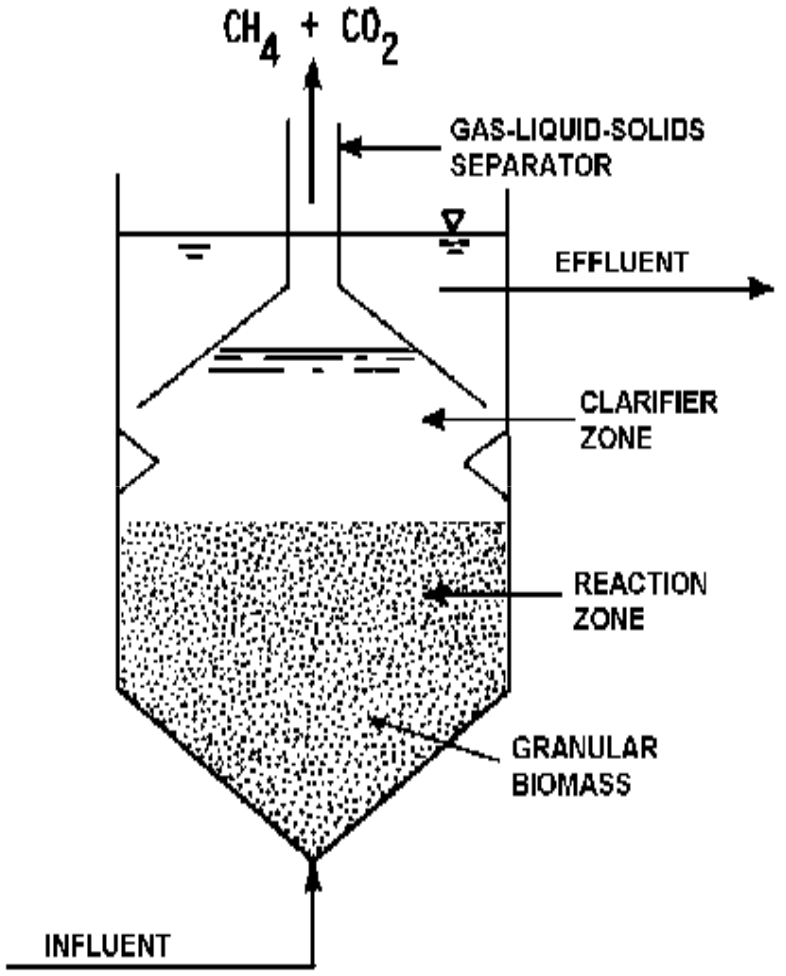


Advanced sewage treatment

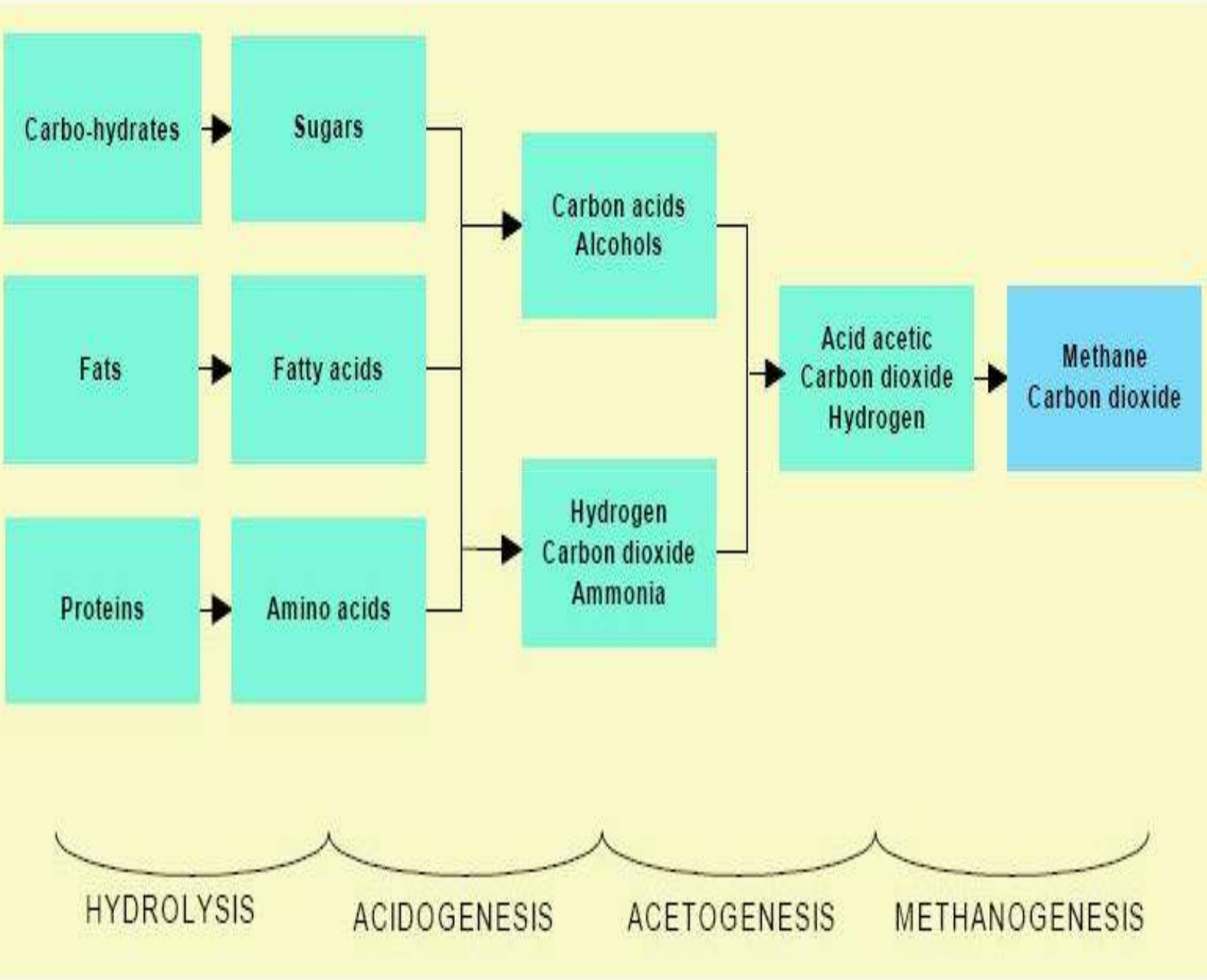
- Removal of substances remaining after primary and secondary treatments
- Nitrates, phosphates, bacteria, viruses, pesticides, toxic metals etc. removal
- Chlorination – kill harmful bacteria
- UV light, ozone treatment – other methods
- Sludge – fertilizer
- Untreated substance leach to the ground water – build up in food chain

Upflow anaerobic sludge blanket (UASB) reactor

- Four stages of anaerobic digestion
  - Hydrolysis – polymers to monomers
  - Acidogenesis – monomers to fatty acids, CO_2, H_2
  - Acetogenisis – fatty acids to acetates
  - Methanogenesis – acetates to methane and CO_2
- Granular anaerobic biomass – convert organic compounds
- Biogas collected at the top
- H_2, CO_2, CH_4, acetate, new cell-matter etc.
- COD removal upto 80% achieved



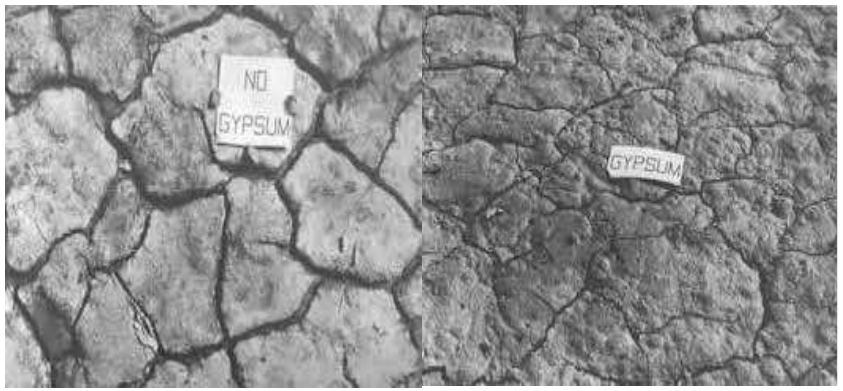
UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR


Carbo-hydrates
Sugars
Fats
Fatty acids
Proteins
Amino acids
Carbon acids
Alcohols
Hydrogen
Carbon dioxide
Ammonia
Acid acetic
Carbon dioxide
Hydrogen
Methane
Carbon dioxide
HYDROLYSIS
ACIDOGENESIS
ACETOGENESIS
METHANOGENESIS

Water Conservation

- Water a precious natural resources
- Water conservation practices
  - Decreasing run-off losses
  - Reducing evaporation losses
  - Storing in soil
  - Reducing irrigation losses
  - Reuse of water
  - Prevention wastage of water
  - Increasing block pricing

Agricultural practices



- Decreasing run-off losses
  - Contour farming
  - Terrace farming
  - Water spreading - channeling or lagoon
  - Chemical wetting agents (surfactants)- increases water intake rates
  - Surface crop residues – Tillage, mulch, animal residue reduce run-off by allowing more time for water to penetrate into the land
  - Chemical conditioners – Gypsum ($CaSO_4.2H_2O$), hydrolyzed polyacrylonitrile improve soil permeability and reduce run-off of sodic soil
  - Water-storage structures – farm ponds, dug-outs etc.

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- Reducing evaporation losses:
  - Effective for sandy soil - horizontal barriers of asphalt placed below the soil surface increase water availability and increase crop yield by 35-40%.
  - Effective for sandy soil - copolymer of starch and acrylonitrile called '*super slurper*' absorb water up to 1400 times its weight.
- Storing water in soil:
  - Standing water on soil for one season can be made available for next season.

