Environmental Toxicology (ET)

Course: ES 535

Dr. Md. Billal Hossain
Ph.D. (JU)
Honours and Masters (DU)
Professional Masters (ITC, UT, Netherlands)

E-mail: mdbhossain05@gmail.com
Cell: 88-01716157306

Toxicity

- Toxicity: The degree to which a substance can harm humans, plants or animals.
- The word “toxicity” describes the degree to which a substance is poisonous or can cause injury. The toxicity depends on a variety of factors: dose, duration and route of exposure, shape and structure of the chemical itself, and individual human factors (ATSDR).
- Toxicity: refers to the property of a chemical to affect survival, growth, and reproduction of an organism.
- Toxicity is the degree to which a chemical substance or a particular mixture of substances can damage an organism
- Toxicity can be Acute, Sub-chronic, or Chronic.
  - Acute Toxicity involves harmful effects in an organism through a single or short-term exposure.
  - Subchronic Toxicity is the ability of a toxic substance to cause effects for more than one year but less than the lifetime of the exposed organism.
  - Chronic Toxicity is the ability of a substance or mixture of substances to cause harmful effects over an extended period, usually upon repeated or continuous exposure, sometimes lasting for the entire life of the exposed organism.

Environmental Toxicology

- Harmful effects of chemical and biological agents can include toxins from pollutants, insecticides, pesticides, and fertilizers all of which can impact an organism and its community through shifts in species diversity and abundance.
- Resulting changes in population dynamics impact the ecosystem by altering its productivity and stability.
- There are many sources of environmental toxicity that can lead to the presence of toxins in our food, water and air.
- These sources include organic and inorganic pollutants, pesticides and biological agents, all of which can have harmful effects on living organisms.

Worldwide Development and Pollution

- Industrial and economic development since world war II:
  - The average real income in developing countries has doubled;
  - Malnutrition has declined by almost one-third;
  - Child death rates have been halved;
  - Average life expectancy has increased by 30 percent; and
  - The percentage of rural families with access to safe drinking water has risen from less than 10 percent to almost 75 percent.
  - Green revolution
  - Chemicals: fertilizers, insecticides and herbicides
  - World food production: high yield grains
  - Improved medicine and medical science technology
  - Industrialisation and Urbanisation

BUT……was not without cost

Selected episodes of different types of toxicological disaster

(Source: Environmental toxicology and human health – vol. i)

Year	Place	Toxicologic problems
79 AD	Pompeii	Volcanic gas especially oxides of nitrogen and sulfur from the eruption of Mount Vesuvius, leading to thousands of deaths.
1700s	England	High incidence of scrotal cancer in chimney sweeps as a result of exposure to polycyclic aromatic hydrocarbons—the first description of occupation-related cancer.
1800s	New Jersey	Outbreak of mercurialism in the hatters working in the felting process of the hatting industry.
1900s	Worldwide	Increased incidence of bladder cancer in dye industry workers as a result of ß-naphthylamine exposure.
1920s–present	Worldwide	Millions at risk of asbestos exposure resulting in marked increase in asbestos-related disease and cancer.
1930	Meuse Valley, Belgium	Smog caused illness and 64 deaths.
1939–1954	Japan	Cadmium contaminated water resulted in Itai-Itai disease.
1948	Donora, Pennsylvania	Smog caused 20 deaths and thousands were ill due to polluted air.
1950	Minamata Bay, Japan	Organic mercury poisoning from the consumption of fish.
1952	London, England	Photochemical smog resulted in 4 000 deaths.
1971	Iraq	Methylmercury contaminated grain resulted in 459 deaths.
1970s	California	1,2 dibromo-3-chloropropane DBCP, a nematocide, resulted in infertility among pesticide workers.

Year	Place	Toxicologic problems
		dioxin into the environment.
1978	Love Canal, New York	Toxic wastes caused great public concern.
1982	Iraq and Iran	Mustard gas used in chemical warfare caused hundreds of casualties.
1984	Bhopal, India	Industrial release of methyl isocyanate vapor resulted in 3 000 deaths and 200 000 injuries.
1986	Chernobyl, Soviet Union	Ionizing radiation from the nuclear power plant resulted in 32 immediate deaths and affected 5 million people.
1990	Bronx, New York	Toxic smoke including carbon monoxide and cyanide resulted in 87 deaths at the Happy Land Social Club.

