Environmental Science
Lecture 17

Soil Pollution and Its Remedies

What is soil? Soil is the thin layer of organic and inorganic materials that covers the Earth's rocky surface. Soil is composed of particles of broken rock that have been altered by chemical and mechanical processes that include weathering and erosion. Pollution of Soil is basically defined as anything that's built up in the soil of persistent toxic compounds, salts, radioactive materials or disease causing agents which have adverse effects on either plant growth or animal health. Soil pollution is also caused by means other than the direct addition of xenobiotic i.e man-made chemicals such as agricultural runoff waters, industrial waste materials, acidic precipitates and radioactive fall out.

Causes of Soil Pollution - Seepage from a landfill, discharge of industrial waste into the soil, Percolation of contaminated water into the soil, Rupture of underground storage tanks, Excess application of pesticides, herbicides or fertilizer, Solid waste seepage, Deforestation and soil erosion.

Now, when you have excess application of pesticides, it is thought by many farmers and people around that a sturdier crop is a more healthier crop which is not necessarily true. Sometimes excessive pesticides could lead to further harm than good. Excessive use and disposal of plastics and polythene wastes, because of this again, the topsoil gets clogged or sometimes clogs water canals and the movement of water and other irrigation facilities.

Industrial Seepage - Solid waste seepage especially from landfills and every city ends up having three to four huge landfills covering acres and acres of land making it pretty much infertile for any future use because it is especially in a developing country like ours, garbage is never segregated as hazardous and non-hazardous. Its all dumped in one place. Heavy metals, batteries, computer parts, domestic garbage, vegetable waste, everything gets dumped in the same place. The most common chemicals involved in causing soil pollution are - Petroleum Hydrocarbons, Heavy Metals, Pesticides and Solvents.

Types of Soil Pollution - Agriculture Soil Pollution which is basically pollution of surface soil and pollution of underground soil. Soil pollution by industrial effluents and solid wastes, this is again pollution of surface soil and disturbances in soil profile which can be seen, not only immediately but over a time as well. Pollution due to urban activities - pollution of surface soil and pollution of underground soil.

Agricultural Soil pollution - Plants on which we depend for food are under attack from insects, fungi, bacteria, viruses, rodents and other such animals and must compete with these weeds for nutrients. To kill unwanted population living in or on their crops, farmers use pesticides. The remnants of such pesticides used on pests may get absorbed by the soil particles and contaminate root crops grown in that soil especially if crops like potato, root crops like groundnuts, all of that means it is entering the food chain since the crop itself gets contaminated. The consumption of such crops causes the pesticide remnants to enter human biological systems, affecting them adversely.

Agricultural effects - Reduced soil fertility, Reduced nitrogen fixation which again becomes a part of a vicious circle because when you have reduced nitrogen fixation farmers are dependent on external fertilizers or nutrient specific fertilizers to add on for the lack of nitrogen in the soil. Again because of excessive nitrogen, there will be other repercussions that they have to face. Increased erodibility, Larger loss of soil and nutrients, Deposition of silt in tanks and reservoirs, Reduced crop yield and Imbalance in soil fauna and flora.

Agricultural effects; Industrial Soil Pollution - large quantity of solid wastes like unused and rejected chemicals like sludge, press mud, sawdust, bottles, plastic materials, etc or any unwanted industrial waste generated during manufacturing processes are dumped over on the surface of soil by almost all industries with different in the degree. Larger the production base, larger is the generation of waste. Traditionally these materials have been dumped around the factory side or entire city. Rarely are they put in anything like incinerators. Even incinerators cause Air pollution. Hence, it could either be water pollution where it enters different water bodies or it could be soil pollution where the basic components of the soil get altered.

Industrial effects - Dangerous chemicals entering underground water, ecological imbalance, release of pollutant gases, Increased salinity or percentage of salt, Reduced vegetation. You can see here, a polluted land with dangerous chemicals and they don't realize herbivores like deers, goats, cows don't realize that it's poisonous, they eat it and then sometimes human beings and carnivores consume these animals and it enters the human ecological system. The picture on the right depicts soil pollution due to ecological, industrial waste. You can see a particular soil sludge, oil sludge that has been created over here which is slowly eradiating and reducing the greenery, the quality of grass as well as plant life which is then going to adversely affect other animal life and human life eventually.

