1103

Soil Pollution - Major Sources and Types of Soil Pollutants

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ABSTRACT

Although soil is a non-renewable natural resource, human has increasingly used it as a contaminant sink since industrial Revolution. It is getting polluted in a number of ways and there is urgency in controlling the soil pollution in order to preserve the soil fertility and increase the productivity. The soil pollution occurs when amounts of some soil elements and other substances may exceed levels recommended for the health of humans, animals, or plants. Certain chemicals occurred naturally in soils as components of minerals may be toxic at certain concentration other harmful substances may end up in soils through human activities, Such as industrial activities, inadequate waste disposal, mining and by accident soil can be contaminated. Detrimental effects of contaminants on soil may be directly related to loss of biodiversity and functions such as the recycling of nutrients consequently we are losing this important natural resource by the accelerated soil pollution. The concept of soil pollution, sources and types should be clear and understood in order to preserve the fertility and the productivity of the soil and to take control measures in a herculean manner, thereby improving the health of all living beings.

***Key words*:** Soil pollution, Pollutant, Soil, Contamination, Pollution control.

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INTRODUCTION

Environmental pollution is being the burning challenge of current living organisms on the earth. Pollution is the introduction of contaminants into an environment, may also defined as an undesirable change in the physical, chemical and biological characteristics of air, water and soil which affect human life, lives of other useful living plants and animals, industrial progress, living conditions and cultural assets[1]. Pollution can take the form of chemical substances, or energy, such as noise, heat, or light energy. Pollutants as the main, element of pollution can be foreign substances or energies, or naturally occurring, they are considered contaminants when they exceed natural levels. Air, water and soil are being polluted differently. Soil being a "universal sink" bears the greatest burden of environmental pollution[2].

The most soil contaminants are from human activity, including, industrial processes, mining, household, business waste, human and animal pharmaceuticals. Different overview of current research and presents case studies are concerning on heavy metals and synthetic organic chemicals as the major soil contaminants. Soil also contains a great number of biological contaminants such as pathogens, (tetanus) and parasites, (hookworm) which cause many well-documented impacts on human health[3].

The interactions between soil science and human health come from many academic disciplines, including chemistry, geology, geography, anthropology, biology, agronomy, sociology, public health and medicine. As a result, to achieve a clear overview of how soil contamination affects our health requires interdisciplinary teams, and good closed communication between researchers from different fields.

POLLUTION AND POLLUTANTS

A pollutant is a substance or energy introduced into the environment that has undesired effects, or adversely affects the usefulness of a resource. A pollutant may cause long- or short-term damage by changing the growth rate of plant or animal species, by interfering with environmental good health or interfering with human, comfort, health, or property values. Some pollutants are biodegradable and therefore will not persist for the long term in the environment[4]. however the degradation products of some pollutants are themselves polluting such as the products Dichlorodiphenildichloroethylene DDE and Dichlorodiphenildichloroethane DDD produced from degradation of dichlorodiphenyltrichloroethane (DDT). Human activities directly or indirectly affect the environment negatively in different ways and different manner[5] stone crusher adds a lot of suspended particulate

matter and noise into the atmosphere. Automobiles emit from their tail pipes oxides of nitrogen, sulphur dioxide, carbon dioxide, carbon monoxide and a complex mixture of unburnt hydrocarbons and black soot which pollute the atmosphere. Domestic sewage and run off from agricultural fields, laden with pesticides and fertilizers, pollute water bodies. Effluents from tanneries contain many harmful chemicals and emit foul smell; these are only a few examples which show how human activities pollute the environment. The agents which cause environmental pollution are called pollutants. Pollutants may be defined as a physical, chemical or biological substance unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms.

Major Forms of Pollution

The major forms of pollution are listed below along with the particular pollutants relevant to each of them:

- ***Air pollution*:** The release of chemicals and particulates into the atmosphere, common air pollutants include carbon monoxide, sulfur dioxide, chlorofluorocarbons (CFCs) and nitrogen oxides produced by industry and motor vehicles. Photochemical ozone and smog are created as nitrogen oxides and hydrocarbons react to sunlight.
- ***Water pollution*:** By the release of waste products and contaminants into surface runoff into river drainage systems, leaching into groundwater, liquid spills, wastewater discharges, and eutrophication and littering.
- ***Soil pollution*:** Occurs when chemicals are released by spill or underground leakage. Among the most significant soil contaminants are hydrocarbons, heavy metals, herbicides, pesticides and chlorinated hydrocarbons.
- ***Radioactive contamination*:** Resulting from 20^{th} century activities in atomic physics, such as nuclear power generation and nuclear weapons research, manufacture and deployment.
- ***Noise pollution*:** This encompasses roadway noise, aircraft noise, industrial noise as well as high-intensity sonar.
- ***Light pollution*:** Includes light trespass, over-illumination and astronomical interference.
- ***Visual pollution*:** This can refer to the presence of overhead power lines, motorway billboards, and scarred landforms (as from strip mining), open storage of trash or municipal solid waste.
- ***Thermal pollution*:** Is a temperature change in natural water bodies caused by human influence, such as use of water as coolant in a power plant.

SOIL POLLUTION

Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, Radioactive materials, or disease causing agents, which have adverse effects on plant growth and animal health[6]. Soil is the thin layer of organic and inorganic materials that covers the Earth's rocky surface. The organic portion, which is derived from the decayed remains of plants and animal, is concentrated in the dark uppermost topsoil. The inorganic portion made up of rock fragments, was formed over thousands of years by physical and chemical weathering of bedrock. Productive soils are necessary for agriculture to supply the world with sufficient food[7].

Key Concepts in Understanding Soil Pollution and Its Effect to Environmental Health

Soil horizons

Formation of soil from the parent material (bedrock): mechanical weathering of rocks by temperature changes, abrasion, wind, moving water, glaciers, chemical weathering activities and lichens. Under ideal climatic conditions, soft parent material may develop into 1 cm of soil within 15 years.

O & A-horizon: Contain a large amount of bacteria, fungi, earthworms, small insects, forms complex food web in soil, recycles soil nutrients, and contribute to soil fertility.

B-horizon/(subsoil): Less organic material and fewer organisms than A-horizon.

C-horizon: Consists of broken-up bedrock, does not contain any organic materials. Chemical composition helps to determine pH of soil and also influences soil's rate of water absorption and retention.

R-horizon: The unweathered rock (bedrock) layer that is beneath all the other layers (Fig. 1).

Soil properties

Soil composition varies considerably across the world. This is more significant to human health, because parent material (the weathered rock materials from which soils are formed), topography, climate, organisms and time will lead to soils with different physical and chemical properties. A soil composition will affect how much water it can hold, the living organisms it supports, which chemical reactions are likely to occur, and how it cycles nutrients. All of these factors will determine what happens to potentially harmful contaminants in soils, how they may be transported or transformed,

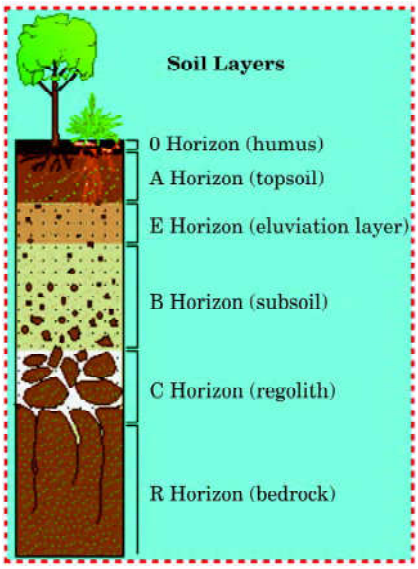

Fig. 1: Different superimposing soil layers[8]

and the extent to which they may be available in chemical forms that are harmful to human health. Soil pH (acidity) is of particular importance because it controls the behavior of metals and many other soil processes. Heavy metal captions (positively charged metal atoms) are most mobile in acid soils. This means that metal contaminants are more available for uptake by plants, or to move into the water supply. Making soil less acidic, by adding lime, is one way to reduce the bioavailability of metals[8].