Agent Orange Vietnam War

- Since World War II, as a result of accelerating industrial development, a large number and quantity of chemicals have been released into the environment. The release has led to increased pollution of the air, water, and soil, potentially contaminating food sources
- During the Vietnam War, between 1962 and 1971, the United States military sprayed nearly 20,000,000 U.S. gallons (75,700,000 l) of chemical herbicides and defoliants in Vietnam,
- The goal was to defoliate rural/forested land, depriving guerrillas of food and cover and clearing sensitive areas such as around base perimeters.
- The program was also a part of a general policy of forced draft urbanization, which aimed to destroy the ability of peasants to support themselves in the countryside, forcing them to flee to the U.S. dominated cities, depriving the guerrillas of their rural support base.

Causes of environmental toxicity

Agent orange Vietnam war

Spraying herbicide

Farmer spraying pesticide on rice field

Drones for spraying pesticides

Environmental Toxicology

Environmental Toxicology

ATSDR Toxicological profiles

- ATSDR (**A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry) is part of the U.S. Department of Health and Human Services.
- A very useful source of information about the toxicological chemistry of various kinds of toxic substances is published by the ATSDR, as ATSDR's Toxicological Profiles.
- It also provide information on specific chemicals and possible health effects
- Toxicological Profiles (Tox Profiles) are a unique compilation of toxicological information on a given hazardous substance.

ATSDR Toxicological profiles (Source: Environmental Chemistry, S.E.Manahan (2000)

Table 23.2 Materials Listed by ATSDR[13]

Acetone	1,2-Dibromoethane	Naphthalene
Acrolein	1,4-Dichlorobenzene	Nickel
Acrylonitrile	3,3'-Dichlorobenzidine	Nitrobenzene
Aldrin/Dieldrin	1,1-Dichloroethane	2-Nitrophenol/
Alpha-,Beta-,Gamma-	1,2-Dichloroethane	4-Nitrophenol
and Delta-Hexachloro-	1,1-Dichloroethene	Otto Fuels
cyclohexane	1,2-Dichloroethene	Pentachlorophenol
Aluminum	1,3-Dichloropropene	Phenol
Ammonia	Diethyl Phthalate	Plutonium
Arsenic	1,3-Dinitrobenzene/	Polybrominated
Asbestos	1,3,5-Trinitrobenzene	Biphenyls
Automotive Gasoline	Dinitrocresols	Polychlorinated
Barium	Dinitrophenols	Biphenyls
Benzene	2,4-Dinitrotoluene/	Polycyclic Aromatic
Benzidine	2,6-Dinitrotoluene	Hydrocarbons (PAH's)
Beryllium	1,2-Diphenylhydrazine	Radon
Bis(2-Chloroethyl) Ether	Disulfoton	RDX
Boron	Endosulfan	Selenium
Bromomethane	Endrin	Silver
1,3-Butadiene	Ethylbenzene	Stoddard Solvent
2-Butanone	Ethylene Glycol and	1,1,2,2-Tetrachloroethane
Cadmium	Propylene Glycol	Tetrachloroethylene
Carbon Disulfide	Fluorides, Hydrogen	Tetryl
Carbon Tetrachloride	Fluoride, and Fluorine	Thallium
Chlordane	Fuel Oils	Thorium
Chlorobenzene	Heptachlor/Heptachlor	Tin
Chlorodibenzofurans	Epoxide	Titanium Tetrachloride
Chloroethane	Hexachlorobenzene	Toluene
Chloroform	Hexachlorobutadiene	Toxaphene
Chloromethane	2-Hexanone	1,1,1-Trichloroethane
Chlorpyrifos	Hydraulic Fluids	1,1,2-Trichloroethane
Chromium	Isophorone	Trichloroethylene
Coal Tar Pitch, and	Jet Fuels (Jp4 And Jp7)	2,4,6-Trichlorophenol
Coal Tar Pitch Volatiles	Lead	2,4,6-Trinitrotoluene
Cobalt	Manganese	Uranium
Copper	Mercury	Used Mineral-Based
Cresols: *o*-Cresol, *p*-	Methoxychlor	Crankcase Oil
Cresol, *m*-Cresol	Methyl Parathion	Vanadium
Cyanide	Methyl Tert-Butyl Ether	Vinyl Acetate
4,4'-Ddt,4,4'-Dde,4,4'-Ddd	4, 4'-Methylenebis-(2-	Vinyl Chloride
Di (2-Ethylhexyl) Phthalate	Chloroaniline) (MBOCA)	White Phosphorus
Di-N-Butylphthalate	Methylene Chloride	Wood Creosote, Coal Tar
Diazinon	Mirex And chlordecone	Creosote, Coal Tar
1,2-Dibromo-	N-Nitrosodi-N-Propylamine	Xylenes
3-Chloropropane	N-Nitrosodiphenylamine	Zinc

