Organic Pollutants in Water Bodies

Md Suhaimi Elias

e-mail:
mdsuhaimi@nuclearmalaysia.gov.my

Chemical pollutant

Definition

Chemical pollution damages the environment and poses both short-term and long-term health dangers to human beings.

The effect to man

- Acute – early effect (high concentration)
- Chronic – late effect (low concentration)

Types of pollutants

Class of pollutants	Significance
Trace elements	Health, aquatic biota
Metal-organic combinations	Metal transport
Inorganic pollutants	Toxicity, aquatic biota
Asbestos	Human health
Algal nutrients	Eutrophication
Radionuclides	Toxicity
Acidity, alkalinity, salinity (in excess)	Water quality, aquatic life
Sewage	Water quality, oxygen levels
Biochemical oxygen demand	Water quality, oxygen levels
Trace organic pollutants	Toxicity
Pesticides	Toxicity, aquatic biota, wildlife
PCB	Possible biological effects
Petroleum waste(PAH, TAH)	Effect on wildlife, esthetics
Pathogens	Health effects
Detergents	Eutrophication, wildlife, esthetics
Sediments	Water quality, aquatic biota, wildlife
Taste, odor, and color	Esthetics

Sources of Pollutant

- Industrial
- Landfill
- Agriculture Activities
- Mining Activities
- Domestic waste
- Spillage/leakage
- Atmospheric fall-out

Two types sources of chemical pollution

- Point Sources
- Non-point Sources

Points sources

Point sources is defined as identifiable inputs where waste is discharged to the receiving water bodies

The discharges of waste to the water bodies is strictly control by DOE

- Environmental Quality Acts 1974
- Sewerage Service Acts 1993
- Local government act 1976

Example of activities generated point sources pollutants

1. Industry - major polluters in Malaysia

- Metal and electroplating -Toxic element and Heavy metal (As, Pb, Hg, Sn, Cd, Zn, Sb)
- Textile – Dye
- Oil Industries (Crude, Lubricant, gasoline, diesel and etc).
- Palm oil mills: ammonia, organics
- Organic chemicals (Dye, -CN, PAH, Organochlorine – PCB,DDT)

2. Mining.

- Radioactive materials (naturally occurring Ra-226)
- Heavy metals
- Metalloids.
- produces acidic water – harmful for organism

3. Land clearing (agriculture, logging)

- Erosion,
- sedimentation,
- yellow river/high suspended solid

4. Landfill

- Solid waste
- Leachate
  - Heavy metal
  - Organic chemical (-CN, NH_3, SOx, NOx, PAH, TAH, Oil and Grease)

5. Sewage treatment plants (STP)

- Solid waste – Heavy metal, high suspended solid
- Organic chemical (NH_3, SOx, NOx, H_2S, PAH, Oil and Grease).
- Microbial

6. Spillage

- Tanker/truck – chemical (acid, alkaline), gasoline and diesel
- Boat and Vessel

Non-point sources

- Atmospheric fall-out – motor vehicle, chimney and haze (forest fire)
- Waste – illegal dumping of waste
- Run-off
- Leakage
- Sewers
- Agriculture – Cattle feed-logs, pig farming, plantations (Eutrophication, Organochlorine –DDT, PCB)
- Other activities. PAH, PCB, Dioxin, pesticide residues

Atmospheric fall-out

- Industrial emissions.
- Incinerator emission.
- Exhaust gas emission – organics, heavy metal, acid rains
- Special pollutants from incinerators: dioxins and furans – accumulate in fish (fat tissue).

Agriculture- Eutrophication

- Fertilisers are often used in farming cause an increase in nutrient levels.
- This causes phytoplankton to grow and reproduce more rapidly, resulting in algal blooms.
- This bloom of algae disrupts normal ecosystem functioning and causes many problems.

Agriculture- Eutrophication

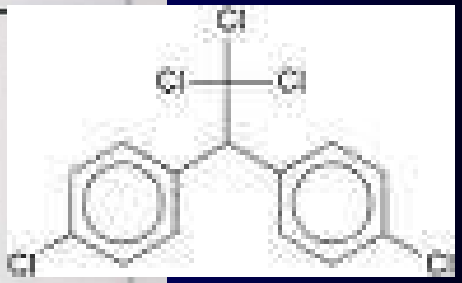
- The algae may use up all the oxygen in the water, leaving none for other marine life (death of many aquatic organisms such as fish).
- The bloom of algae - block sunlight from photosynthetic marine plants under the water surface.
- Some algae even produce toxins that are harmful to higher forms of life. This can cause problems along the food chain and affect any animal that feeds on them.