Soil health

Soil is a dynamic living resource whose wellbeing is vital to both the production of food and fiber for global balance and ecosystem function and in that, it represents a unique balance between physical, chemical and biological factors[9]. Soil health is defined as the continued capacity of the soil to function as a vital living system, by recognizing that it contains biological elements that are key to ecosystem function within land-use boundaries to sustain biological activity, promote the quality of air and water environments and maintain plant, animal and human health[10]. Farmers often use the term 'soil health', which is similar to the term 'soil quality' used by soil scientists. A healthy soil has several physical, chemical and biological properties: it needs to incorporate adequate organic matter, have a good structure, and be home to a diverse mix of organisms. These properties allow the soil to carry out important functions, and may be

achieved in a natural setting by a soil reaching equilibrium with its surroundings, or in managed settings by human intervention to improve the soil's health. Agricultural soil health is linked to human health, as poor soils yield fewer crops with decreased nutritional value. Healthy soils also limit erosion, and help improve air and water quality[11]. Contamination can seriously affect soil's ability to perform some of its key functions in the ecosystem. Soil is a living resource, but once contamination exceeds a certain threshold, the soil may be considered functionally dead'. Pollution by heavy metals and many organic contaminants is practically irreversible[12].

Path of Contaminants from Soils to Human Intake

Contaminated Soil can enter our bodies *via* four main different routes: eating, inhalation, through the skin and indirect contact:

Eating soil (geophagia)

Children under three, in particular, are very likely to eat soil while playing outdoors. As they are considered particularly sensitive to contaminants, young children are thought to be at highest risk from contaminated soils for example, children absorb lead *via* their digestive system five times more efficiently than adults. Accidental ingestion may occur in adults for example, by eating vegetables with some soil still attached, but in some parts of the world, adults also deliberately eat soil for a number of cultural reasons. It is commonly believed that direct ingestion is the most important pathway for human exposure to soil contamination, although other specific pathways have some importance in certain situations. When consumed, some chemicals are absorbed through the lining of the mouth, while others are swallowed and move into the digestive system. From here, they may be absorbed into the body and transported to the liver. Once in the liver, some chemicals are largely returned to the digestive system *via* bile, but others will enter the bloodstream. Some chemicals are broken down to a certain extent in the liver before they reach the blood[13]. Where chemicals are not absorbed, and remain in the gut, they generally do not cause an adverse response, unless they have some direct toxicity to the gut lining.

Inhalation

Working with soil example, in agriculture, the release of particles into the air may be inhaled by workers and others nearby. Very small particles may lodge in the lungs, and there is a chance that contaminants may be absorbed into the bloodstream. Compared to ingestion, this is a far less significant source of exposure, but may be relevant to those exposed repeatedly over a long time period.

Skin contact

Absorption through the skin tends to favour more volatile, organic compounds. This is less of a problem for heavy metals, although some specific forms like Cr(VI), the more toxic form of chromium, or inorganic mercury can cause skin contact problems. Absorption of a chemical through the skin is known as 'dermal absorption', or 'cutaneous' or 'transcutaneous absorption'.

Indirect contact

Soil contaminants may move from soils into ground or surface water, leading to contaminated drinking water. They may also be taken up by plants which are subsequently consumed, either by humans or by agricultural livestock, causing contaminants to enter the human food chain. Some of these effects may be quite significant, as in the case of dioxins accumulating up the food chain, or large quantities of cadmium in crops grown in contaminated soils. High levels of arsenic in drinking water supplies are often another significant indirect result of soil contamination. Arsenic may also be naturally present in groundwater. A contaminant becomes toxic in the human body once the body's own detoxification systems become overloaded[3]. At this point, the body starts to be exposed to excess amounts either of the chemical itself or of a metabolite produced when the body's normal metabolic pathways (the means of processing the toxic compound) are saturated. If a chemical accumulates in tissues, reaching critical toxicity may be an event that results from long-term accumulation. Factors that are relevant in this case are the body's rate of elimination and the overall 'body burden' and the quantity of chemicals stored in body tissues[14]. Reliable data from human populations exposed to known levels of chemicals are not common, with the exception of human pharmaceuticals. For the majority of chemical contaminants, levels likely to pose risks to human health are estimated from toxicology studies on laboratory animals, and models (Fig. 2).

Causes of Soil Pollution

Soil pollution is caused by the presence of man-made chemicals or natural alteration of soil in the environment. Generally soil contamination arises from the rupture of underground storage links, application of pesticides, and percolation of contaminated surface water to subsurface strata, oil and fuel dumping, leaching of wastes from landfills or direct discharge of industrial wastes to the soil[15]. The most common chemicals involved are petroleum hydrocarbons, solvents, pesticides, lead and other heavy metals. This occurrence of this phenomenon is correlated with the degree of industrialization and intensities of chemical usage. A soil pollutant is any factor which deteriorates the quality, texture and mineral content of the

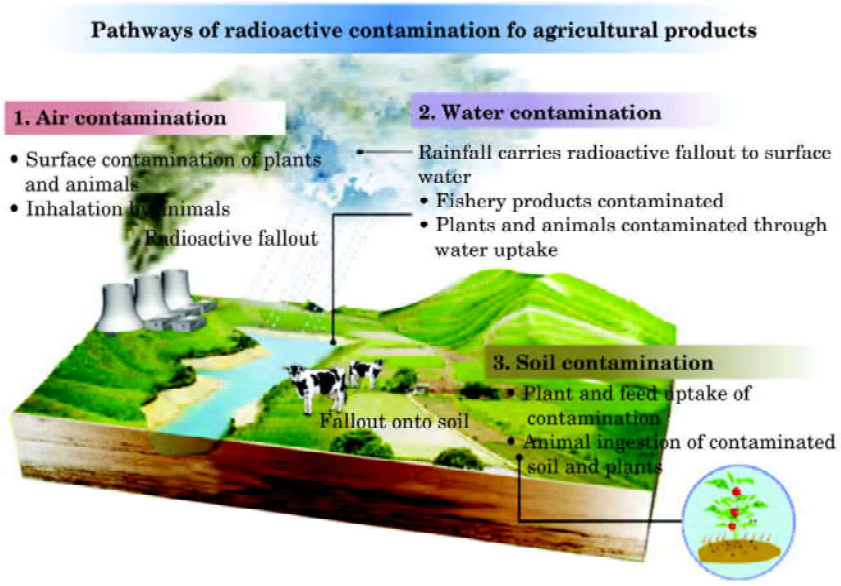

Fig. 2: Pathways of radioactive contamination to agricultural products[13]

soil or which disturbs the biological balance of the organisms in the soil. Soil pollution may be classified into natural causes and man-made causes.

Natural causes

Some of natural causes of soil pollution are earthquakes, landslides, hurricanes, and flood. Such natural disasters cause severe damage to the composition of soil.

Man-made causes

Some of man-made causes of soil pollution are:

Industrial activity: Industrial activity has found to be the biggest contributor of soil pollution in the last century, especially since the amount of mining and manufacturing has increased. Most industries are dependent on extracting minerals from the Earth. Whether it is iron ore or coal, the by products are contaminated and they are not disposed in a manner that can be considered safe. As a result, the industrial wasteL lingers in the soil surface for a long time and makes it unsuitable for use.