The ATSDR 2019 Substance Priority List

2019 RANK	SUBSTANCE NAME	TOTAL POINTS
1	ARSENIC	1676
2	LEAD	1531
3	MERCURY	1458
5	POLYCHLORINATED BIPHENYLS	1345
6	BENZENE	1327
7	CADMIUM	1318
11	CHLOROFORM	1201
12	AROCLOR 1260	1191
13	DDT, P,P'-	1181
14	AROCLOR 1254	1172
15	DIBENZO(A,H)ANTHRACENE	1160
16	TRICHLOROETHYLENE	1155
17	CHROMIUM, HEXAVALENT	1149
18	DIELDRIN	1143
19	PHOSPHORUS, WHITE	1141
20	HEXACHLOROBUTADIENE	1127
22	CHLORDANE	1125
25	ALDRIN	1115
28	HEPTACHLOR	1101
32	TOXAPHENE	1089
35	CYANIDE	1069
40	ENDRIN	1038
43	BERYLLIUM	1030

2019 RANK	SUBSTANCE NAME	TOTAL POINTS
93	HEXACHLOROBENZENE	844
273	METOLACHLOR	539
274	1,2-DICHLOROETHENE, CIS-	538
275	1,2,3-TRICHLOROPROPANE	537

- Prioritizes substances based on frequency of occurrence at NPL (National Priority List) sites, toxicity, and potential for human exposure to the substances found at NPL sites.

Environmental pollutants

- There are many sources of environmental toxicity that can lead to the presence of toxins in our food, water and air.
- These sources include organic and inorganic pollutants, pesticides and biological agents, all of which can have harmful effects on living organisms.

➢ **Organic pollutants** includes **phenols, chlorinated phenols**, endocrine disrupting chemicals, azo dyes, polyaromatic hydrocarbons, polychlorinated biphenyls, pesticides, POP's, etc.,

➢ **Inorganic pollutants** includes a variety of toxic heavy metals such as cadmium (Cd), chromium (Cr), arsenic (As), lead (Pb), mercury (Hg), ...

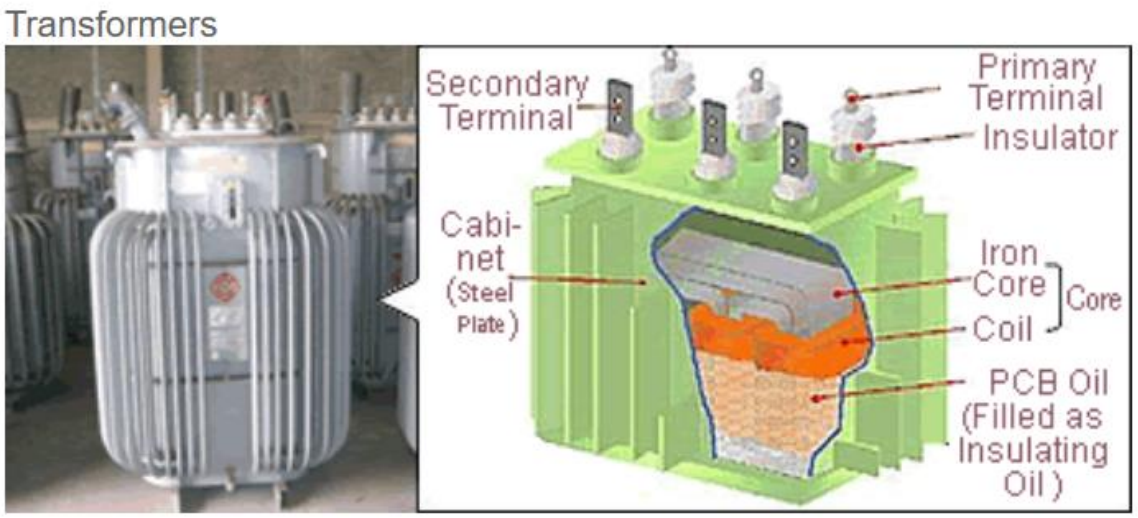
- Ammonia (NH3), hydrogen sulfide (H2S), carbon monoxide (CO), carbon dioxide (CO2), nitrite (NO2), and sulfite (SO2)

POPs

- Persistent Organic Pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes.
- POPs persist in the environment for long time, are capable of long-range transport, bio-accumulate in human and animal tissue and bio-magnify in food chains, and have potentially significant impacts on human health and the environment.
- Exposure to POPs can cause serious health problems including certain cancers, birth defects, dysfunctional immune and reproductive systems, greater susceptibility to disease and even diminished intelligence.
- POPs are widely distributed throughout the environment as a result of natural processes involving soil, water and, most notably, air;
- Accumulate in the fatty tissue of living organisms including humans, and are found at higher concentrations at higher levels in the food chain; and are toxic to both humans and wildlife.