Organochlorine in water

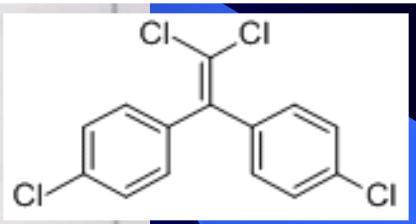
The most concern in class of persistent organic pollutants such as DDT, DDE Aldrin-dieldrin, Chlordane, Endosulfan, Endrin, Heptachlor, Lindane, Mirex, etc.

Organochlorine/Chlorinated hydrocarbon

t-DDT	bukan-DDT	PCB
2,4-DDE *	a- BHC*	PCB 18
4,4-DDE	b-BHC*	PCB 28
2,4-DDD*	g-BHC (Lindane)	PCB 29*
4,4-DDD	d-BHC*	PCB 44
2,4-DDT*	a-Klordane	PCB 52
4,4-DDT	g-Klordane	PCB 66
	Aldrin	PCB 101*
	cis-Nanoklor*	PCB 104
	Dieldrin	PCB 118*
	Endosulfan I*	PCB 128
	Endosulfan II*	PCB 138
	Endosulfan Sulfate	PCB 170*
	Endrin	PCB 180
	Endrin aldehyde *	PCB 187*
	HCB	PCB 195*
	Heptaklor	PCB 200
	Heptaklor epoksida	PCB 206*
	MIREX *	
	Oxyklordane	
	trans-Nanoklor	



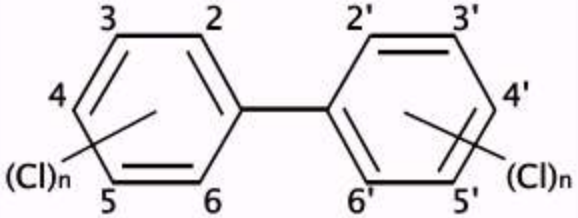
DDT Structure



DDE Structure

Organochlorine/Chlorinated hydrocarbon

IUPAC Name	BZ[3] Congener Number	CASRN
Biphenyl	0	92-52-4
2-Chlorobiphenyl	1	2051-60-7
3-Chlorobiphenyl	2	2051-61-8
4-Chlorobiphenyl	3	2051-62-9
2,2'-Dichlorobiphenyl	4	13029-08-8
2,3-Dichlorobiphenyl	5	16605-91-7
2,3'-Dichlorobiphenyl	6	25569-80-6
2,4-Dichlorobiphenyl	7	33284-50-3
2,4'-Dichlorobiphenyl	8	34883-43-7
2,5-Dichlorobiphenyl	9	34883-39-1
2,6-Dichlorobiphenyl	10	33146-45-1
3,3'-Dichlorobiphenyl	11	2050-67-1
3,4-Dichlorobiphenyl	12	2974-92-7
3,4'-Dichlorobiphenyl	13	2974-90-5
3,5-Dichlorobiphenyl	14	34883-41-5
4,4'-Dichlorobiphenyl	15	2050-68-2
2,2',3-Trichlorobiphenyl	16	38444-78-9
2,2',4-Trichlorobiphenyl	17	37680-66-3
2,2',5-Trichlorobiphenyl	18	37680-65-2



PCB Structure

209 Congener Number

DDT (Dichloro diphenyl tricloroethane)

- Banned since 1970s but still illegally use
- Carcinogenicity effect to man
- In environment converted to more toxic DDE
- Fresh water quality criteria 0.001µg/L

Methoxychlor

- Popular DDT substitute
- Reasonably biodegradable
- Low toxicity to mammal
- Fresh water quality criteria 0.03 μg/L

Lindane(BHC)

- Used to control insect, plant pest, animal parasites
- Widely manufactured
- Lack of odor
- Fresh water quality criteria 0.01μg/L

Chlordane

- Effective against mite
- Carcinogenic effect Class 1
- Fresh water quality 0.01 µg/L