Agricultural activities: Chemical utilization has gone up tremendously since technology provided us with modern pesticides and fertilizers. They are full

of chemicals that are not produced in nature and cannot be broken down by it. As a result, they seep into the ground after they mix with water and slowly reduce the fertility of the soil. Other chemicals damage the composition of the soil and make it easier to erode by water and air. Plants absorb many of these pesticides and when they decompose, they cause soil pollution since they become a part of the land.

Indiscriminate use of fertilizers: The major nutrients like nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and more must be obtained from the soil. Farmers generally use fertilizers to correct soil deficiencies. Fertilizers contaminate the soil with impurities, which come from the raw materials used for their manufacture. Mixed fertilizers often contain ammonium nitrate (NH_4NO_3), phosphorus as P_2O_5, and potassium as K_2O. For instance, As, Pb and Cd present in traces in rock phosphate mineral get transferred to super phosphate fertilizer. Since the metals are not degradable, their accumulation in the soil above their toxic levels due to excessive use of phosphate fertilizers becomes an indestructible poison for crops. The over use of NPK fertilizers reduce quantity of vegetables and crops grown on soil over the years. It also reduces the protein content of wheat, maize, grams, etc., grown on that soil. The carbohydrate quality of such crops also gets degraded[16]. Excess potassium content in soil decreases Vitamin C and carotene content in vegetables and fruits and these vegetables and fruits grown on over fertilized soil are more prone to attacks by insects and disease.

Indiscriminate use of pesticides, insecticides and herbicides: Plants on which we depend for food are under attack from insects, fungi, bacteria, viruses, rodents and other animals, and must compete with weeds for nutrients. To kill unwanted populations living in or on their crops, farmers use pesticides. The first widespread insecticide use began at the end of World War II and included DDT (dichlorodiphenyltrichloroethane) and gammaxene. Insects soon became resistant to DDT and as the chemical did not decompose readily, it persisted in the environment. Since it was soluble in fat rather than water, it biomagnified up the food chain and disrupted calcium metabolism in birds, causing eggshells to be thin and fragile. As a result, large birds of prey such as the brown pelican, ospreys, DDT has been now been banned in most developed countries.but Ironically many of them still produce DDT for export to other developing Nations whose needs outweigh the problems caused by it[17].

Waste disposal: Subsequently a growing cause of soil contamination is how we dispose our waste. While industrial waste is sure to cause contamination, there is another way in which we are adding to the pollution. Every human produces a certain amount of personal waste products by way or urine and feces. There is also a large amount that is dumped directly into landfills in the form of diapers. Even the sewer system ends at the landfill, where the biological waste pollutes the soil and water. This is because our bodies are

full of toxins and chemicals which are now seeping into the land and causing pollution of soil. In general, solid waste includes garbage, domestic refuse and discarded solid materials such as those from commercial, industrial and agricultural operations[18]. They contain increasing amounts of paper, cardboards, plastics, glass, old construction material, packaging material and toxic or otherwise hazardous substances. Since a significant amount of urban solid waste tends to be paper and food waste, the majority is recyclable or biodegradable in landfills. Similarly, most agricultural waste is recycled and mining waste is left on site. The portion of solid waste that is hazardous such as oils, battery metals, heavy metals from smelting industries and organic solvents are the ones we have to pay particular attention to. These can in the long run, get deposited to the soils of the surrounding area and pollute them by altering their chemical and biological properties[19].

OIL POLLUTION

It is for a long time that oil materials and its derivatives cause soil pollution as a result of transportation or storage. Oil pollution is an inevitable outcome as a result of rapid population growth and industrialization process, based on which, soil pollution can be observed by oil hydrocarbon materials vastly around exploration and refining installations typically *via* transfer of these materials. In addition to the direct emission of these pollutants, dusts of burning gases along with oil have managed to add toxic and harmful substances to the soils of the region for long years. If more oil materials are penetrated into the more depth of soil, removing its pollution is a difficult task and will cost dearly[20].

Accidental Oil Spills

Oil leaks can happen during storage and transport of chemicals. This can be seen at most of the fuel stations. The chemicals present in the fuel deteriorate the quality of soil and make them unsuitable for cultivation. These chemicals can enter into the groundwater through soil and make the water undrinkable.

Radioactive Wastes

Living organisms are continuously exposed to a variety of radiations called background radiations. If the level of the radioactive radiations increases above a certain limit it causes harmful effects to living beings. This harmful level of radiations emitted by radioactive elements is called radioactive pollution. There are two sources of radiation pollution, namely natural sources and arthropogenic sources. Atomic radioactive minerals are one of natural sources of radioactive pollution. During mining of uranium, radon gas is constantly released into the air. The parent of radon 222 ($t_{1/2}$ = 3.82

days) is radium 226 which has a half-life of 1602 years. Radium-226 is widely distributed in rocks, sediments and soils along with isotopes of uranium[21] radioactive radiations from these natural sources are known as natural or background radiation.

Urbanization

Man is blamed for most of the land degradation, productive area is fast reducing because of developmental activities such as human settlement, industries, roads, railways, airports etc.[22]. Pollution of surface soils by 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 cement pieces. On a rough estimate Indian cities are producing solid city wastes to the tune of 50,000–80,000 metric tons every day. If left uncollected and decomposed, they are a cause of several problems such as:

- ***Clogging of drains*:** Causing serious drainage problems including the burst or leakage of Drainage lines leading to health problems.
- ***Barrier to movement of water*:** Solid wastes have seriously damaged the normal movement of water thus creating problem of inundation, damage to foundation of buildings as well as Public health hazards.
- ***Foul smell*:** Generated by dumping the wastes at a place.
- ***Increased microbial activities*:** Microbial decomposition of organic wastes generate large Quantities of methane besides many chemicals to pollute the soil and water flowing on its surface.
- ***When such solid wastes are hospital wastes they create many health problems*:** As they may have dangerous pathogen within them besides dangerous medicines, injections.

Mining

The main source of metal pollutants in soils is mining and smelting activities, mining can contaminate soils over a large area. Agricultural activities near a mining project may be particularly affected[23]. Mining operations routinely modify the surrounding landscape by exposing previously undisturbed earthen materials, Erosion of exposed soils, extracted mineral ores, tailings, and fine material in waste rock piles can result in substantial sediment loading to surface waters and drainage ways. In addition, spills and leaks of hazardous materials and the deposition of contaminated windblown dust can lead to soil contamination[23]. Human health and environmental risks from soils generally fall into two categories namely contaminated soil resulting from windblown dust, and soils contaminated from chemical spills and residues. Fugitive dust can pose significant environmental problems at

some mines. The inherent toxicity of the dust depends upon the proximity of environmental receptors and type of ones being mined. High levels of arsenic, lead, and radionucleides in windblown dust usually pose the greatest risk. Soils contaminated from chemical spills and residues at mine sites may pose a direct contact risk when these materials are misused.

Deforestation

Soil Erosion occurs when the weathered soil particles are dislodged and carried away by wind or water. Deforestation, agricultural development, temperature extremes, precipitation including acid rain, and human activities contribute to the soil pollution through this kind of erosion. Humans speed up this process by construction, mining, cutting of timber, over cropping and overgrazing. It results in floods and cause soil erosion. Forests and grasslands are an excellent binding material that keeps the soil intact and healthy. They support many habitats and ecosystems, which provide innumerable feeding pathways or food chains to all species. Their loss would threaten food chains and the survival of many species. During the past few years quite a lot of vast green land has been converted into deserts. The precious rain forest habitats of South America, tropical Asia and Africa are coming under pressure of population growth and development especially timber, construction and agriculture. Many scientists believe that a wealth of medicinal substances including a cure for cancer and aids, lie in these forests. Deforestation is slowly destroying the most productive flora and fauna areas in the world, which also form vast tracts of a very valuable sink for CO_2[24].