- Reducing irrigation losses:
  - Lined or covered canals to reduce seepage
  - Irrigation in morning or evening to reduce evaporation losses
  - Sprinkling and drip irrigation conserve water by 30-50%
  - Growing less water consuming hybrid crop
- Re-use of water:
  - Treated wastewater can be used for fertigation
  - Using grey water from washing and bath-tubs for watering gardens and washing cars.
- Preventing wastage of water:
  - Closing taps when not in use
  - Repairing any leakage from pipes
  - Using small capacity flush in toilets
- Increasing block pricing:
  - Water tax

Watershed Management

- Watershed – delineated area with a well-defined topographic boundary and one water outlet.
  - Complex interactions of soil, landform, vegetation, land use activities and water
  - Humans and animals – integral part.
  - Sustained food production, water supply for irrigation, power generation etc. (1949-first watershed management by Damodar Valley corporation

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- Watershed degradation
  - Uncontrolled, unplanned and unscientific land use activities (ex-overgrazing, deforestation, mining, industrialization, shifting cultivation, soil erosion etc.)
- Watershed Management - Rational utilization of natural resources for optimum production causing minimum damage
  - Objectives
    - Rehabilitate watershed through proper land use
    - Beneficial developmental activities – domestic water supply, irrigation, hydropower generation etc.
    - Minimize risks of floods, droughts and landslides
    - Develop rural areas with clear plans for economy improvement

Watershed management practices

- Water harvesting – proper storage of water for use in dry seasons, helps moderation of floods
- Afforestation and agroforestry – prevent soil erosion
- Mechanical measures to reduce soil erosion and runoffs – no-till farming, terracing, contour cropping, strip cropping etc,
- Scientific mining and quarrying – to minimize destructive effects of mining – hills lose stability lead to landslides – Contour trenching 1 m intervals, soil binding plants like Ipomoea and vitex
- Public participation – people's involvement is key – proper education and incentives – effective participation
- Himalayan region vital – several anthropogenic activities accelerate slope instability – prevent overgrazing, terracing, contour farming etc.

Blue Revolution

- Remarkable emergence of aquaculture as an important and highly productive agricultural activity - all forms of active culturing of aquatic animals and plants, occurring in marine, brackish, or fresh waters.
- Focused development and management of the fisheries sector to increase both fish production and fish productivity from aquaculture and fisheries resources marine fisheries sector
- The scheme has the following components (GoI):
  - National Fisheries Development Board (NFDB) and its activities.
  - Development of Inland Fisheries and Aquaculture.
  - Development of Marine Fisheries, Infrastructure and Post-Harvest Operations.
  - Strengthening of Database & Geographical Information System of the Fisheries Sector.
  - Institutional Arrangement for Fisheries Sector.
  - Monitoring, Control and Surveillance (MCS) and other need-based Interventions.
  - National Scheme on Welfare of Fishermen.

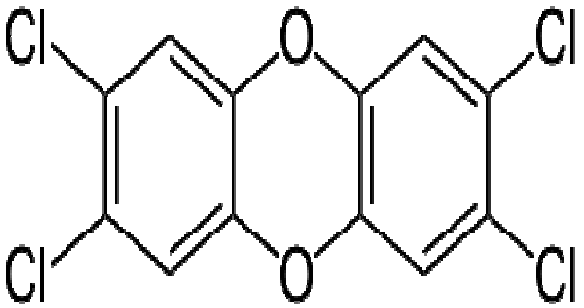
Solid Waste Management

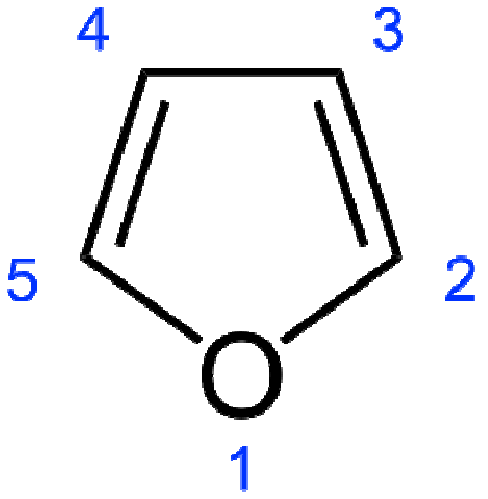
- Population increase – waste increase
  - Indiscriminate generation – beyond rectification
- Minimize adverse effects - management of solid waste
- Solid waste can be divided into two types. One type is industrial solid waste produced by mines, farms, and industries that supply people with goods and services. The other is municipal solid waste (MSW), often called *garbage or trash, which consists of the combined* solid waste produced by homes and workplaces
- Sources
  - Domestic – polyethylene bags, empty metal cans, glass bottles, waste papers, cloth etc.
  - Shops – packaging material, egg shells, tea leaves, etc.
  - Biomedical – anatomical, pathological, infectious wastes etc.
  - Construction/demolition – debris, rubble, wood, concrete etc.
  - Horticulture/slaughter house – vegetable parts, remains of slaughtered animals

- Biodegradable – decomposed by micro-organisms. Ex. Vegetable wastes etc.
- Non-biodegradable – cannot be decomposed, ex. Polyethylene bags, scrap metal, glass etc.
- Industrial wastes
  - Chemical industries – organic, acids, alkalis, etc.
  - Metal and mineral processing industries – hazardous and toxic materials
  - Thermal power plants – fly ash
  - Nuclear power plants – radio active wastes
  - Others – rubber, plastic, paper, glass, wood, oils, paints, asbestos, batteries etc.
  - Disposal problem in developed countries

Effects

- Insect breed on biodegradable wastes – foul smell
- Industrial wastes – changes biological and physicochemical characteristics of soil, percolation contaminate ground water
- Separation of wastes difficult - burning produce dioxins, furans and polychlorinated biphenyls - cancer

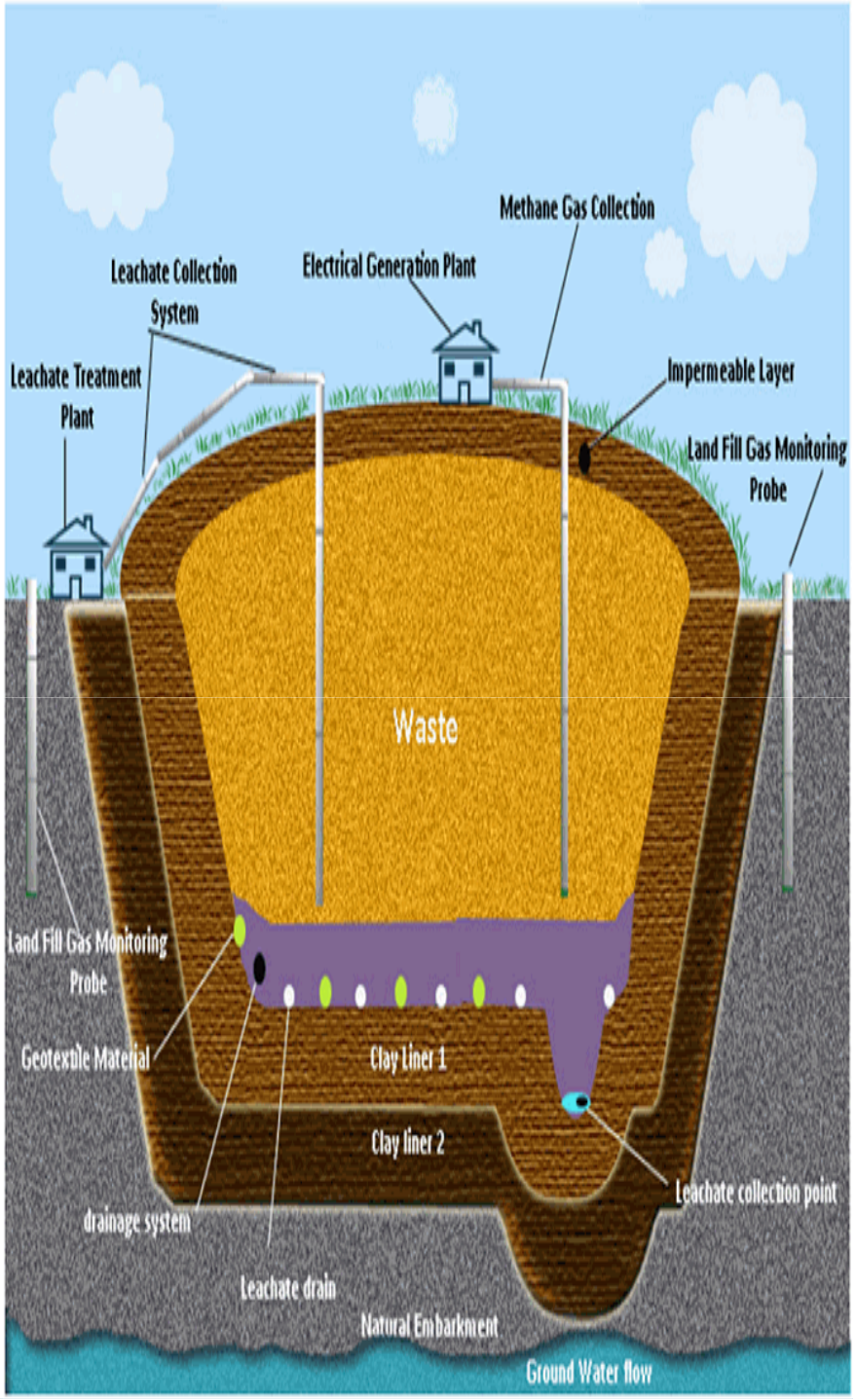




Management

- Reduce use of raw materials – metal cans
- Reuse of waste materials – waste paper, rubber, refillable containers
- Recycling of materials –
  - Old - metals, glass melted, recast into new useful products
  - New - cellulose insulation from paper, fuel pellets from kitchen waste etc
- 3R's save money, energy, land space, pollution