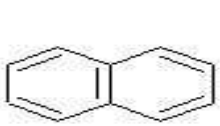
Aldrin-Dieldrin

- Persistent and stable in soil, effective against insect in soil.
- Organism convert aldrin to dieldrin
- Carcinogenic to mice. Carcinegenic agents class 2B
- Fresh water quality criteria 0.003 µg/L
- Banned in Malaysia since 1970s but still available illegally

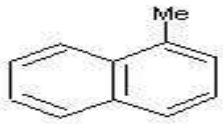
Petroleum Hydrocarbon

- Aliphatic (straight chain – C_2 to C_{60})
- Polycyclic aromatic hydrocarbon (PAH)

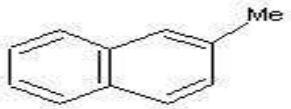
PAH Compounds



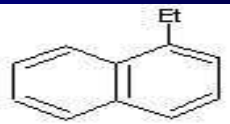
naphthalene



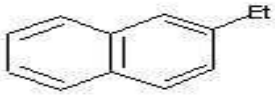
1-Methylnaphthalene



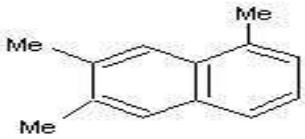
2-Methylnaphthalene



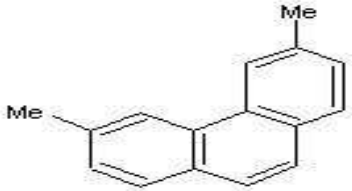
1-Ethylnaphthalene



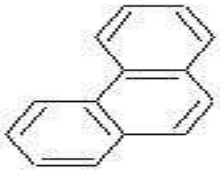
2-Ethylnaphthalene



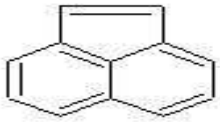
2,3,5-Trimethylnaphthalene



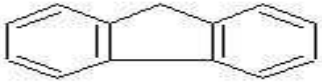
3,6-Dimethylnaphthalene



phenanthrene

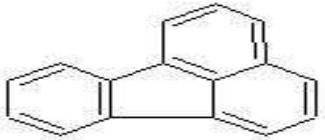


acenaphthylene

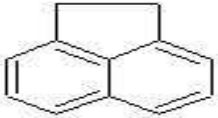


Fluorene

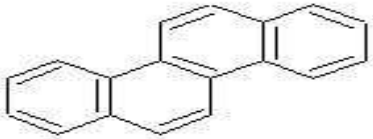
anthracene



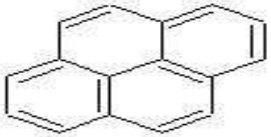
Fluoranthene



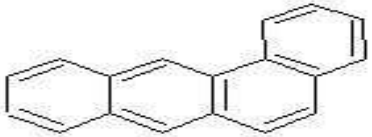
Acenaphthene



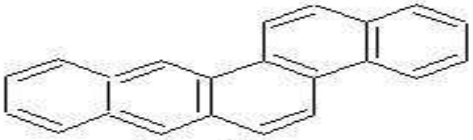
Chrysene



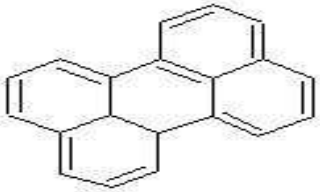
Pyrene



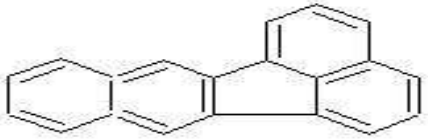
Benz[a]anthracene



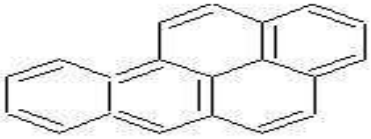
Benzo[b]chrysene



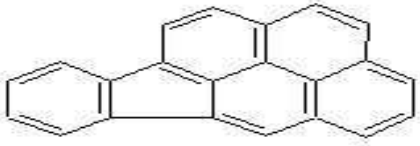
Perylene



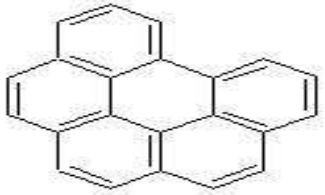
Benzo[k]fluoranthene



Benzo[a]pyrene

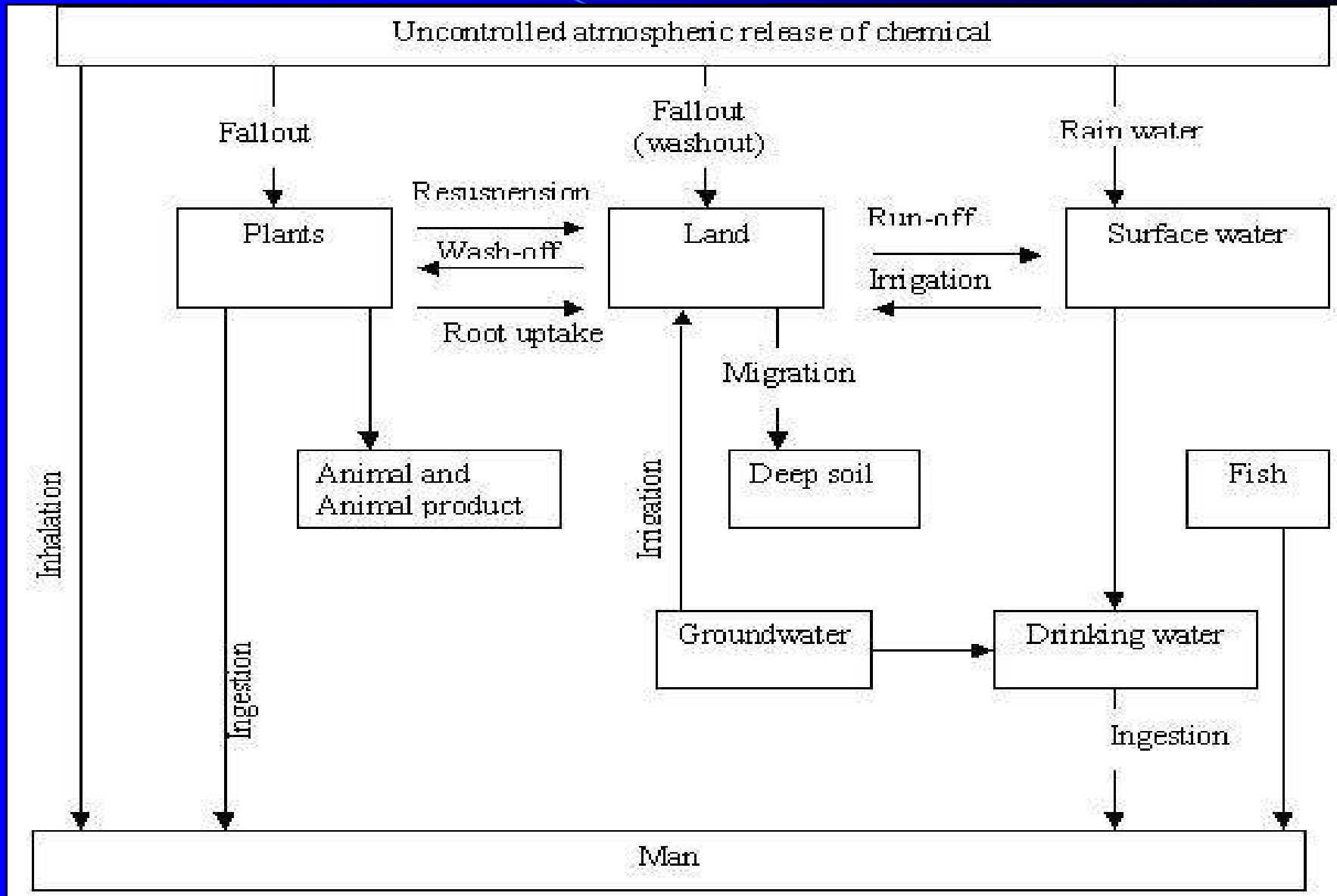


Indeno[1,2,3-cd]pyrene



Benzo[ghi]perylene

Example of activities generated non-point sources pollutants



Some of typical primary constituents of sewage from a city sewage system

Constituents	Potential sources	Effects in water
Oxygen demanding substances	Mostly organic material, particularly human feces	Consumed dissolved oxygen
Refractory organics	Industrial waste, household products	Toxic to aquatic life
Viruses	Human waste	Cause disease major deterrent to sewage recycle through water system