Acid Rain

Acid rain is formed when pollutants present in the air mixes up with the rain and fall back on the ground. The polluted water could dissolve away some of the important nutrients found in soil and change the structure of the soil.

Pollution of Underground Soil

Many dangerous chemicals like cadmium, chromium, lead, arsenic, selenium products are likely to be deposited in underground soil. Similarly underground soils polluted by sanitary Wastes generate many harmful chemicals. These can damage the normal activities and Ecological balance in the underground soil. This is mostly caused by Chemicals released by industrial wastes and decomposed and partially decomposed materials of sanitary wastes.

SOURCES OF SOIL POLLUTION

In modern economies, various types of activity, including agriculture, industry and transportation, produce a large amount of wastes and new types of pollutants. Soil, air and water have traditionally been used as sites for the disposal of all these wastes. For example, beef cattle in the United States are estimated to produce 92 million mt/year of manure, while dairy cattle produce 27 million mt/year[25]. Some of this manure may wash into nearby streams, and pollute rivers, lakes and soil. The most common kinds of waste can be classified into four types: agricultural, industrial, municipal and nuclear[26].

Agricultural Sources

The main agricultural source of Soil pollution caused by the overuse of fertilizers and pesticides Agricultural wastes include a wide range of organic materials often containing pesticides, animal wastes, and timber by-products. Many of these, such as plant residues and livestock manure, are very beneficial if they are returned to the soil. However, improper handling and disposal may cause pollution. A study carried out by Kasno *et al*.[27] in an area of intensive lowland rice farming in West Java found that the levels of lead and cadmium in the soil were fairly low. Lead was present in soil samples in a range of 10–43 ppm, while the levels of cadmium were 0.19–0.49 ppm. The content of lead and cadmium which were present may have originated in applications of phosphate fertilizer. Phosphate fertilizer is essential in intensive agriculture, with its high rainfall and rapid leaching. These conditions result in a low soil pH and high levels of iron and aluminum oxide. These in turn immobilize the phosphorus in the soil solution, and hinder its uptake by plants. Based on the levels of lead and cadmium in rice[27] found that intensive lowland rice areas could be divided into three categories: Highly polluted soils, soils with medium pollution, and unpolluted soils. These results indicate that after 30–40 years of phosphate application, the productivity of these soils could still be sustained. Another study was conducted in tea plantations in an area of West Java which is important for agroforestry and tourism[28]. The aim of the study was to evaluate the effect of air pollution by automobiles on soil quality. The result of the soil survey showed that the lead content of the soil in the plantations increased near main roads. The level of soil pollution by lead, most of which was produced by petrol combustion depended on the distance from the main road. However, the cadmium content in soils was not influenced by the distance from the main road. This indicates that the cadmium content in the soil was not the result of air pollution, but may have resulted from the application of high levels of phosphate fertilizer in these areas.

Non-agricultural Sources

Industrial waste

Products may be in gas, liquid or solid form. The most important gases are carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). They are produced by combustion in industry and by automobiles, and they pose a hazard to the environment. Food processing plants produce both liquid and solid wastes. Another urban waste is municipal garbage. This is made up of materials discarded by homes and industry. It contains paper, plastic and organic materials. Some of these can be recycled by composting or they may be burnt or disposed of in landfills. Sewage sludge is the product of treatment plants and the materials processed in the treatment plants are domestic and industrial wastes. They are usually liquid mixtures, composed both of solids, and dissolved organic and inorganic materials. The water is separated from the solid part by a number of treatments before it is environmentally safe for discharge into streams or lakes. The content of major nutrients and micronutrients in sewage sludge varies depending on the source. Data indicates that the nitrogen content of textile sludge is generally high. However, the heavy metal content is also high. Some trace elements are required in small amounts by plants and animals, whereas others are hazardous to human health.

Based to the result obtained on a study conducted to find industrial pollution in areas surrounding. These areas are being polluted by heavy metals from sewage sludge produced by the textile industry. This waste is often disposed directly into rivers, all of which can be used to irrigate crop in agriculture. Soil surveys conducted by[29] revealed that there were very high concentrations of boron, cadmium and lead. Falling soil productivity in these areas caused a reduction in rice yields and farmers' incomes. After 20 years of contamination, the average rice yield had decreased by about 80%. The initial rice yield of about 4-6 mt/ha had become 1 mt/ha. However, the heavy metal content in the soil had increased by about 18–98%, compared to unpolluted soil. A greenhouse study using polluted soil showed that high concentrations of lead, cadmium, copper, chromium and boron were found in the plant tissue, roots and grain of rice but generally the most of the pollutants had accumulated in the root system.

Mining and smelting

Gold mining is carried out by individuals rather than companies especially in developing countries; they use traditional methods for separating the gold from the raw material. The main waste product from this process is mud and rubble which contain a high concentration of mercury. These wastes are disposed of directly in the river, which is also used as a source of irrigation water or in domestic activities. A soil survey conducted in some

areas nearby mining site found that the soil surrounding the traditional mining was polluted by mercury and the concentration of mercury in soil near the mining was higher 3 times than in more distant soils[29].

Types of Soil Pollutants and their Impact on Ecological Health

Once contaminants are in soils, where they go as their destination and how quickly they travel depends on many factors. Some organic contaminants (carbon-based compound) can undergo chemical changes or degrade into products that may be more or less toxic than the original compound. Note that chemical elements such as heavy metals cannot break down, but their characteristics may change so that they can be more or less easily taken up by plants or animals[30]. Different contaminants vary in their tendency to:

- End up in water held in the soil or in the underlying groundwater by leaching through the soil
- Volatilize (evaporate) into the air
- Bind tightly to the soil.

The soil properties also affect the rate of contaminants and whether they can be readily taken up by plants or animals. Site management and land use such as gardening practices can affect some soil characteristics. Important soil characteristics that may affect the behavior of contaminants include (Fig. 3):

- Soil mineralogy and clay content (soil texture)
- pH (acidity) of the soil
- Amount of organic matter in the soil
- Moisture levels
- Temperature
- Presence of other chemicals.

Heavy Metals

Heavy metal contamination refers to the excessive deposition of toxic heavy metals in the soil caused mostly by human activities. Heavy metals in the soil include some significant metals of biological toxicity, such as mercury (Hg), cadmium (Cd), lead (Pb), chromium (Cr) and arsenic (As), etc. They also include other heavy metals of certain biological toxicity, such as zinc (Zn), copper (Cu), nickel (Ni), stannum (Sn), vanadium (V), etc. In recent years, with the development of the global economy, both type and content of heavy metals in the soil caused by human activities have gradually increased, resulting in the deterioration of the environment[31–34]. Heavy metals are highly hazardous to the environment and organisms. It can be enriched through the food chain. Once the soil suffers from heavy metal contamination, it is difficult to be remediated.