- Discarding wastes
  - Sanitary landfills – garbage spread as thin layers – completely covered to avoid percolation – methane gas for heat/electricity
  - Composting – biodegradable waste decompose in oxygen rich medium – manure
  - Incineration - burning at high temperatures – removal of batteries, plastics etc, – reduce dioxins. PCB's

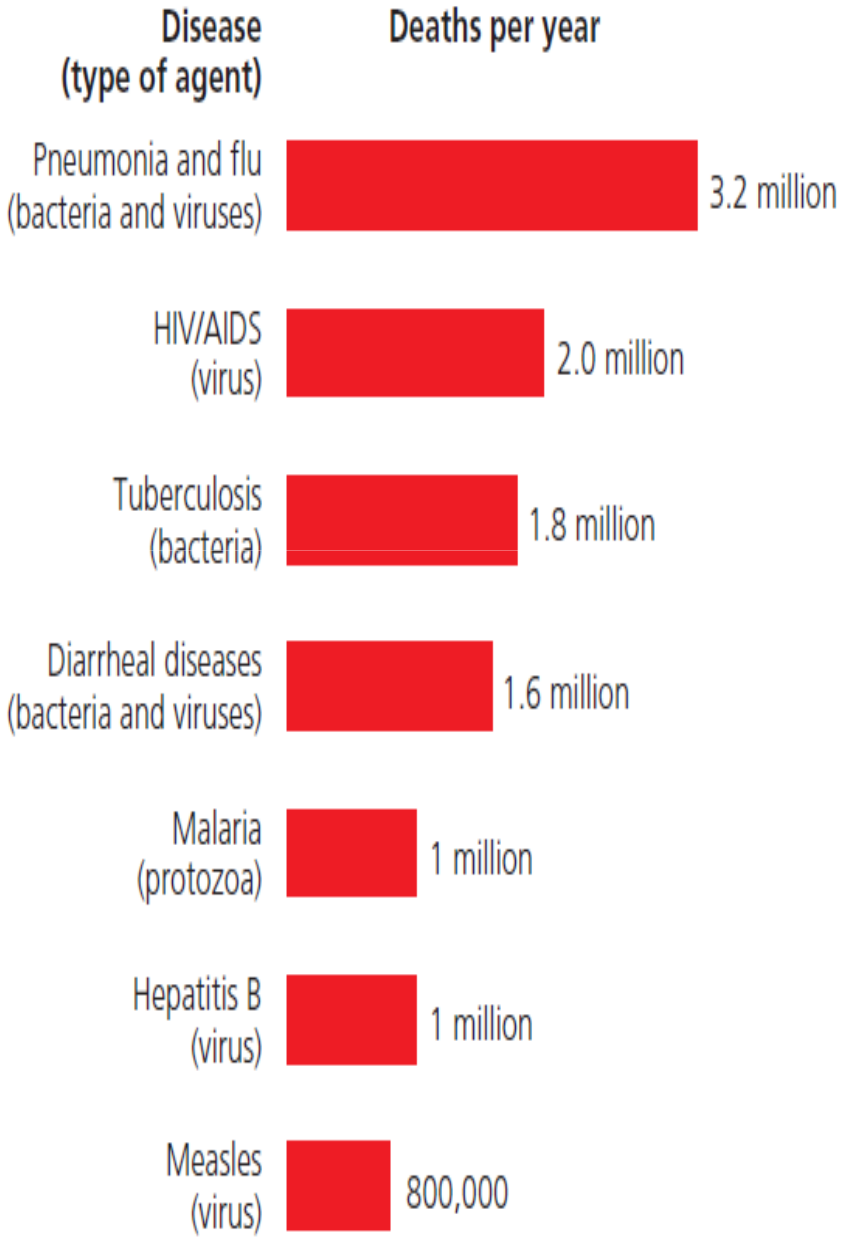


Environmental hazards

- Five major hazards – Biological, physical, chemical, cultural, lifestyle choices
- Biological hazards from more than 1,400 pathogens that can infect humans. Examples are bacteria, viruses, parasites, protozoa, and fungi.
- Chemical hazards from harmful chemicals in air, water, soil, food, and human-made products
- Nuclear hazard : harmful radiations from nuclear sources

Biological hazards

- Infectious – tuberculosis, flu, measles, AIDS etc.
- Non-infectious - diabetes, heart diseases, cancers etc.
- Viral diseases and parasites kill large numbers of people – flue, HIV, TB, *hepatitis B virus*
- More than half of all infectious diseases throughout history transmitted to humans from wild or domesticated animals. Eg. Avian flu, HIV/AIDS, and West Nile virus - *ecological medicine*
- *Parasites – malaria*
- *Exercise hygene*



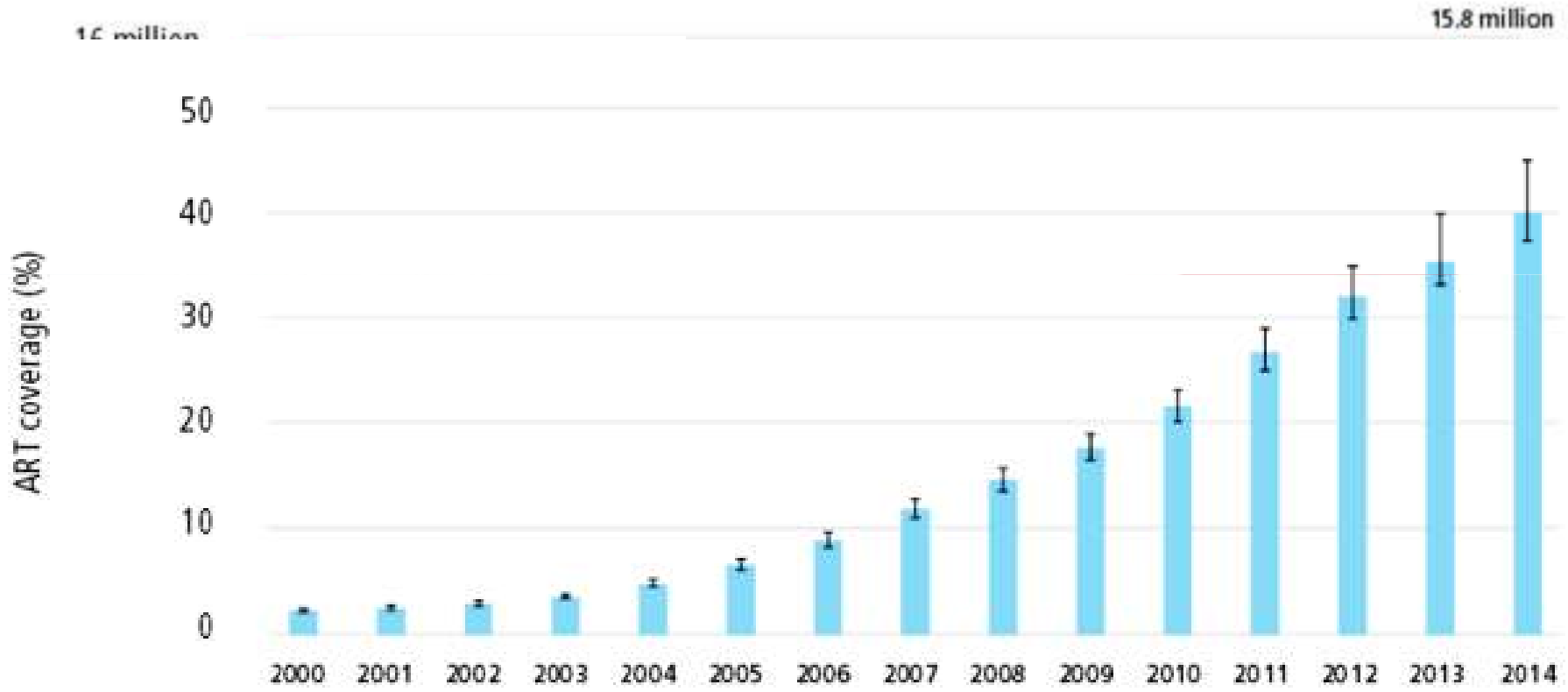
The Global HIV/AIDS Epidemic

- The global spread of *acquired immune deficiency syndrome (AIDS)*, caused by infection with the *human immunodeficiency virus (HIV)*, is a major global health threat.
- The virus itself is not deadly, but it cripples the immune system and leaves the body vulnerable to infections such as tuberculosis (TB).
- Transmitted from one person to another by unsafe sex, sharing of needles by drug users, infected mothers who pass the virus on to their offspring before or during birth, and exposure to infected blood
- People with AIDS are 30 to 50 times more likely to develop active TB. The WHO reported in 2009 that one of every four deaths from TB was an AIDS victim.
- The second biggest viral killer is the human immunodeficiency virus (HIV). On a global scale, HIV infects about 2.5 million people each year, and the complications resulting from AIDS kill about 2 million people annually.
- Since the HIV virus was identified in 1981, this viral infection has spread around the globe. According to the WHO, in 2008, a total of about 33 million people worldwide (more than 1 million in the United States) were living with HIV.
- About 72% of them were in African countries located south of the Sahara Desert (sub-Saharan Africa) - In 2008 there were about 2.7 million new cases of AIDS—an average of about 7,400 new cases per day—half of them in people between the ages of 15 and 24

- Treatment that includes combinations of expensive antiviral drugs can slow the progress of AIDS, but they are expensive.
- With such drugs, a person with AIDS, on average, can expect to live about 24 years after being infected at a cost of about $25,200 a year.
- Such drugs cost too much for most AIDS victims living in less-developed countries where AIDS infections are widespread.
- It takes an average of 10 to 11 years for an HIV infection to progress to AIDS for people who do not take such antiviral drugs - long incubation period means that infected people often spread the virus for a number of years without knowing they are infected.
- Currently, there is no cure for HIV or AIDS. Those who get AIDS will almost certainly die from it, unless something else kills them.
- The premature deaths of teachers, health-care workers, soldiers, and other young, productive adults affect the population age structures in African countries such as Botswana
- These deaths also lead to diminished education and health care, decreased food production and economic development, and the disintegration of families.