Polychlorinated Biphenyls (PCBs)

- PCB's are organic pollutants that are still present in our environment today despite being banned in many countries such as the United States and Canada.
- Due to the persistent nature of PCBs in aquatic ecosystems, many aquatic species contain high levels of this chemical.
- For example, fish farmed salmon have been shown to have significantly higher PCB levels.



পিসিবিযুক্ত ট্র্যান্সফরমার তেল স্বাস্থ্যের জন্য মারাত্মক ক্ষতিকর

পিসিবিযুক্ত ট্র্যান্সফরমার তেলের সংস্পর্শে আসলে—

- মাথা ব্যথা, বমি বমি ভাব, খেতে অনিচ্ছা, অনিদ্রা, ওজন কমে যাওয়া, স্নায়ু দুর্বলতা, হৃদ স্পন্দনের সমস্যা, যকৃতের সমস্যা, চোখের নানা ধরনের সমস্যা এমনকি প্রজননতন্ত্রেরও ক্ষতি হতে পারে।
- রোগ প্রতিরোধ ক্ষমতা কমে যেতে পারে এমনকি বিভিন্ন অঙ্গহানী হতে পারে।
- কোনো কোনো ক্ষেত্রে টিউমার বা ক্যান্সারের মতো দূরারোগ্য ব্যাধির সৃষ্টি হতে পারে।

পিসিবিযুক্ত ট্র্যান্সফরমার তেল পরিবর্তনের সময়ে—

খেয়াল রাখতে হবে যেন এই তেল শরীরের কোন অংশের সংস্পর্শে না আসে।

- প্রয়োজনীয় সুরক্ষার জন্য গ্লোভস, বুট, মাস্ক, এপ্রন বা কভারোল ব্যবহার করতে হবে।

পপ্‌স সম্পর্কে সতর্ক হোন

বাংলাদেশ বিদ্যুৎ উন্নয়ন বোর্ড

পরিবেশ অধিদপ্তর

কৃষি সম্প্রসারণ অধিদপ্তর

Heavy Metals

- Their effect on health could occur through at least two mechanisms: first, by increasing the presence of heavy metals in air, water, soil, and food, and second, by changing the structure of the chemical. For example, chromium III can be converted to or from chromium VI, the more toxic form of the metal.
- These metals can include mercury, lead, aluminum and cadmium, Nickel, Arsenic. For example, In natural waters arsenic normally occurs in the oxidation states **+III (arsenite) and +V (arsenate)**. Arsenite is more soluble than arsenate and is more toxic
- It has been shown that fish are exposed to higher cadmium levels and grow at a slower rate than fish exposed to lower levels or none.

Environmental Toxicology

- Pesticides:
- Pesticides are a major source of environmental toxicity. Uses to kill an undesirable plant or animal pest.
- These chemically synthesized agents have been known to persist in the environment long after their administration.
- The poor bio-degradability of pesticides can result in bio-accumulation of chemicals in various organisms along with bio-magnification within a food web.
- Pesticides can be categorized according to the pests they target.
- Insecticides are used to eliminate agricultural pests that attack various fruits and crops.
- Herbicides target herbal pests such as weeds and other unwanted plants that reduce crop production

DDT

- Dichlorodiphenyltrichloroethane (DDT) is an organochlorine insecticide that has been banned due to its adverse effects on both humans and wildlife.
- DDT was widely used by farmers in order to kill agricultural pests.
- The impact of DDT on human health received worldwide attention from the general public, political and scientific communities, with the publication of Rachel Carson's Silent Spring.
- DDT, that were released into the environment were toxic to both animals and humans
- DDT is not easily biodegradable and thus the chemical accumulates in soil and sediment runoff.
- Water systems become polluted and marine life such as fish and shellfish accumulate DDT in their tissues.
- Furthermore, this effect is amplified when animals who consume the fish also consume the chemical, demonstrating biomagnification within the food web.
- The process of bio-magnification has detrimental effects on various bird species.
- Rapid declines in bird populations have been seen various parts of the world.