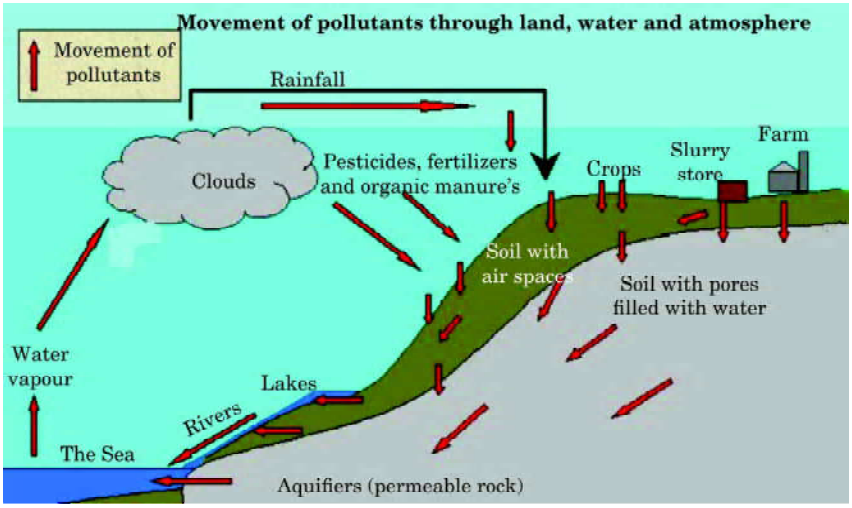

Fig. 3: Movement of pollutants through land, water and atmosphere (30)

In the past, heavy metal soil contamination was not considered as important as air and water pollution, because soil contamination was often with wide range and was more difficult to be controlled and governed than air and water pollution. However, in recent years the soil contamination by heavy metals in developed countries becomes to be serious and it is thus paid more and more attention and became a hot topic of environmental protection worldwide[35].

CHARACTERISTICS OF HEAVY METALS AS SOIL CONTAMINANTS

Wide Distribution

With the development of economy and society, heavy metal contamination has become increasingly common in the world. It is almost a serious threat to every country. In the world's top ten environmental events, two events have related to heavy metal contamination[36].

Strong latency

Heavy metal contamination is colorless and odorless, so it is difficult to be noticed. It does not explicitly damage the environment in a short period. Nevertheless, when it exceeds the environmental tolerance, or when environmental conditions have changed, heavy metals in the soil may be activated and cause serious ecological damage therefore, heavy metal contamination is called chemical Time Bombs (CTBs)[37].

Irreversibility and Remediation Hardness

If the air and water are polluted, the pollution problem can be reversed certainly by dilution and Self-purification after switching off the sources of pollution. However, it is difficult to use dilution or self-purification techniques to eliminate heavy metal contamination and to get soils improved. Some soils contaminated by heavy metals are likely to take one or two hundred years to be remediated[37]. Therefore, heavy metal contamination needs relatively high cost of remediation and the remediation cycle is relative with long period.

Complex Heavy Metal Contamination

In the past, soil contamination was mainly caused by a single heavy metal. However, in recent years more cases are found to be caused by a variety of heavy metals[38] the complex contamination caused by a variety of heavy metals will always amplify the contamination by heavy metals separately[39]. Showed that in terms of the influence on soil respiration, Cu+ Pb > Pb > Cu.

Sources of Heavy Metals

Excess heavy metals in the soil originate from many sources, which include atmospheric deposition, sewage irrigation, improper stocking of the industrial solid waste, mining activities, the use of pesticides and fertilizers in agriculture etc[40]. The Table 2 describe different sources of heavy metal contaminants of soils across the world.

Atmosphere to Soils Pathway

Heavy metals in the atmosphere are mainly from gas and dust produced by energy, transport, metallurgy and production of construction materials. Excepting mercury, heavy metals basically go into the atmosphere in the form of aerosol and deposit to the soil through natural sedimentation and precipitation, etc. For example, the lead pollution in a downtown, Central Sweden, was reported mainly from the urban industrial copper plant, sulfuric acid plant, paint factory, and the large amount of waste from mining and chemical industries[41] Due to transporting by wind, these fine lead particles spread from industrial waste heap to surrounding areas. The superimposed chromium contamination by a heavy industrial factory producing.

Chromium[42] in Nanjing was reported more than 4.4 times of the local background value. The chromium contamination was centered on the chimney of workshop, ranging up to 1.5 km^2, and extending 1.38 km away.

A sulfuric acid production plant in Russia[43] was reported to contaminate the environment because of the discharge of S, V, and As from the factory chimneys. Transport, especially the automotive transport, causes serious heavy metal contamination (Pb, Zn, Cd, Cr, Cu, etc.) of the atmosphere and soils[44] Heavy metals come from burning leaded gasoline and the dust produced by automobile tire wear. In the Nanjing section of Nanjing-Hangzhou highway, the soil on both sides of the road had formed contamination zone of Pb, Cr, and Co. And the contamination zone was direction of the both sides of the highway. The amount of heavy metals which went into the soil through natural deposition and raining sedimentation are related to the level of development of heavy industry, the city's population density, land utilization and traffic level. Soil contamination became to be heavier as closing to the city[45].

Sewage to Soils Pathway

Wastewater can be divided into several categories, sanitary sewage, chemical wastewater, industrial mining wastewater and urban mining mixed sewage, etc. Heavy metals are brought to the soil by irrigative sewage and are fixed in the soil in different ways[46] it causes heavy metals (Hg, Cd, Pb, Cr, etc.) to continually accumulate in the soil year by year. Sewage irrigation is a feasible way to solve the problem of crop irrigation in the arid area. However, heavy metal contamination caused by sewage irrigation must be paid enough attention. Quality of irrigative sewage must be strictly controlled within the national quality standard for irrigation water.

Solid Wastes to Soils Pathway

There are a variety of solid wastes which have complex composition of which mining and industrial solid Waste contamination is the most serious. When these wastes are in the process of being piled or governed, heavy metals move easily due to the facilitation of sunlight, raining and washing. And they spread to the surrounding water and soils at the shape of funnel and radiation. With the development of industry and the acceleration of urban environmental construction, sewage treatment is continuing to be strengthened[42]. In general, Cr, Pb, Cu, Zn and As in the sludge will exceed the control standards easily.

Agricultural Supplies to Soils Pathway

Fertilizers, pesticides and mulch are important agricultural inputs for agricultural production[40]. On the other side, the long-term excessive application has resulted in the heavy metal contamination of soils. The vast majority of pesticides are organic compounds, and a few are organic - inorganic compound or pure mineral, and some pesticides contain Hg, As,

Cu, Zn and other heavy metals[47]. Heavy metals are the most reported pollutants in fertilizers. Heavy metal content is relatively low in nitrogen and potash fertilizers, while phosphoric fertilizers usually contain considerable toxic heavy metals followed by compound fertilizers[48]. Cd is an important heavy metal contaminant in the soil and is brought to soils with the application of phosphoric fertilizers. In recent years, the mulch has been promoted and used in large areas, which results in white pollution of soils, because the heat stabilizers, which contain Cd and Pb, are always added in the production process of mulch. This increases heavy metal contamination of soils distributed along the direction of the highway[49].

Negative Impact of Heavy Metal Contaminants on Soils

Microorganisms and enzymatic activity in soil

Lee *et al*.[50] concluded that microbial biomass of the soil is an important indicator of determining the extent of soil contamination and Microbial activity is inhibited significantly in the heavy metal contaminated soil. The microbial biomass in the soil contaminated by Cu, Zn, Pb and other heavy metals are always inhibited severely[52]. The soil's microbial biomass near the mine was significantly lower than that far away from the mine. And the effects of different concentrations of heavy metals and different heavy metals on soil microbial biomass were different[52]. Studied the effect of different concentrations of heavy metals on soil microbial biomass, and found that only if the concentration of heavy metals in the soil was three times above the environmental standard, established by the European Union, it could inhibit microbial biomass. low concentrations of heavy metals could stimulate microbial growth and increase microbial biomass; while high concentrations could decrease soil microbial biomass significantly[53]. In addition, the enzymes in the soil play an important role in the process of organic matter decomposition and nutrient cycling. Studies have shown that the activities of enzymes in the soil are related to the heavy metal contamination. The activities of almost all enzymes in the soil were significantly reduced by 10 to 50 times with the increase of the concentration of heavy metals[52].