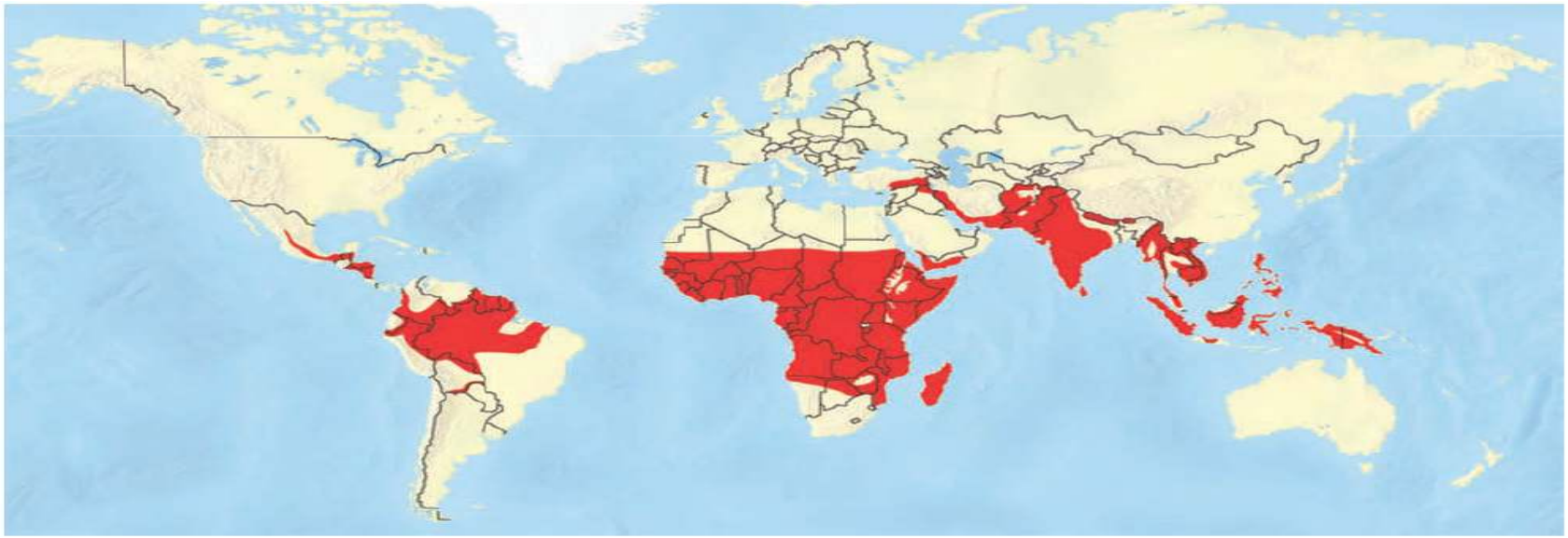
HIV/AIDS

Estimated numbers of people receiving antiretroviral therapy globally and by WHO Region and percentage coverage globally, 2000–2015



Malaria

- *Over the course of human history, malarial protozoa probably have killed more people than all the wars ever fought*
- Caused by a parasite that is spread by the bites of certain types of mosquitoes - It infects and destroys red blood cells, causing intense fever, chills, drenching sweats, severe abdominal pain, vomiting, headaches, and increased susceptibility to other diseases.



Global outlook:â•‡ About 40% of the world's population lives in areas in which malaria is prevalent. Malaria kills at least 1 million people a year or about 2 people every minute. More than 80% of these victims live in sub-Saharan Africa and most of them are children younger than age 5. According to the WHO, every 45 seconds, a child in Africa dies of malaria

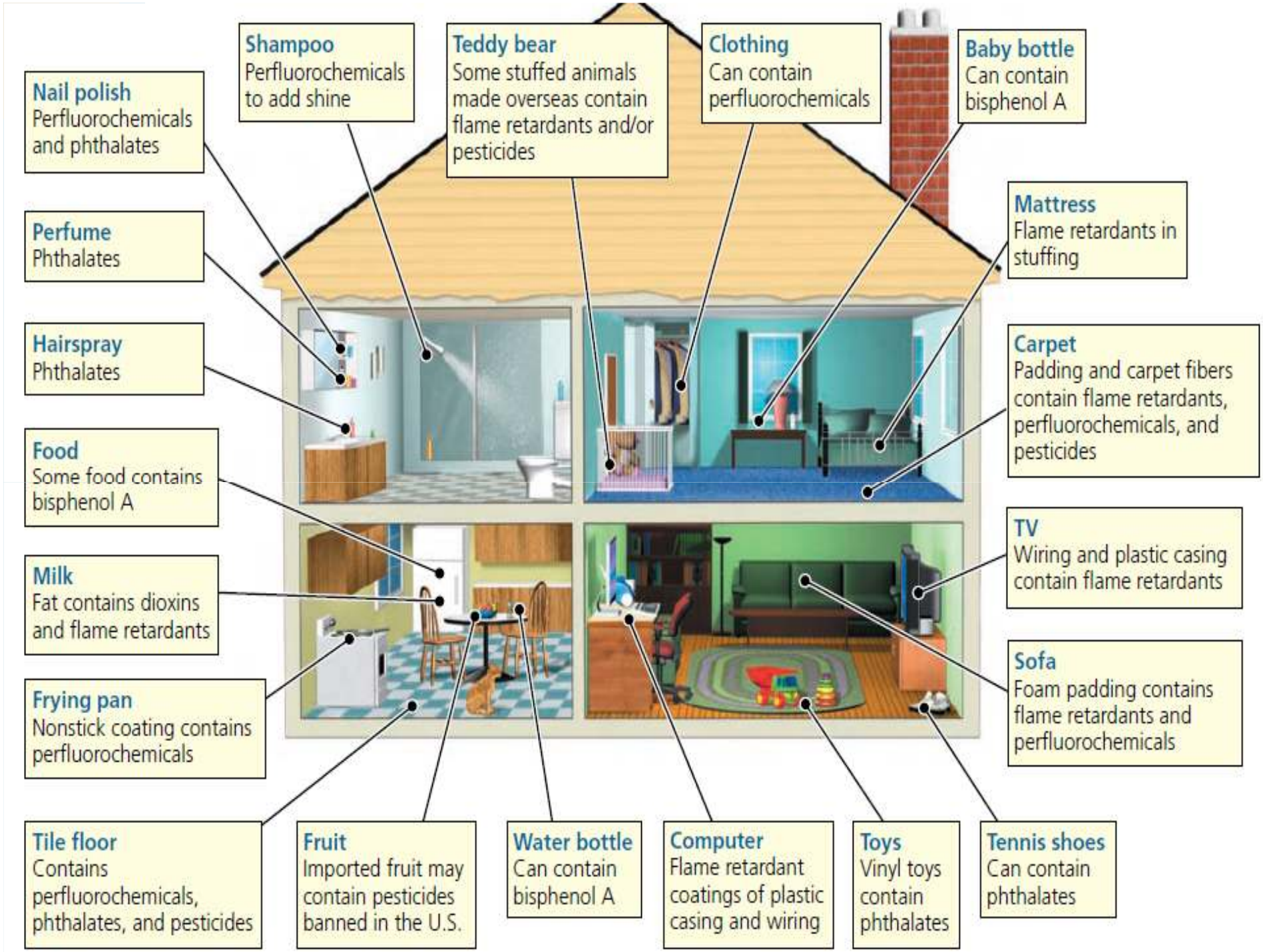
- People with HIV are more vulnerable to malaria, and people with malaria are more vulnerable to HIV
- *Anopheles mosquito* have become genetically resistant to most insecticides. Worse, the *Plasmodium parasites have become* genetically resistant to common antimalarial drugs

Remedy :

- Research on new ways to combat malarial mosquitoes
- To provide poor people in malarial regions with free or inexpensive, long-lasting, insecticide-treated bed nets and window screens
- By spraying the insides of homes with low concentrations of the pesticide DDT twice a year
- Zinc and vitamin A supplements could also be given to children to boost their resistance to malaria

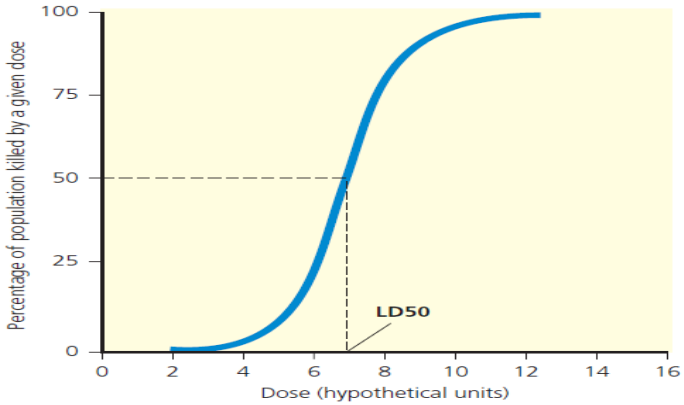
Chemical hazards

- Toxic chemical - can cause temporary or permanent harm or death to humans and animals. Eg. As, Pb, Hg, vinyl chloride (used to make PVC plastics), and polychlorinated biphenyls (PCBs)
  - **Carcinogens -** chemicals, types of radiation, or certain viruses that can cause or promote *cancer Eg.* As, benzene, chloroform, formaldehyde, UV etc.
  - **Mutagens –** cause mutations, or changes, in the DNA molecules found in cells, or that increase the frequency of such changes. Eg. Nitrous acid
  - **Teratogens -** cause harm or birth defects to a fetus or embryo. Eg. benzene, Cd, Pb, Hg
  - Some chemicals may affect our immune, nervous, and endocrine systems – Eg. As, methylmercury, and dioxins, BPA (HAA)