Soil Pollution due to Urbanization - Urban activities generate large quantities of city wastes including several Biodegradable materials like vegetables, animal wastes, papers, wooden pieces, carcasses, plant twigs, leaves, cloth wastes as well as sweepings and many non-biodegradable materials such as plastic bags, plastic bottles, plastic wastes, glass bottles, glass

pieces, stone or cement pieces. On a rough estimate Indian cities are producing solid city wastes to the tune of 50,000 - 80,000 metric tons everyday. If left uncollected and decomposed, they are a cause of several problems.

Urbanization effects - Clogging of drains, Inundation of areas, public health problems, Pollution of drinking water sources, Foul smell and release of gases, Waste management problems. Soil pollution by heavy metals, Soil pollution by pesticides and organic contaminates, Soil pollution by nitrates and phosphorus and Soil pollution by artificial radionuclides. Heavy Metals - even factories at times burn their wastes in incinerators and that again causes huge problems with air pollution and as discussed it later leads to acid rain or acid precipitation. Heavy Metals- Soil contamination by heavy metals such as cadmium, lead, chromium, copper, zinc, mercury and arsenic is a matter of great concern. Heavy metals are present naturally in the soil but their levels are increased by; Industries (non-ferrous industries, power plants, iron, steel and chemical industries); agriculture (irrigation with polluted water, use of mineral fertilisers); waste incineration; combustion of fossil fuels and road traffic that is basically exhaust from automobiles. Pollution of agricultural soils by heavy metal may lead to reduced eels and elevated levels of these elements in agricultural products and thus to their introduction into the food chain. Heavy metal deposits on grassland soil remain predominantly in the top few centimeters and are directly ingested with soil by grazing animals.

Heavy metals are toxic and inhibits the soil's micro organic activity. Their concentration in the soil can remain for decades and even for centuries. Reduction of heavy metal emissions is the most direct way to decrease the atmospheric deposition of these elements and their build-up in the soil. Despite the great increase in traffic, for example a reduction in lead emissions has been achieved through incentives to use unleaded petrol. Implementing complex measures that reduce soil acidification could more efficiently reduce heavy metals. On agricultural land, heavy metal quantities can be decreased by using low-metal content resources for fertilisers, replacing inorganic pesticides with organic products, and other similar methods.

Nitrates and phosphorus - Nitrogen and phosphorus are elements essential to all forms of life and are therefore relevant to soil systems and food crops. Although they are important plant nutrients, excessive application may lead to nitrogen or phosphate saturation in the soil and eventually contaminate the groundwater. The amount of leaching depends on the soil, the local climate and the style of crop management. If you look at Phosphorus, this basically accumulates in the upper layer of the soil in regions with high livestock densities. In soils saturated with phosphorus, especially those with shallow groundwater, high phosphorus concentration occurs in the upper groundwater layer and in surface water, resulting in eutrophication. Moving on to Nitrogen, the problem of nitrate pollution is recognised internationally and is usually associated with intensive agricultural practices. Good agricultural practices that alleviate the problem are;

the selection of crops that require fewer nutrients, a timely application of fertiliser in the growing season, improved methods of manure application, shortening the length of the grazing season, reducing the intensity of grassland use i.e by lowering the density of cattle because when pesticides or any such fertilizers are going to be used in a maximum growing season, if you let grazing animals in at that point of time, the chances of the elements entering the food chain and the food system is much higher, hence it is important that we implement the grazing season as well as the application season of these materials.