Detergents	Household detergents	Esthetics, prevent grease and oil removal, toxic to aquatic life
Phosphates	Detergents	Algal nutrients
Oil and Grease	Cooking, food processing, industrial waste	Esthetics, harmful to some aquatic life
Salts	Human waste, water softeners, industrial waste	Increase water salinity
Heavy metals	Industrial waste, chemical laboratories	Toxicity
Chelating agents	Some detergents, industrial waste	Heavy metal ion solubilization and transport
Suspended solid	All sources	Esthetics, harmful to aquatic life

Water Pollution Control

- Environmental Quality Act 1974 (Act 127)
- Section 25, Restrictions on pollution of inland waters
  - Fine not exceeding one hundred thousand ringgit or to imprisonment for a period not exceeding five years or both.
- Regulations

(a) Environmental Quality (Sewage) regulation 2009

(b) Environmental Quality (Industrial Effluent) regulation 2009

(b) Environmental Quality Regulations (Prescribed Premises) (Raw Natural Rubber), 1978.

(c) Environmental Quality Order (Prescribed Premises) (Crude Palm Oil), 1977.

(d) Environmental Quality (Prescribed Activities) (Environmental Impact Assessment, EIA) Order 1987.

(e) Environmental Quality (Scheduled waste) Regulations 2005.

(f) Environmental Quality (Prescribed Premises) (Scheduled wastes treatment and Disposal Facilities) Regulations 1989.

http://www.doe.gov.my/en/content/environmental-quality-act-1974

Treatment

- Industrial waste treatment
- Sewage treatment
- Denitrification
- Ozon treatment

Industrial waste treatment

1. The sewage first goes through a primary phase.
    - Suspended, solid particles and in organic material removed by the using of filters or retention pond.
2. The secondary phase of the treatment.
    - Involves the reduction of organic, this is done with the use of biological filters and processes that naturally degrade the organic waste material.
3. The final stage of treatment is the tertiary phase
    - Almost all solid particles are removed from the water and chemical additives are supplied to get rid of any left-over impurities.

Sewage treatment

- Untreated sewage from a property flows into the septic tank and the solids are separated from the liquid.