Nail polish
Perfluorochemicals and phthalates
Shampoo
Perfluorochemicals to add shine
Teddy bear
Some stuffed animals made overseas contain flame retardants and/or pesticides
Clothing
Can contain perfluorochemicals
Baby bottle
Can contain bisphenol A
Mattress
Flame retardants in stuffing
Perfume
Phthalates
Hairspray
Phthalates
Carpet
Padding and carpet fibers contain flame retardants, perfluorochemicals, and pesticides
Food
Some food contains bisphenol A
TV
Wiring and plastic casing contain flame retardants
Milk
Fat contains dioxins and flame retardants
Sofa
Foam padding contains flame retardants and perfluorochemicals
Frying pan
Nonstick coating contains perfluorochemicals
Tile floor
Contains perfluorochemicals, phthalates, and pesticides
Fruit
Imported fruit may contain pesticides banned in the U.S.
Water bottle
Can contain bisphenol A
Computer
Flame retardant coatings of plastic casing and wiring
Toys
Vinyl toys contain phthalates
Tennis shoes
Can contain phthalates

Toxicity

- Toxicity is a measure of the harmfulness of a substance – anything above certain limit is a poison
- Children 100 times more at risk than adults
- Pollution prevention - *precautionary principle*
- LD50 – measure of toxicity

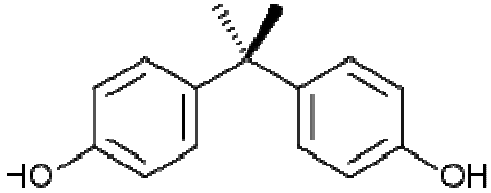


Toxicity Ratings and Average Lethal Doses for Humans

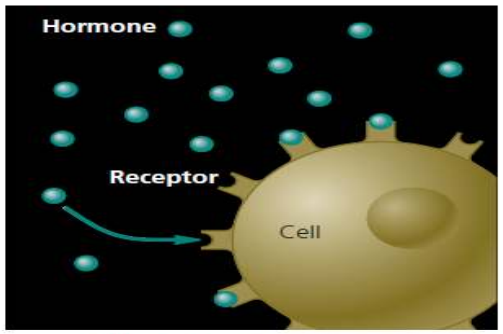
Toxicity Rating	LD50 (milligrams per kilogram of body weight)*	Average Lethal Dose**	Examples
Supertoxic	Less than 5	Less than 7 drops	Nerve gases, botulism toxin, mushroom toxin, dioxin (TCDD)
Extremely toxic	5–50	7 drops to 1 teaspoon	Potassium cyanide, heroin, atropine, parathion, nicotine
Very toxic	50–500	1 teaspoon to 1 ounce	Mercury salts, morphine, codeine
Moderately toxic	500–5,000	1 ounce to 1 pint	Lead salts, DDT, sodium hydroxide, sodium fluoride, sulfuric acid, caffeine, carbon tetrachloride
Slightly toxic	5,000–15,000	1 pint to 1 quart	Ethyl alcohol, Lysol, soaps
Essentially nontoxic	15,000 or greater	More than 1 quart	Water, glycerin, table sugar

*Dosage that kills 50% of individuals exposed.
**Amounts of substances in liquid form at room temperature that are lethal when given to a 70-kilogram (150-pound) human.

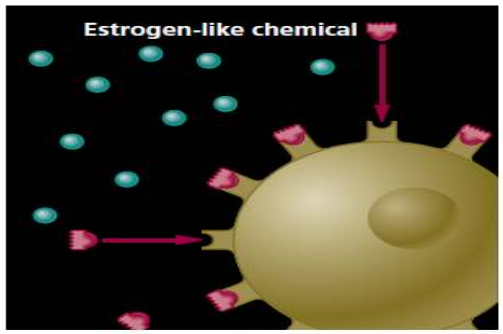
BPA



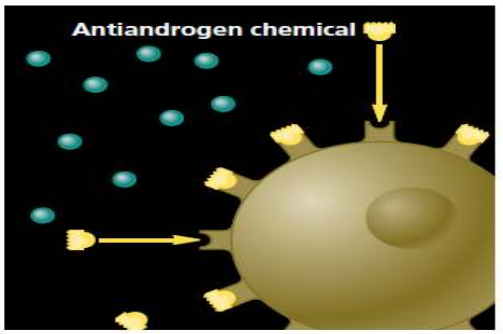
- bisphenol A – (Harmonally Active Agents) owing to shapes similar to those of natural hormones - allows them to attach to molecules of natural hormones and to disrupt the endocrine systems.
- The endocrine system is a complex network of glands that release tiny amounts of hormones into the bloodstreams of humans and other vertebrate animals
- Hormones, the chemical messengers regulate the bodily systems that control sexual reproduction, growth, development, learning ability, and behaviour.
- Each type of hormone has a unique molecular shape that allows it to attach to certain parts of cells called receptors, and to transmit its chemical message



Normal Hormone Process



Hormone Mimic



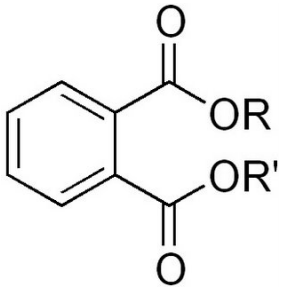
Hormone Blocker

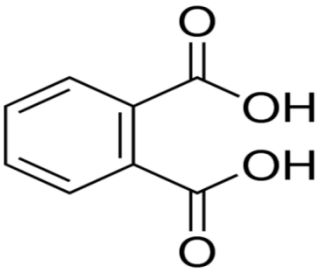
- A widely used estrogen mimic is bisphenol A (BPA). It is a chemical building block in certain hardened plastics (especially shatter-proof polycarbonate) that are used in a variety of products including
- Baby bottles and sipping cups, reusable water bottles, sports drink and juice bottles, microwave dishes, and food storage containers.

Remedy

- Some scientists believe that as a precaution, during this period of research, governments and individual consumers should act to sharply reduce the use of potentially harmful hormone disrupters, especially in products used widely by pregnant women, infants, and young children.
- Consumers now have a choice, since most makers of baby bottles, sipping cups, and sports water bottles offer BPA-free alternatives.
- To avoid BPA contamination, some consumers are also choosing glass bottles and food containers instead of those lined with plastic resins.

Phthalates





- Considered as hormonally active agents (HAAs).
- Sources :
  - These chemicals are used to soften polyvinyl chloride (PVC) plastic found in a variety of products, and they are used as solvents in many consumer products.
  - Phthalates are found in many perfumes, cosmetics, baby powders, body lotions for adults and babies, hair sprays, deodorants, nail polishes, and shampoos for adults and babies.
- Effects:
  - Exposure of laboratory animals to high doses of various phthalates has caused birth defects and liver cancer, kidney and liver damage, immune system suppression, and abnormal sexual development.
- Remedy :
  - As a precautionary measure avoid using materials having phthalates in it.
- More research is needed before banning or severely restricting HAAs, which would cause huge economic losses for companies that make them.

Mercury

- Humans are exposed to mercury in three ways.
  - *First, we may inhale vaporized elemental* mercury (Hg) or particles of inorganic mercury salts such as mercury sulfide (HgS) and mercuric chloride ($HgCl_2$).
  - *Second, we can* eat fish contaminated with highly toxic methylmercury (CH_3Hg^+).
  - The *third way involves* consuming high-fructose corn syrup (HFCS), widely used as a sweetener in beverages and food products.
- Effects: Mercury (Hg) and its compounds are all toxic. Research indicates that long-term exposure to high levels of mercury can permanently damage the human nervous system, kidneys, and lungs. Fairly low levels of mercury can also harm fetuses and cause birth defects
- Sources : In air from rocks, soil, and volcanoes and by vaporization from the ocean - account for about one-third of the mercury reaching the atmosphere each year.
- According to the EPA, the remaining two-thirds come from human activities—primarily from the smokestacks of coal-burning power plants, waste incinerators, cement kilns, and coal-burning industrial facilities. When it rains, these emissions are washed out of the atmosphere onto the soil and into bodies of water

- Under certain conditions in aquatic systems, bacteria can convert inorganic mercury compounds to highly toxic *methylmercury, which can be biologically* magnified in food chains and webs – case study – Minamata disease, Japan 1956

Solutions

Mercury Pollution

Prevention

Phase out waste incineration

Remove mercury from coal before it is burned

Switch from coal to natural gas and renewable energy resources such as wind, solar cells, and hydrogen

Convert coal to liquid or gaseous fuel

Phase out use of mercury in batteries, TVs, compact fluorescent lightbulbs, and all other products unless they are recycled

Control

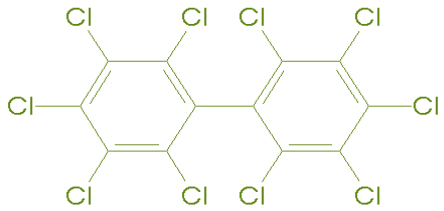
Sharply reduce mercury emissions from coal-burning plants and incinerators

Heavily tax each unit of mercury emitted by coal-burning plants and incinerators

Require labels on all products containing mercury

Collect and recycle mercury-containing electric switches, relays, compact fluorescent lightbulbs, and dry-cell batteries