Dose-Response Relationship

- **Exposure**—the state of having no protection from something harmful. *to cause an adverse effect, a toxicant must first come in contact with an organism. The* means by which an organism comes in contact with the substance is the route of exposure (e.g., in the air, water, soil, food, medication) for that chemical.
- **Dose**—a quantity of a medicine or drug taken or recommended to be taken at a particular time. *the total amount of a toxicant administered to an organism at specific time intervals.*
- Dose-response is a relationship between exposure and health effect, that can be established by measuring the response relative to an increasing dose. This relationship is important in determining the toxicity of a particular substance
- It relies on the concept that a dose, or a time of exposure (to a chemical, drug, or toxic substance), will cause an effect (response) on the exposed organism. Usually, the larger or more intense the dose, the greater the response, or the effect. This is the meaning behind the statement “the dose makes the poison.”

Dose Response Relationship

- The dose – response relationship provides an estimation of the relationship between the dose of a chemical agent and incidence of effects in a population.
- The dose is the actual amount of a chemical that enters the body. The dose received may be due to either acute (short) or chronic (long-term) exposure.
- Approaches to characterizing dose – response relationships: include effect levels: such as lethal dose 50 (LD 50), lethal concentration 50 (LC 50), effective dose 50 (ED 50), No observed adverse effect levels (NOAELs), margins of safety.

Assignments

Sl. No.	Name	ID	Topic
A	Pratiti Sarker	PG05-56-22-003	Pesticides and Related Materials: Polychlorinated Biphenyls (PCB)
	Md Abu Morshed Ananda Basunia	PG05-57-22-001	
	H. M. Zahir Raihan	PG05-57-22-002	
B	Manmatha Bepary	PG05-56-22-004	Dose- Response Relationships
	Tanvir Ahmed	PG05-56-22-005	
	Md Rashidul Islam Sany	PG05-57-22-004	
C	Md. Jewel Molla	PG05-56-22-006	Incidents of itai-itai Disease
	Tanvir Hossain	PG05-57-22-003	
	Md Mehedi Hasan	PG05-57-22-005	
D	Dabobrota Kumar Mondal	PG05-56-22-008	Target Organ Toxicity
	Muhammad Hamidul Kabir	PG05-57-22-006	
	Shamiha Shahab	PG05-57-22-007	
D	Md. Atikur Rahman	PG05-56-22-009	Occurrence of Toxicants
	Nirmal Chandra Sinha	PG05-57-22-008	
	Md. Rakibul Alam	PG05-57-22-009	
E	Md. Mehedi Hasan	PG05-56-22-010	Toxic Action of Pollutants
	Md. Sadid Rahman	PG05-57-22-010	
	Md. Abu Taher Khan	PG05-57-22-011	
F	Chowdhury Nazmul Alam	PG05-56-22-011	Factors Affecting Xenobiotic Action
	Dilip Kumar Mondal	PG05-57-22-012	
	Sahnaj Akter	PG05-57-22-013	
G	Nilakar Bishwas	PG05-56-22-012	Biotransformation
	Md. Ashraful Hoque	PG05-57-22-014	
	Rakibul Islam	PG05-57-22-015	
H	Masruk Ahmad	PG05-56-22-013	Soil and Water Pollution- Environmental Metals and Metalloids
	Md. Ferdaus Jaman	PG05-57-22-016	
	Md Mahabub Hasan	PG05-57-22-017	
I	Md Imran Hossain Chowdhury	PG05-56-22-014	Pesticides and Related Materials: DDT
	Jyotish Chandra Roy	PG05-57-22-018	
	Mohammad Saiful Islam	PG05-57-22-019	
J	Kh. Mosheur Rahaman	PG05-57-22-020	Incidents of Minamata Disease
	Md Maruf Hossain	PG05-57-22-021	
	Md. Abdur Razzaque	PG05-57-22-022	
K	Md. Abdulla-Hill-Kafi	PG05-57-22-023	Air Pollution-Particulate Matter
	Israt Jahan	PG05-57-22-024	
	Md Abdul Halim Khan	PG05-57-22-025	
L	Md. Mazharul Alom	PG05-57-22-026	Defense Responses to Toxicants
	Md Mahabubur Rahman	PG05-57-22-027	
	Md Shariful Imam	PG05-57-22-028	