- Solid material is separated depending on their density. Heavier particles settle at the bottom of the tank whereas lighter particles, such as soap scum, will form a layer at the top of the tank.
- Biological processes are used to help degrade the solid materials.
- The liquid then flows out of the tank into a land drainage system and the remaining solids are filtered out.

Denitrification

- Fertilisers contain nitrogen, and are often applied to crops, to increase the yield.
- Bacteria in the soil convert the nitrogen in the fertilizer to nitrates, making it easier for the plants to absorb.
- Immobilization is a process where the nitrates become part of the soil organic matter.
- When oxygen levels are low, another form of bacteria then turns the nitrates into gases such as nitrogen, nitrous oxide (N_2O) and nitrogen dioxide.
- The conversion of these nitrates (NO_3)into gas is called denitrification.
- This prevents nitrates from leaching into the soil and contaminating groundwater.

Ozone Treatment

- The generators convert oxygen into ozone by using ultraviolet radiation or by an electric discharge field.
- Ozone is a very reactive gas that can oxidise bacteria, moulds, organic material and other pollutants found in water.
- Using ozone to treat wastewater has many benefits:
  - Kills bacteria effectively.
  - Oxidises substances such as iron and sulphur so that they can be filtered out of the solution.
  - There are no nasty odours or residues produced from the treatment.
  - Ozone converts back into oxygen quickly, and leaves no trace once it has been used.

The disadvantages of using ozone as a treatment

- The treatment requires energy in the form of electricity; this can cost money and cannot work when the power is lost.
- The treatment cannot remove dissolved minerals and salts.
- Ozone treatment can sometimes produce by-products such as bromate that can harm human health if they are not controlled.

CONCLUSION

- Chemicals in drinking water are of much concern because they are in the form readily available for body uptake.
- Chemical may also go into our body system through intake of food contaminated with chemical (food chain).
- Some chemical do accumulated in the body system and may cause chronic effect after prolong exposure.