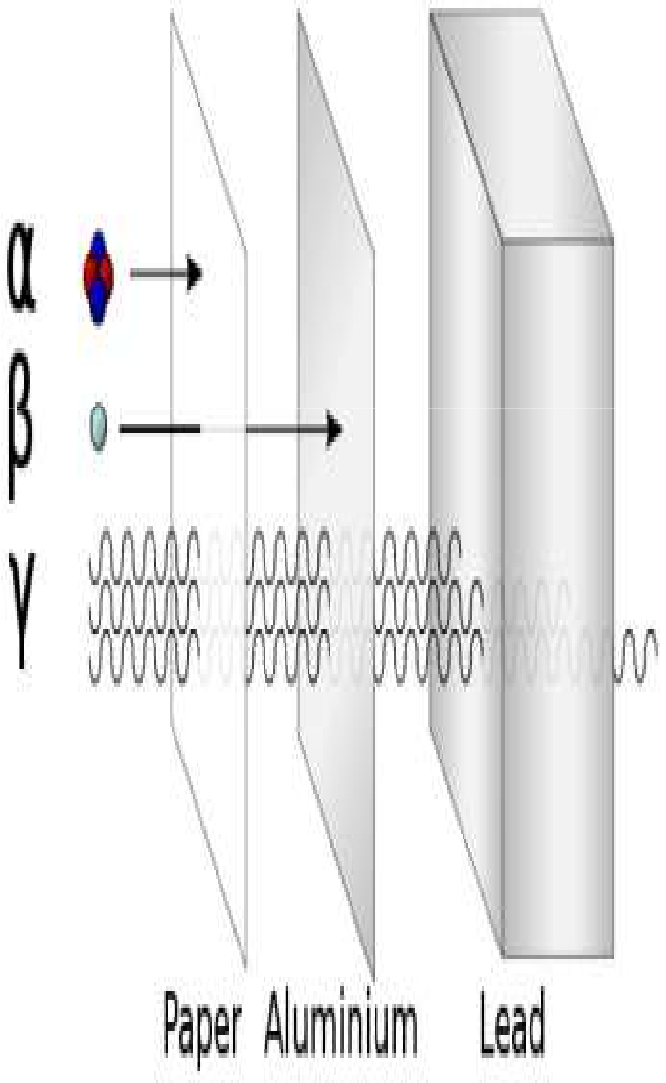
PCB



- PCBs (polychlorinated biphenyls) are a class of more than 200 chlorine-containing organic compounds that are very stable and nonflammable - teratogens
- Sources :
  - Paints, fire retardants in fabrics, preservatives, adhesives, and pesticides
- Effects :
  - Cause liver and other cancers in test animals and, according to the environmental protection agency (EPA), probably can cause cancers in humans.
  - Exposure of foetuses to PCBs in the womb to learning disabilities in children.
- As PCBs breakdown very slowly in the environment, they can travel long distances in the air and be deposited far away from where they were released, they are fat soluble, PCBs can also be biologically magnified in food chains and webs
- PCBs are now found everywhere—in soil, air, lakes, rivers, fish, birds, your body, and the bodies of polar bears & penguins in the Arctic; even in many living organisms

Nuclear hazards

- Radioactive decay - α, β-particles and γ - rays – high speed – variable penetration powers
- Sources
  - Natural – cosmic rays, radon-222, soil, rocks, air, water and food
  - Anthropogenic – nuclear power plants, X-rays, test laboratories etc.
  - Mining of Uranium – crops, water - humans



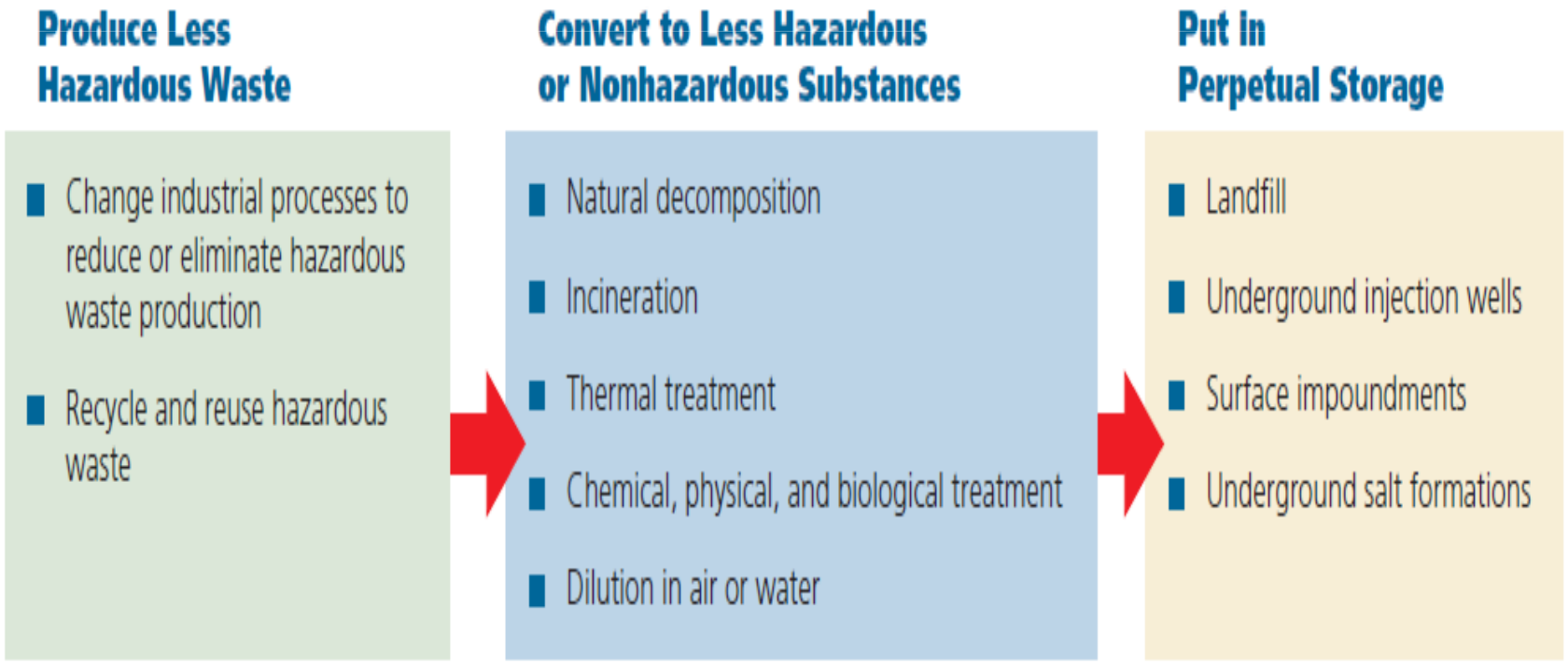
- Effects
  - Genetic damage – mutations in the DNA
  - Somatic damage – burns, miscarriages, eye cataract, cancer
  - Radio active Iodine (I^{131}) cause thyroid cancer, Sr90 – cancer of bone marrow
- Control
  - Siting of nuclear power plants to be done carefully
  - Proper disposal of radioactive laboratory wastes

Hazardous Waste

- Solid waste contributes to pollution and represents the unnecessary consumption of resources; hazardous waste contributes to pollution as well as to natural capital degradation, health problems, and premature deaths
- Eg. Electronic waste, or e-waste, consists of discarded television sets, cell phones, computers, and other electronic devices
- Source of toxic and hazardous pollutants, including polyvinylchloride (PVC), brominated flame retardants, lead, and mercury – contaminate air, water, and soil, and cause serious health problems and early death for e-waste workers
- Most e-waste ends up in landfills and incinerators, even though 80% of the components in these devices contain materials that can be recycled or reused.

Management

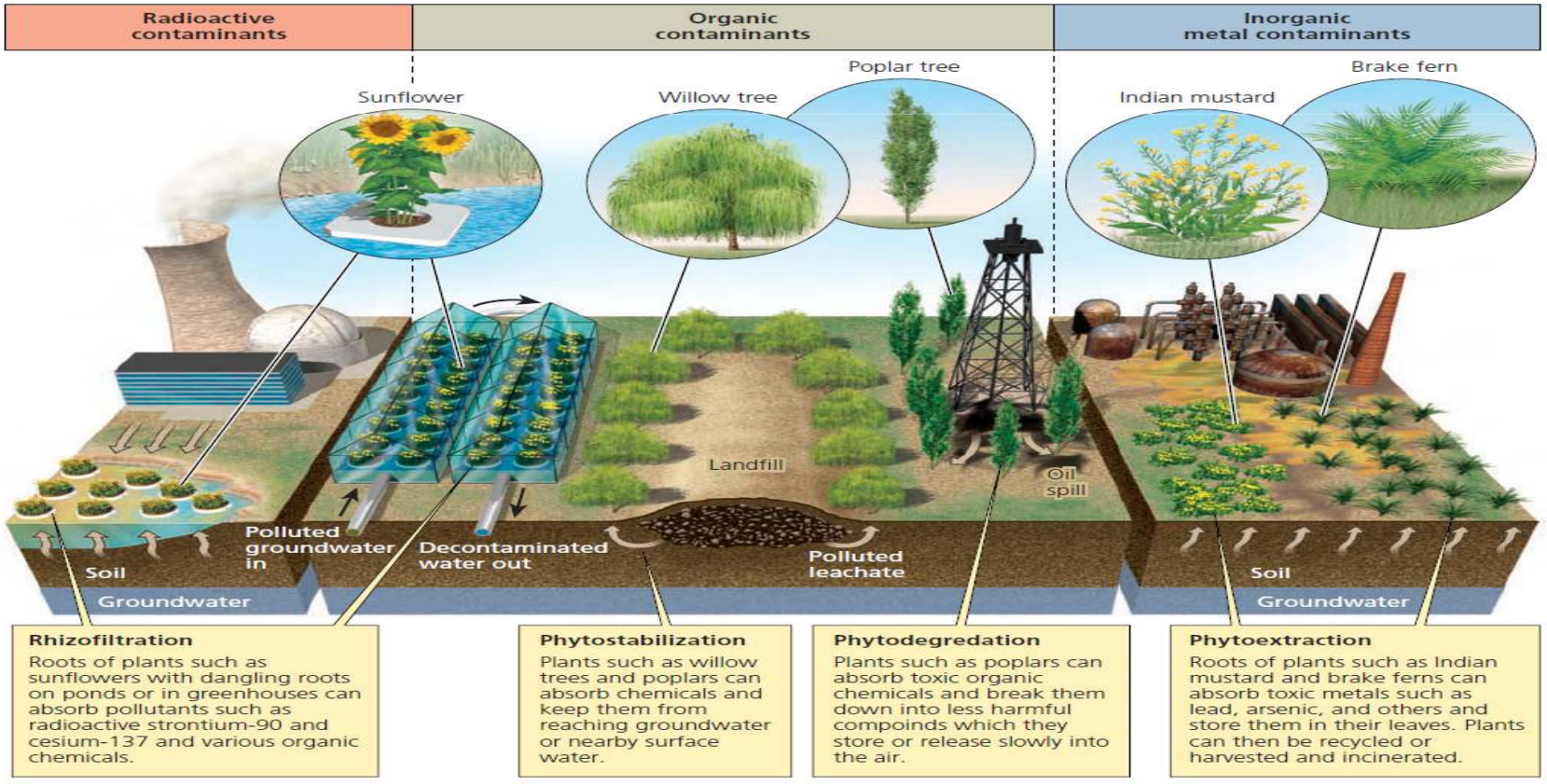
- Sustainable approach to hazardous waste is first to produce less of it, then to reuse or recycle it, then to convert it to less hazardous materials, and finally to safely store what is left
- Integrated Management of Hazardous Waste