Impact on the plants

The Low concentration of soil heavy metals, will not affect the growth of plants in a certain range. But if the concentration is too high, the content of heavy metals enriched by the plant exceeds its tolerance threshold, and thus the plant will be poisoned and it even leads to death of the plant[54]. In Florida, it was found that if the copper content in soil was more than 50 mg/kg, it would affect citrus seedlings; if soil copper content reached 200 mg/kg, wheat would wither[55]. Research found that the growth of cabbage and

bean seedling under Cd concentration of 30 µmol/ L was inhibited: the root length decreased, and the plant height and leaf area dropped[56] Cd may interfere with crop photosynthesis and protein synthesis, and may cause membrane damage, etc.

Impact on Human Health

The preview research showed that heavy metals in urban soils may go into the human body through skin absorption and inhalation of dust, etc., and thus directly damage, especially children's health. They also affect the urban environmental quality and damage human health indirectly through polluting the food, water and atmosphere. In a study carried out by Yabe *et al*.[57] on the content of Pb in children blood, found that the contaminated soil dust in the city was an important factor to affect human health. Cd may damage the metabolism of calcium, which will cause calcium deficiency and result in cartilage disease and bone fractures. Agency for Toxic Substances Management Committee has listed Cd as the sixth most toxic substance that damages human health. Pb mainly enters human body through the digestive tract and respiratory tract, and then goes into the blood circulation in the form of soluble salts, protein complexes or ions, etc. 95% of the insoluble phosphate lead accumulates in bones. Pb is strongly pro-organizational, It affects and damages many of the body organs and systems, such as kidney, liver, reproductive system, nervous system, urinary system, immune system and the basic physiological processes of cells and gene expression. Cu, Zn and Ni are essential trace metals in the human body, but if the body takes excessive Cu, Zn and Ni from the outside environment, they will damage human health. Ni and Cu are tumor promoting factors, people who are in direct contact with the Ni powder are more likely to suffer from respiratory cancer, and the content of Ni in the environment is positively correlated with nasopharyngeal carcinoma[58].

Classes of Soil Contaminated by Heavy Metal

The level of heavy metal contamination in the soil is analyzed and determined by geoaccumulation index (Igeo), which was established by Muller[59] geoaccumulation index is obtained by comparing the contamination levels before contamination and present contamination. The computation of Igeo through this following fulmula: $Igeo= \log^2(Cn/1.5Bn)$ where Cn is the measured mass fraction of the metal (mg/kg^{-1}). Bn is the background mass fraction of the metal (mg/kg^{-1}) to calculate Igeo. Muller's evaluation method[59] can be used to evaluate the level of heavy metal contamination in soils, as shown in Table 1 & 2 below:

Table 1: Geoaccumulation index classification

Geoaccumulation index	*Classification*	*Level of contamination*
5 < I geo ≤ 10	6	Extremely serious
4 < I geo ≤ 5	5	Strong to extremely serious
3 < I geo ≤ 4	4	Strong
2 < I geo ≤ 3	3	Moderate to strong
1 < I geo ≤ 2	2	Moderate
0 < I geo ≤ 1	1	Light to moderate
I geo ≤ 0	0	Non contamination

Source: [60]

Table 2: Different sources of heavy metals contaminating soils annually in the world (1000 t • a–1).

Source	*AS*	*Cd*	*Cr*	*Cu*	*Hg*	*Ni*	*Pb*	*Zn*
Agriculture and food waste	0~0.6	0~0.3	4.5~90	3~38	0~1.5	6~45	1.5~27	12~150
Farmyard manure	1.2~4.4	0.2~1.2	10~60	14~80	0~0.2	3~36	3.2~20	50~320
Logging and timber	0~3.3	0~2.2	2.2~18	3.3~52	0~2.2	2.2~23	6.6~8.2	13~65
Industry waste municipal wastes	0.09~0.7	0.88~7.5	6.6~33	13~40	0~0.26	2.2~10	18~62	22~97
Municipal sludge	0.01~0.24	0.02~0.34	1.4~11	4.9~21	0.01~0.8	5.0~22	2.8~9.7	18~57
Organic wastes	0~0.25	0~0.01	0.1~0.48	0.04~0.61	_	0.17~3.2	0.17~3.2	0.13~2.1
Metal processing	0.01~0.21	0~0.08	0.65~2.4	0.95~7.6	0~0.08	0.84~2.5	4.1~11	2.7~19
Solid wastes coal ash	6.7~37	1.5~13	149~446	93~335	0.37~4.8	56~279	45~242	112~484
Fertilizer	0~0.02	0.03~0.25	0.03~0.38	0.05~0.58	_	0.20~3.5	0.42~2.3	0.25~1.1
Marl	0.04~0.5	0~0.11	0.04~0.19	0.15~2.0	0~0.02	0.22~3.5	0.45~2.6	0.15~3.5
Commodity impurities	36~41	0.78~1.6	305~610	395~790	0.55~0.82	6.5~32	195~390	310~620
Atmospheric deposition	8.4~18	2.2~8.4	5.1~38	14~36	0.63~4.3	11~37	202~263	49~135
Total	52~112	5.6~38	484~1309	41~1367	1.6~15	106~544	479~1113	689~2054

Source: [61]

DIOXINS

The term "dioxin" refers to a group of chemical compounds sharing certain similar structures and biological characteristics, Several hundred of these toxic compounds exist and are members of three closely related families: the chlorinated dibenzo–*p*–dioxins (CDDs), chlorinated dibenzofurans (CDFs) and certain polychlorinated biphenyls (PCBs). Sometimes the term dioxin is also used to refer to the most well–studied and one of the most toxic dioxins, 2,3,7,8–tetrachlorodibenzo–*p*–dioxin (TCDD)[62]. Dioxin compounds are not created intentionally, but are formed inadvertently by a number of human and natural activities. These activities include combustion and incineration, forest fires, chlorine bleaching of pulp and paper, certain types of chemical manufacturing and processing, and other industrial processes (2000) Burning materials that may contain chlorine such as plastics, wood treated with pentachlorophenol (PCP), pesticide–treated wastes, other chemicals such as polychlorinated biphenols (PCBs), and even bleached paper can produce dioxins[63]. Cigarette smoke, some home–heating systems, and exhaust from vehicles using leaded and unleaded gasolines as well as diesel fuels also produce small amounts of dioxins.

Sources of Dioxin Exposure

The largest source is past application of contaminated herbicides on agricultural soils. Waste incineration, industrial processes and deposition onto soils from atmospheric fallout are also significant sources, in addition to sewage sludge application. When dioxins enter soils, they remain in the very top layer at the top of 0.1 cm with a half–life of 9–15 years. At deeper soil levels, dioxins can persist for 25–100 years. With dioxins persisting in the human body with a half–life of up to 11 years, it can be quite difficult to make direct correlations between concentrations of dioxins in human tissue and local soils[3].

Although dioxins form locally, their environmental distribution is global and are found throughout the world. The highest levels of these compounds are found in some soils, sediments and food, especially dairy products, meat, fish and shellfish. Very low levels are found in plants, water and air. Extensive stores of PCB–based waste industrial oils, many with high levels of PCDFs, exist throughout the world. Long–term storage and improper disposal of this material may result in dioxin release into the environment and the contamination of human and animal food supplies. PCB–based waste is not easily disposed of without contamination of the environment and human populations. Such material needs to be treated as hazardous waste and is best destroyed by high temperature incineration.