Pesticides and Organic contaminants - Pesticides pollute the soil directly by affecting the organisms that reside in it. Soil, however, can act as a vector for the pollution of surface water and groundwater. Organic pollutants enter the soil via atmospheric deposition, direct spreading onto land, contamination by wastewater and waste disposal. In addition to pesticides, organic contaminants include many other components such as oils, chlorinated hydrocarbons, PCBs and dioxins. There is such a wide variety of organic substances that their detection and monitoring in the soil is practically impossible and another main issue with these things is, it cannot be constantly monitored every cycle of crops. It can only be done when land is going to be bought or sold or if there is a water body that's undergoing certain changes in eutrophication or changes in plant and animal life but to ensure there is a regulatory mechanism, its important that farmers keep their eyes opened as well as knowledge is dispersed among farmers about what kind of crops, what kind of fertilizers and pesticides can be used to enable a healthy agricultural life as well as crops as well as ecological cycles. The use of pesticides can lead to the destruction of soil micro flora and fauna which leads to both physical as well as chemical deterioration. Severe yield reduction in crops and leaching of toxic chemicals into groundwater and potentially threatening drinking water resources.

Primordial Radionuclides - Primordial radionuclides are left over from the creation of the Earth. They typically have half-lives of hundreds of millions of years. Examples include uranium - 235, uranium - 238, thorium - 232, and potassium - 40. Primordial radionuclides end up in soil as part of the rock cycle which includes weathering. Tree or plant roots dig down into cracks in the Earth, prying the rock apart and turning it into soil. Natural radioactivity in soil varies based on soil type, mineral makeup and density. Man-made activities such as mining, may accelerate the movement of primordial radionuclides into soil. These are effects of Urbanization, land fills, contamination of water, soil waste. You can see the landfills and collection of plastic bags right by water bodies and the picture on the right bottom depicts a water body that's just turned into a huge puddle.

Some more effects of soil pollution - Pollutiono runs off into rivers and kills the fish, plants and other aquatic life. Crops and fodder grown on polluted soil may pass the pollutants on to the customers. Polluted soil may no longer grow crops and fodder. Soil structure is damaged ie clay

ionic structure gets impaired permanently sometimes. Corrosion of foundations and pipelines which leads to other problems eventually. May release vapours and hydrocarbon into buildings and cellars. May create toxic dusts. May poison children playing in the area.

Impact of Soil Pollution

People living near polluted land have higher instances of migraine, nausea, fatigue, miscarriage, skin disorders. Long time exposure leads to cancer, leukemia, reproductive disorders, kidney and liver damage as well as failure of the central nervous system. Children often suffer from developmental problems and weakened immune systems especially near radioactive zones where they don't even realize their soil is quite naturally radioactive. If nothing is done to clean up soil pollution, water supplies could also become contaminated either because of groundwater or soil water run off, threatening the human species. Sudden fires or explosions will occur from underground landfill gases, pipelines and building structures may corrode and once beautiful regions will turn into cesspools which a lot of these experts are warning about. Some more effects of Soil pollution - dead aquatic life, clogged up soils and water bodies. Another view of soil contamination - excavation showing soil contamination at a disused gasworks. Even though this particular gaswork site has been closed for a number of years when a part of the soil was excavated, you can see the level of pollution it has undergone. A couple of feet under the surface of the soil which means the groundwater is getting polluted as well as the basic fertility of the soil is lost.

Soil contamination or soil pollution as part of land degradation is caused by the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals or improper disposal of waste. This type of contamination typically arises from the failure caused by corrosion of underground storage tanks including piping used to transmit the contents, it can be pipelines used to transfer natural gas, pipelines taking fuel, petrol, anything. Application of pesticides, percolation of contaminated surface water to subsurface strata, oil and fuel dumping, disposal of coal ash, leaching of wastes from landfills or direct discharge of industrial wastes to the soil. The most common chemicals involved are petroleum hydrocarbons, lead, polynuclear aromatic hydrocarbons such as naphthalene and benzo(a)pyrene, solvents, pesticides and other heavy metals. This occurrence of this phenomenon is correlated with the degree of industrialization and intensities at which different chemicals are used in those industries.

The concern over soil contamination basically stems primarily from health risks, direct contact with contaminated soil, vapors from contaminants and from secondary contamination of water supplies within the underlying reach of these soils. Mapping of contaminated soil sites and the resulting cleanup are time consuming and expensive tasks, requiring extensive amounts of

geology, hydrology, chemistry, computer modeling skills and GIS in Environmental Contamination, as well as an appreciation of the history of industrial chemistry.