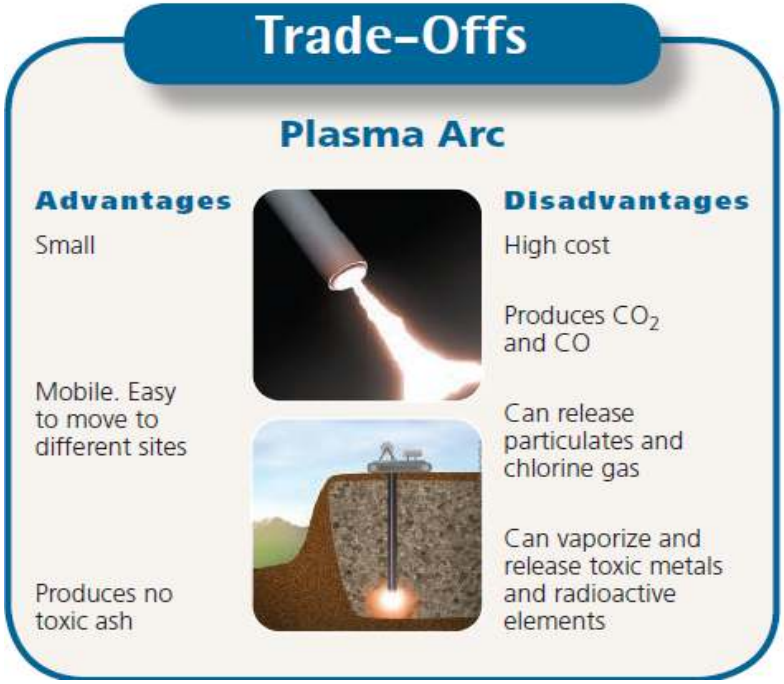
Detoxify Hazardous Wastes

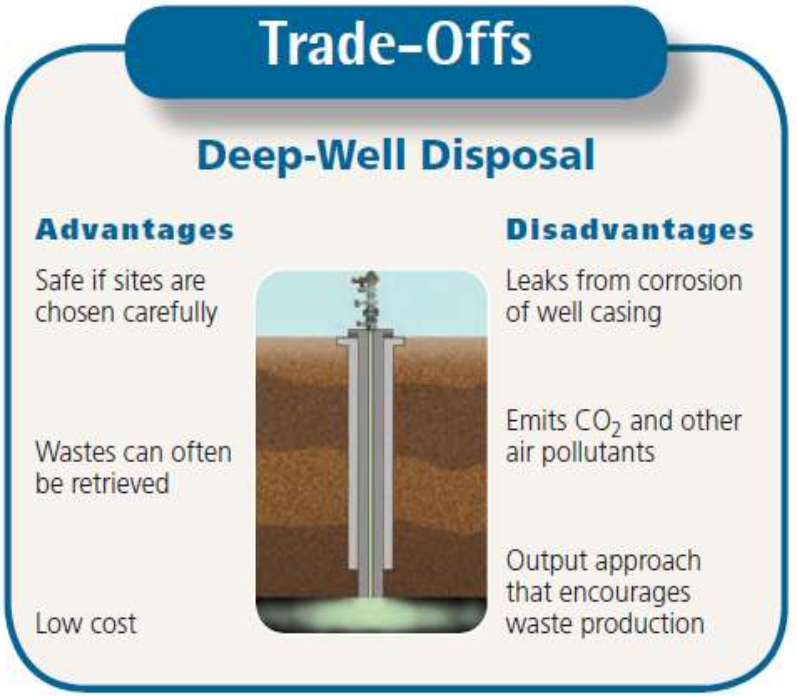
- *Physical methods for detoxifying hazardous wastes* - charcoal or resins are used to filter out harmful solids, distilling liquid wastes to separate out harmful chemicals, and precipitating, or allowing natural processes to separate, such chemicals from solution.
- *Chemical methods are used to convert hazardous* chemicals to harmless or less harmful chemicals through chemical reactions. *cyclodextrin—a type of sugar made from cornstarch— used to* remove toxic materials such as solvents and pesticides from contaminated soil and groundwater. To clean up a site contaminated by hazardous chemicals, a solution of cyclodextrin is applied
- *Nanomagnets, magnetic* nanoparticles coated with certain compounds that can remove various pollutants from water. For example, magnetic nanoparticles coated with chitosan, used to remove oil and other organic pollutants from contaminated water

- **Biological methods** – *bioremediation* - bacteria and enzymes help to destroy toxic or hazardous substances, or convert them to harmless compounds - a contaminated site is inoculated with an army of microorganisms that breakdown specific hazardous chemicals, such as certain organic solvents, PCBs, pesticides, and oil, leaving behind harmless substances such as water and water-soluble chloride salts.
- *Phytoremediation* involves using natural or genetically engineered plants to absorb, filter, and remove contaminants from polluted soil and water – slow process

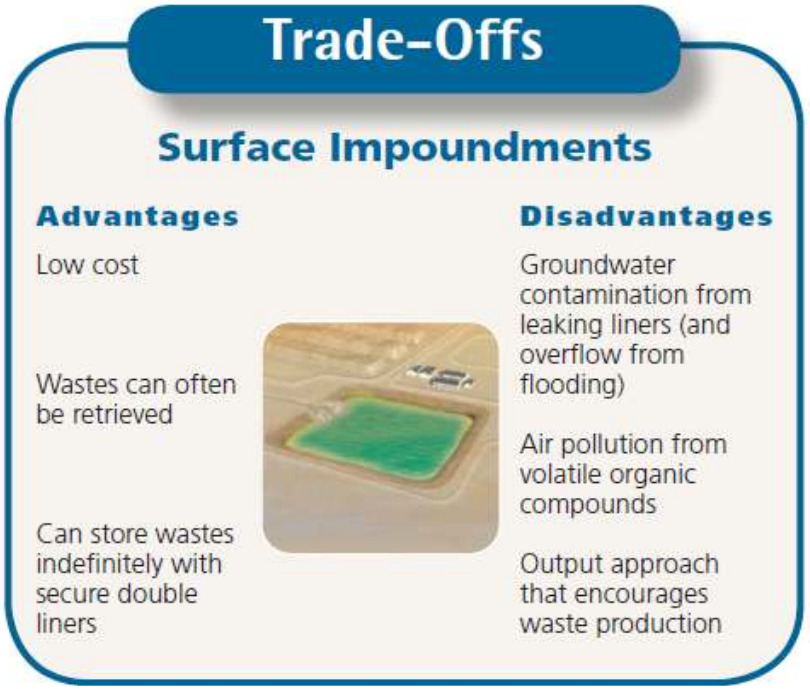


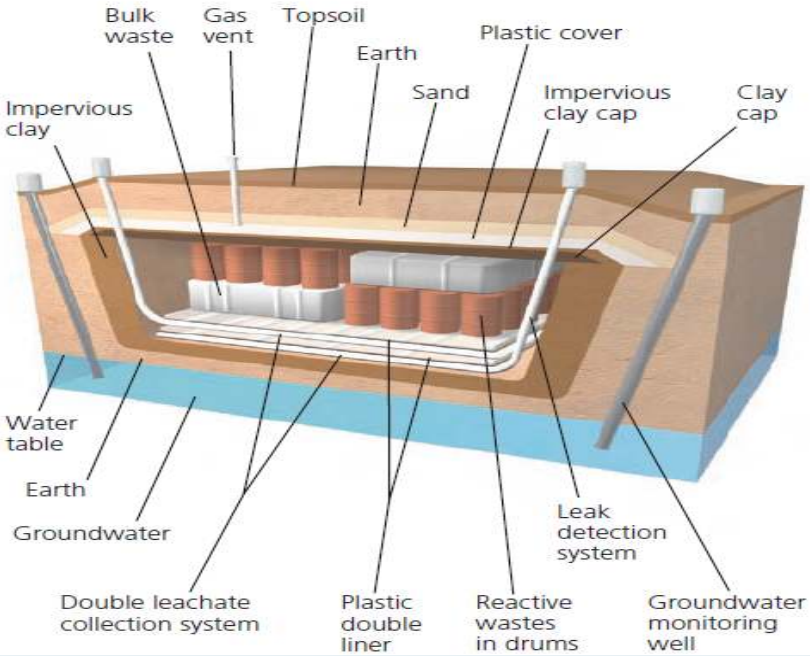
- Detoxify hazardous waste using plasma arc torch, which breaks them down at very high temps.
- Waste converted to CO & hydrogen and a glassy solid material that can be used to encapsulate toxic metals from leaching into ground water
- Deep-well Disposal : Liquid hazardous wastes are pumped under pressure through a pipe into dry, porous rock formation far beneath aquifers.
- Advantages : low cost, wastes can be retrieved
- Disadvantages : emits CO_2 and other air pollutants