Toxicity of Dioxins to Humans and Wildlife

Dioxins are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer. Dioxins are everywhere all humans have background exposure leading to a body burden of these chemicals, which is not expected to affect human health when low. But due to the highly toxic potential of this class of compounds, reducing current background exposure is advisable. Once dioxins have entered the body, they remain for a long time because of their chemical stability and their ability to be stored in body fat[64]. Short–term exposure of humans to high levels of dioxins may result in skin lesions, such as chloracne and patchy darkening of the skin, and altered liver function. Long–term exposure is linked to impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions. Chronic exposure of animals to dioxins has resulted in several types of cancer. TCDD was evaluated by the WHO's International Agency for Research on Cancer[64] and, based on animal data and on human epidemiology data, was classified as a 'known human carcinogen'. However, it does not affect genetic material and there is a level of exposure below which cancer risk would be negligible. Concerns about dioxins are often centered on immediate effects rather than long–term effects (chronic). Fetuses, infants, and children may be more sensitive to dioxin exposure because of their rapid growth and development. Data on risks to children are limited, however, and it is not known if children in the general population are experiencing adverse effects from dioxin[62]. Based on data from animal studies, exposure to low levels of dioxins over long periods or high level exposures at sensitive times might weaken the immune system[65].

Asbestos

Asbestos is the generic commercial designation for a group of naturally occurring mineral silicate fibers of the serpentine and amphibole series with high tensile strength, flexibility, and resistance to heat, chemicals, and electricity. These include the serpentine mineral chrysotile (also known as 'white asbestos'), and the five amphibole minerals–actinolite, amosite(also known as 'brown asbestos'), anthophyllite,crocidolite (also known as 'blue asbestos'), and tremolite[66]. It was once used widely in the production of many industrial and household products because of its useful properties, including fire retardation, electrical and thermal insulation, chemical and thermal stability, and high tensile strength. However, asbestos is recognized as a cause of various diseases and cancers and is considered a health hazard if inhaled[67].

Chemical and Physical Properties of the Agent

The silicate tetrahedron (SiO_4) is the basic chemical unit of all silicate minerals. The number of tetrahedra in the crystal structure and how they are arranged determine how a silicate mineral is classified. Serpentine silicates are classified as 'sheet silicates' because the tetrahedra are arranged to form sheets. Amphibole silicates are classified as 'chain silicates' because the tetrahedral are arranged to form a double chain of two rows aligned side by side. Magnesium is coordinated with the oxygen atom in serpentine silicates. In amphibole silicates, cationic elements such as aluminium, calcium, iron, magnesium, potassium, and sodium are attached to the tetrahedra. Amphiboles are distinguished from one another by their chemical composition. The chemicalformulas of asbestos minerals are idealized. In natural samples, the composition varies with respect to major and trace elements[66]. Asbestos fibres tend to possess good strength properties (*e.g.*, high tensile strength, wear and friction characteristics); flexibility (*e.g.*, the ability to be woven); excellent thermal properties (*e.g.*, heat stability; thermal, electrical and acoustic insulation); adsorption capacity; and, resistance to chemical, thermal and biological degradation[66,68].

Natural Occurrence

Asbestos minerals are widespread in the environment, and are found in many areas where the original rock mass has undergone metamorphism[66,69]. Examples include large chrysotile deposits in the Ural Mountains in the Russian Federation, in the Appalachian Mountains in the USA, and in Canada[70]. They may occur in large natural deposits or as contaminants in other minerals (*e.g.*, tremolite asbestos may occur in deposits of chrysotile, vermiculite, and talc). The most commonly occurring form of asbestos is chrysotile, and its fibres are found as veins in serpentine rock formations. Asbestiform amphiboles occur in relatively low quantities throughout the earth's crust and their chemical composition reflects the environment in which they form[71].

Asbestos can enter the soil and sediment through natural (*e.g.*, weathering and erosion of asbestos–bearing rocks) and anthropogenic (*e.g.*, disposal of asbestos–containing wastes in landfills) sources. The practice of disposing asbestos–containing materials in landfills was more common in the past, and is restricted in many countries by regulation or legislation[69].

Uses

Today, however, asbestos is recognized as a cause of various diseases and cancers and is considered a health hazard if inhaled. The current survey estimates that over the last several decades 100,000 deaths globally have been due to asbestos exposure, and the WHO states that 90,000 people die

a year globally because of occupational asbestos exposure. As described above, asbestos has several chemical and physical properties that make it desirable for a wide range of industrial applications. By the time industrial and commercial use of asbestos peaked, more than 3000 applications or types of products were listed[68]. Over 90% of asbestos 5 fiber produced today is chrysotile, which is used in asbestos–cement (A–C) construction materials: A–C flat and corrugated sheet, A–C pipe, and A–C water storage tanks. Other products still being manufactured with asbestos content include vehicle brake and clutch pads, roofing, and gaskets. Though today asbestos is hardly used in construction materials other than asbestos–cement products, it is still found in older buildings in the form of friable surfacing materials, thermal system insulation, non–friable flooring materials, and other applications. The maintenance and removal of these materials warrant special attention.

Negative Impact on Human Health

Information on the health effects of asbestos in humans comes mostly from studies of people who were exposed in the past to high levels of asbestos in the workplace. These asbestos workers were found to have increased chances of getting two types of cancer: cancer of the lung tissue itself, and mesothelioma, a cancer of the thin membrane that surrounds the lung and other internal organs. Both lung cancer and mesothelioma are usually fatal. These diseases do not appear immediately, but develop only after a number of years. There is also some evidence from studies of workers that breathing asbestos can increase the chances of getting cancer in other locations (*e.g.*, stomach, intestines, esophagus, pancreas, kidneys), but this is less certain. Members of the public who are exposed to lower levels of asbestos may also have increased chances of getting cancer, but the risks are usually small and are difficult to measure directly[64]. the epidemiological evidence showed a high incidence of lung cancer among workers exposed to chrysotile, amosite, anthophyllite, and with mixed fibres containing crocidolite, and tremolite. Pleural and peritoneal mesotheliomas were reported to be associated with occupational exposures to crocidolite, amosite, and chrysotile. Gastrointestinal tract cancers were reported to have been demonstrated in groups occupationally exposed to amosite, chrysotile or mixed fibres containing chrysotile. An excess of cancer of the larynx in occupationally exposed individuals was also noted. Finally the *Monograph* points out that mesothelioma may occur among individuals living in neighbourhoods of asbestos factories and crocidolite mines, and in persons living with asbestos workers[67]. Dioxins can alter the fundamental growth and development of cells in many ways. For example dioxins may:

- Cause cancer,
- Disrupt the endocrine system, and
- Cause reproductive and developmental effects

ORGANIC POLLUTANTS PESTICIDES, FERTILIZERS AND OTHER AGRICULTURE PRODUCT

Organic (carbon–based) pollutants include pesticides, fertilizers. All those once released into air or water will end up in soils, with the exception of those that are deposited at the bottom of oceans. Among organic pollutants some are referred to as 'POPs,' or persistent organic pollutants, which do not break down quickly in the environment. Types of organic pollutants found in soil include:

- Polychlorinated biphenyls (PCBs)
- Polybrominated biphenyls
- Polychlorinated dibenzofurans (PCDFs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Organophosphorus and carbamate insecticides (pesticides)
- Herbicides
- Organic fuels (gasoline, diesel)
- Pharmaceuticals and their metabolites

Health effects of organic pollutant exposure

The health effects of organic pollutants could include the following[13,72]:

- Individuals with increased exposure to pesticides (*e.g.*, farmers, landscapers) appear to be at greater risk of non–Hodgkin lymphoma. Studies have also shown a greater risk among children from homes where pesticides are frequently used, or otherwise subject to higher exposure.
- Some studies have linked leukaemia, particularly in children, with insecticides. Timing of exposure is significant, with children exposed in the womb most likely to be affected. Pesticides have also been linked to brain cancer in children whose parents are exposed to high levels of pesticides, for example, through work.
- Some studies have linked pesticides to breast cancer and benign breast changes, although other studies have produced findings that disagree and pesticide exposure to kidney cancer and pancreatic cancer.
- Several studies have linked pesticides to increased risks of prostate cancer, particularly relating to the fumigant methyl bromide. Links have also been made between stomach cancer and atrazine[72].
- Long–term effects of pesticides on the nervous system include cognitive and psychomotor dysfunction, and neurodegenerative and neurodevelopmental effects. Pesticide poisonings result in well described acute and chronic neurotoxic syndromes. Chronic effects from low or moderate exposures have been less well documented.