In North America and Western Europe the extent of contaminated land is best known, with many of countries in these areas having a legal framework to identify and deal with such environmental problems. Usually huge industrial conglomerates have an insurance policy just to avoid such suits of environmental degradation and health hazards resulting from this. Developing countries tend to be less tightly regulated despite some of them having undergone significant industrialization. This is like, we are aware of the danger since other parts of the world have already faced it but we aren't willing to put our foot down and say that this is not going to be allowed here because as a developing country, we cannot lose out on any chance of industrialization or any chance of foreign investments and this is our basic attraction here. We do not have stringent laws protecting the environment at different levels of pollution. Most people are beginning to outsource their production and manufacturing jobs here. This type of contamination or pollution is typically from failure due to corrosion of underground storage tanks. Industrial wastes get discharged into either into the groundwater or to the surface of different kinds of ground fillings come into being and heavy metals are sometimes permanently settled into the soil and this affects not only the growth of plants but also enters the food chain and eventually the human part of the ecological system. We need to be aware of landfills, hydrocarbons from petroleum products, solvents and especially the heavy metals that are naturally occurring or direct discharge of industrial wastes to the soil. The most common chemicals involved are petroleum hydrocarbons, solvents, lead, pesticides and other heavy metals. Treated sewage sludge, known in the industry as biosolids has become controversial as a fertilizer to the land. As it is the byproduct of sewage treatment, it generally contains contaminants such as organisms, pesticides and heavy metals other than soil. Contaminated or polluted soil directly affects human health through direct contact with soil or via inhalation of soil contaminants which have vaporized. This poses a greater threat because infiltration of soil contamination into groundwater aquifers used for human consumption, not just for immediate human consumption but many decades or centuries down the road. Sometimes you might not realize what caused this contamination. These areas are apparently far removed from any apparent source of above ground contamination.

Chronic exposure to benzene at sufficient concentrations is known to be associated with higher incidence of leukemia. Mercury and cyclodienes are known to induce higher incidences of kidney damage, some irreversible. PCBs and cyclodienes are linked to liver toxicity. Organophosphates and carbamates can induce a chain of responses leading to neuromuscular blockage.

Cleanup Options - clean up or environmental remediation is analysed by environmental scientists who utilize field measurement of soil chemicals and also apply computer models (GIS in Environmental Contamination) for analysing transport and fate of soil chemicals. Various technologies have been developed for remediation of oil-contaminated soil/sediments. There are several principal strategies for remediation; Excavate soil and take it to a disposal site away from ready pathways for human or sensitive ecosystem contact. This technique also applies to dredging of bay muds containing toxins. Aeration of soil contaminates its site with a risk of creating air pollution. We have to be aware of which is a worse known devil. Air pollution, once it goes into a state of vapor, it becomes difficult to control as it dissipates over a larger pace of area. What happens when it goes through the soil? It has the same effect but with groundwater as well as aquifers which lead to contamination of not only water of immediate use but also for centuries down the road. Thermal remediation by introduction of heat to raise subsurface temperatures sufficiently high to volatilize chemical contaminants out of the soil for vapour extraction. Technologies include ISTD, electrical resistance heating (ERH). Bioremediation, involving microbial digestion of certain organic chemicals. Techniques used in bioremediation include land farming, biostimulation and bioaugmenting soil biota with commercially available microflora. Extraction of groundwater or soil vapour with an active electromechanical system, with subsequent stripping of the contaminants from the extract. Contaminant of the soil contaminants such as by capping or paving over in place. Phytoremediation or using plants such as willow to extract heavy metals. Mycoremediation, or using fungus to metabolize contaminants and accumulate heavy metals.

When we end up using different kinds of plants as well different parts of the soil structure to reduce the contamination level in the soil, there is nothing better than that as a great option because we can identify certain plant species that absorb certain extra heavy metals and those can be planted in areas where heavy metal poisoning is noticed. This needs a lot of study with respect to plant life, geology, soil, everything needs to be studied and its an interrelation of all these types of study.