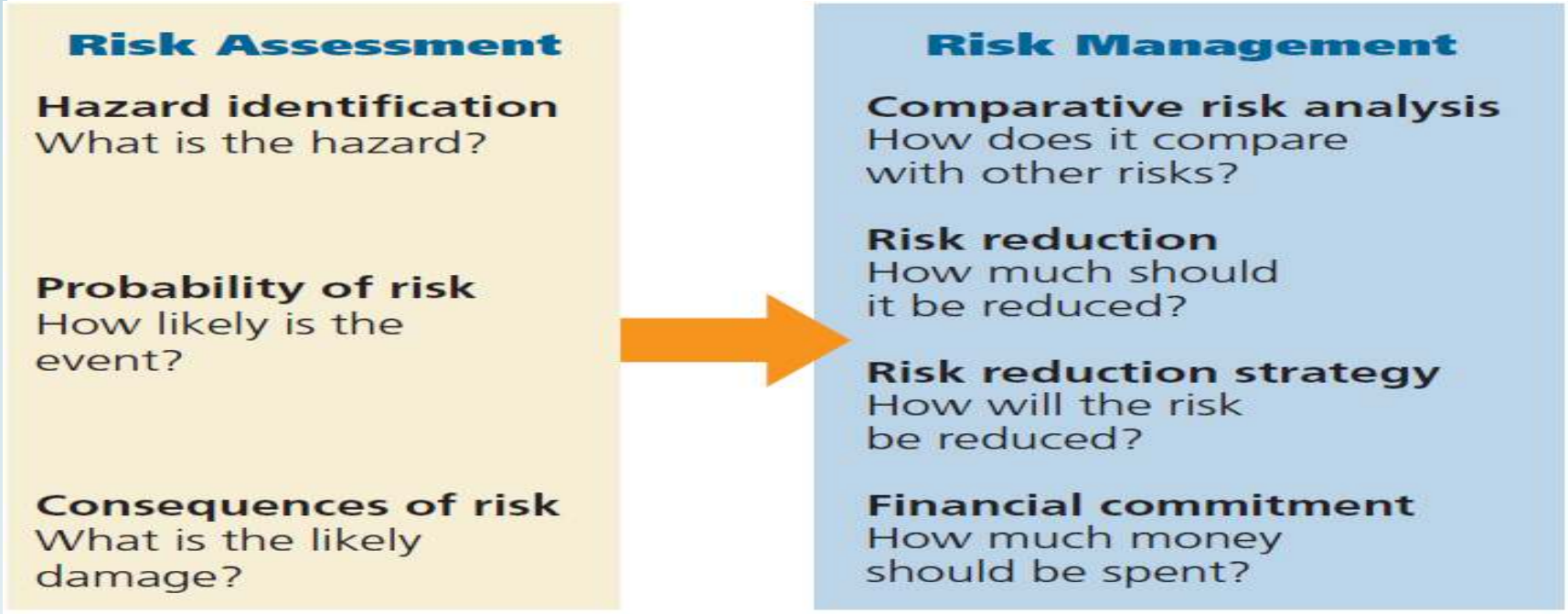
- Surface impoundments : lined ponds, pits or lagoons where liquid hazardous wastes are stored.
- Advantages : wastes can be retrieved, low cost
- Disadvantages : Ground water contamination from leaking liners, air pollution from volatile organic compounds
- Landfills : liquid and solid hazardous wastes are put into drums or other containers and buried in carefully designed and secure landfills
- Biomimicry : mimic nature in which wastes of one manufacturer become the raw materials for another





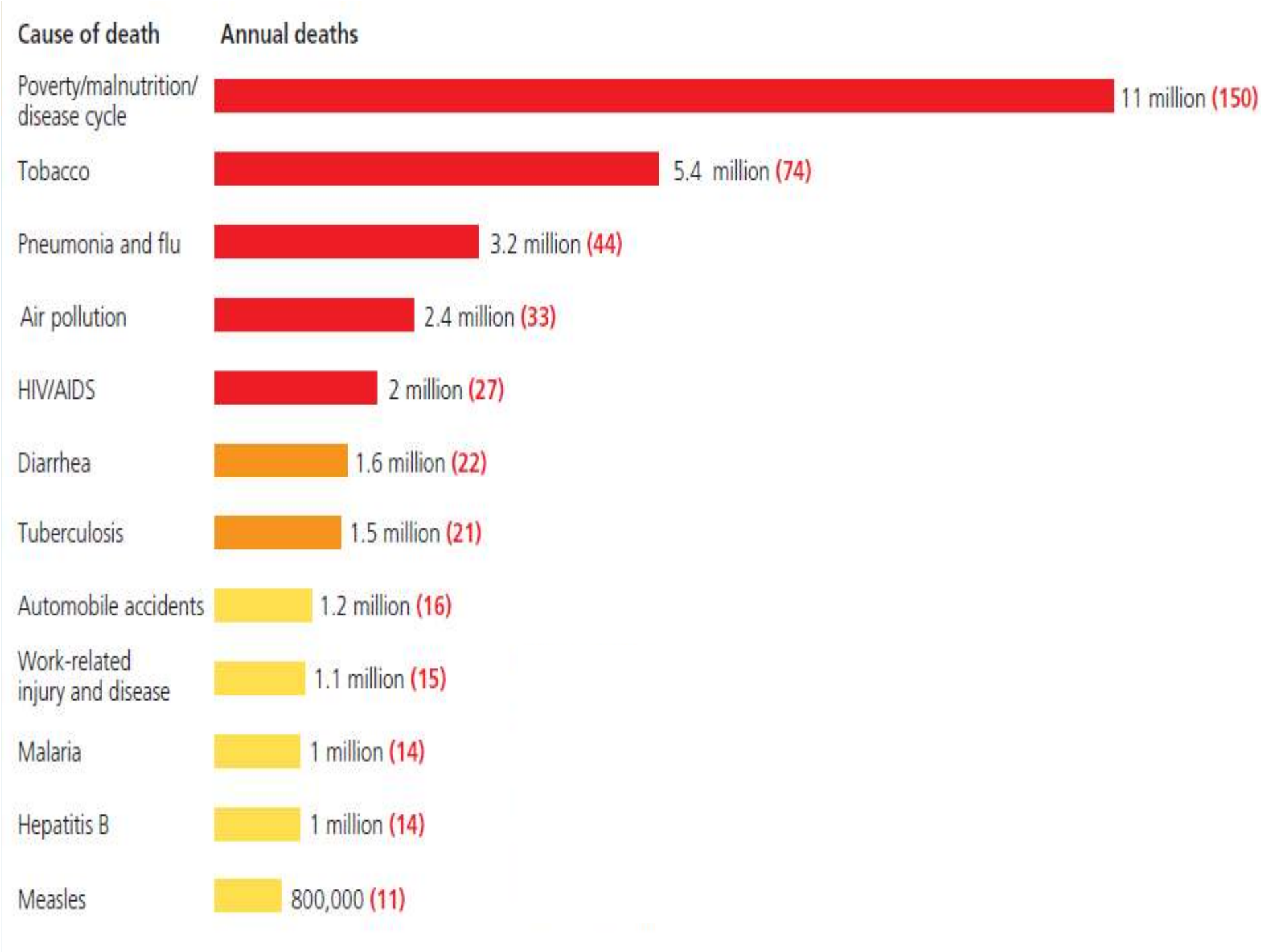
Risk

- Risk - It is the probability of suffering harm from a hazard that can cause injury, disease, death, economic loss, or damage.
- Risk assessment – It is the process of using statistical methods to estimate how much harm a particular hazard can cause to human health or to the environment, helps us to estimate the probability of a risk, compare it with the probability of other risks, and establish priorities for avoiding or managing risks.
- Risk management – It involves deciding whether or how to reduce a particular risk to a certain level and at what cost.



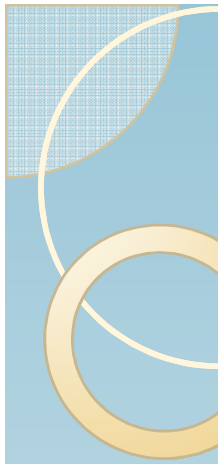
Risk evaluation

- The greatest health risks come from poverty, gender, and lifestyle choices
- Risk analysis involves identifying hazards and evaluating their associated risks
- *Compare risks – how risky compared to others*
- *Determine how much of a risk you are willing to accept*
- *Determine the actual risk involved – do not go by media coverage*
- *Concentrate on evaluating and carefully making important lifestyle choices – change habits which are very much in our hands*


Cause of death
Annual deaths
Poverty/malnutrition/ disease cycle
11 million (150)
Tobacco
5.4 million (74)
Pneumonia and flu
3.2 million (44)
Air pollution
2.4 million (33)
HIV/AIDS
2 million (27)
Diarrhea
1.6 million (22)
Tuberculosis
1.5 million (21)
Automobile accidents
1.2 million (16)
Work-related injury and disease
1.1 million (15)
Malaria
1 million (14)
Hepatitis B
1 million (14)
Measles
800,000 (11)

Case studies

- Air pollution
  - Donora air pollution disaster (USA, 1948) – four day cloud (sulfuric acid, steel plants, zinc smelter) – inversion – 20 died
  - Bhopal Gas Tragedy (1984) – MIC – lack of coolant – 5100 lost lives
- Water pollution
  - Arsenic pollution (WB, Bangladesh, 1978, 1993) – Pb arsenate and copper arsenite – long exposure – lung, bladder cancer – children more effected
- Landfill pollution
  - Love canal tragedy (NY, 1977) – William love – dump site for sealed drums of chemicals – school built – chemical burns/foul smell – 26 organic toxic compounds identified
- Nuclear disaster
  - Chernobyl (Ukraine, 1986) – faulty shutting down, explosion – 31 died – thyroid cancer



End of module 3