Many studies have shown that occupational pesticide exposure could increase the risk of later developing Parkinson's disease.

- Those exposed to pesticides also had a greater frequency of chromosome aberrations (genotoxic effects), although it is hard to separate these effects from other sources of genetic damage, such as smoking, alcohol or radiation[13]. Overall, few studies have been conducted on the toxicity of complex chemical mixtures in soils. The effects of the soil and organisms within it upon organic pollutants are unknown. The data that do exist tend to be on short–term, high level exposure of these chemicals, which is less relevant to the potential low–level, long term health impacts from living near to contaminated soil (soil).

The chemical industry creates (or previously created) these compounds in very large quantities, to use in a wide range of products including plastics, refrigerants, preservatives and pesticides. Many POPs are actually by–products of these processes, and are not useful in their own right. Examples include dioxins, and polychlorinated dibenzofurans (PCDFs).

EFFECTS OF SOIL POLLUTION

Effect on Human Health

The human life depends upon the soil health and we consider soil as the first resources of our everyday life consequently its contamination has major consequences on our health. Crops and plants grown on polluted soil absorb much of the pollution and then pass these on to us. This could explain the sudden surge in small and terminal illnesses. Long term exposure to such soil can affect the genetic make–up of the body, causing congenital illnesses and chronic health problems that cannot be cured easily. In fact, it can sicken the livestock to a considerable extent and cause food poisoning over a long period of time. The soil pollution can even lead to widespread famines if the plants are unable to grow in it.

Effect on Growth of Plants

The ecological balance of any system gets affected due to the widespread contamination of the soil. Most of plants are unable to adapt when physical, chemical, and biological properties of soil changes so radically in a short period of time. Fungi and bacteria found in the soil that bind it together begin to decline, which creates an additional problem of soil erosion, The soil fertility decrease slowly, making land unsuitable for agriculture and any local vegetation to survive. The soil pollution causes large tracts of land to become hazardous to health. Unlike deserts, which are suitable for its native vegetation, such land cannot support most forms of life.

Decreased Soil Fertility

The toxic chemicals present in the soil can decrease soil fertility and therefore decrease in the soil yield. The contaminated soil is then used to produce fruits and vegetables which lacks quality nutrients and may contain some poisonous substance to cause serious health problems in people consuming them.

Toxic Dust

The emission of toxic and foul gases from landfills pollutes the environment and causes serious effects on health of some people. The unpleasant smell causes inconvenience to other people.

Changes in Soil Structure

The death of many soil organisms such as earthworms and microbes in the soil can lead to alteration in soil structure. Apart from that, it could also force other predators to move to other places in search of food.

A number of ways have been suggested to control the current rate of pollution. Such attempts at cleaning up the environment require plenty of time and resources to be pitched in. Industries have been given regulations for the disposal of hazardous waste, which aims at minimizing the area that becomes polluted. Organic farming as agriculture method is being supported, which do not use chemicals like pesticides and fertilizers. Use of plants that can remove the pollutants from the soil is being encouraged. However, the road ahead is quite long and the prevention of soil pollution will take many more years.

Control of Soil Pollution

The following steps have been suggested to control soil pollution. To help prevent soil erosion, we can limit construction in sensitive area. In general we would need less fertilizer and fewer pesticides if we could all adopt the three R's: Reduce, Reuse, and Recycle. This would give us less solid waste.

Extraction and Separation Techniques

In solvent extraction, the contaminated and oil is mixed with an extracting agent in general (an aqueous solution but preferably an organic solvent). Potential applications include the removal of metals such as cadmium, copper, zinc, nickel, chromium, arsenic, antimony and lead using a mineral solution, zinc lead, organo–metallic compounds and some cyanides using

sodium hydroxide solution. Hydrocarbons and halogenated hydrocarbons can also be removed[73]. Contamination is often preferentially present in the finer or coarser fraction of the soil or the organic components like humus, contamination can therefore, be removed in some cases using a process which separates the soil into fractions on the basis of specific gravity or particle size or settling velocity.

Thermal methods (physical method)

In thermal methods, there are two ways of heat treatment; removal of contaminants by evaporation either by direct heat transfer from heated air or an open flame or by indirect heat transfer, and destruction of the contaminants directly or indirectly at an appropriate temperature. The gas leaving the heating appliance must be treated to destroy or remove any contaminants or unwanted products of combustion. A related process is stream stripping in which steam is injected into soil to aid evaporation of relatively volatile contaminants which may be water soluble or insoluble.

Chemical methods

Treatment of the soil in suspension in a suitable liquid and without sludging is the two possible methods. In these, intimate, contact between soil and chemical is essential and should be frequently done so that the process of detoxification is complete.

Microbial treatment methods

The microbial treatment methods appear to be more promising which can deal with whole range of organic contaminants including phenol, polychlorinated hydrocarbons, oil and oil products, dioxins, etc. There are two different ways of approaching the problems.

1. A community of microbes already existing on the site is collected and cultured in the Laboratory.
2. Strains of microbes are developed in the laboratory that is capable of metabolizing particular chemicals.

Excavation of the soil prior to treatment offers the greatest scope for creating optimum conditions. The excavated soil can be placed on thin layers to various depth using standard earth moving techniques and microbes and nutrients applied using standard agricultural techniques such as fertilizing, ploughing, harrowing, etc.

Reducing chemical fertilizer and pesticide use

Applying bio–fertilizers and manures can reduce chemical fertilizer and pesticide use. Biological methods of pest control can also reduce the use of pesticides and thereby minimize soil pollution.

Reusing of materials

Materials such as glass containers, plastic bags, paper, cloth etc. can be reused at domestic levels rather than being disposed, reducing solid waste pollution.

Recycling and recovery of materials

This is a reasonable solution for reducing soil pollution. Materials such as paper, some kinds of plastics and glass can and are being recycled. This decreases the volume of refuse and helps in the conservation of natural resources. For example, recovery of one tonne of paper can save 17 trees.

Reforestation

Control of land loss and soil erosion can be attempted through restoring forest and grass cover to check wastelands, soil erosion and floods. Crop rotation or mixed cropping can improve the fertility of the land.

Solid Waste Treatment

Proper methods should be adopted for management of solid waste disposal. Industrial wastes can be treated physically, chemically and biologically until they are less hazardous. Acidic and alkaline wastes should be first neutralized; the insoluble material if biodegradable should be allowed to degrade under controlled conditions before being disposed. As a last resort, new areas for storage of hazardous waste should be investigated such as deep well injection and more secure landfills. Burying the waste in locations situated away from residential areas is the simplest and most widely used technique of solid waste management.

CONCLUSIONS

Soil pollution is a result of many activities and experiments done by mankind which end up contaminating the soil. Industrial wastes such as harmful gases and chemicals, agricultural pesticides, fertilizers and insecticides are the most common causes of soil pollution. The othersare ignorance towards soil management and related systems, unfavorable and harmful irrigation