Lecture 10 Causes, effects and control of soil pollution.

Soil Pollution

Soil is the loose and unconsolidated outer layer of earth's crust that is powdery in nature and made up of small particles of different sizes. Soil ecosystem includes inorganic and organic constituents, and the microbial groups. Soil microorganisms are the active agents in the decomposition of plant and animal solid wastes and said to be nature's garbage disposal system. The soil microbes keep our planet earth free of unwanted waste materials and recycle the elements (C, N, and P) through mineralization. Soil microbes decompose a variety of compounds, cellulose, lignin, hemi cellulose, proteins, lipids, hydrocarbons etc. The soil microbial community has little or no action on many man made synthetic polymers. The persistent molecules that fail to be metabolized or mineralized have been termed as recalcitrants.

Soil pollutants

Pesticide pollution

In modern agriculture the use of various agrochemicals is a common practice. These include pesticides, herbicides, insecticides, fungicides and others. Pesticides applied on seed or foliage ultimately reach the soil. Accumulation of pesticide residues in the biosphere creates ecological stress causing contamination of soil, water, and food. Persisting chemicals may also be hazardous to human health and should be eliminated. Persistent pesticides may accumulate in the bodies of animals and over a period of time increase in concentration if the animal is unable to flush leading to bioaccumulation. When an affected animal is eaten by a carnivore, the pesticide is further concentrated in the carnivore. This phenomenon ie. Increasing in the concentration of a nondegradable substance along the food chain is called Biomagnification.

Another problem associated with insecticides is the ability of insects become resistant. Most pesticides kill beneficial predators and parasites. The short term and long term health effects to the persons using the pesticides and public that consumes the food are the major concerns. Exposure to small quantities for longer time causes mutations leads to cancer. Pesticides or their metabolites affect many soil microbes and their activities. Seed treatment with mercuric fungicides are found to be inhibitory to *Rhizobium* (nodulation and nitrogen fixation), *Nitrosomonas and Nitrobacter* (nitrification).

Fertilizer pollution

The agricultural production depends on chemical fertilizer application, as most of our high yielding varieties are fertilizer responsive. Continuous application of chemical fertilizers alone lead to deterioration of soil properties and cultivated soils loose their natural characteristics. Fertilizers like ammonium sulphate, ammonium chloride and urea reduce the soil pH. Many crops, like potato, grapes, citrus, beans are sensitive to chloride toxicity. In integrated nutrient management, to sustain the productivity of our soils, organic manures and bio fertilizers are recommended as supplements to chemical fertilizers.

Nitrate pollution

Nitrogen occurs in many forms in the environment and takes part in many biochemical reactions. The four forms of nitrogen that are of particular significance in environmental technology are organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. In water contaminated with sewage, most of the nitrogen is originally present in the form of complex organic molecules (protein) and ammonia (NH_3). These substances are eventually broken down by microbes to form nitrites and nitrates.

Nitrogen, particularly in the nitrate form, is a basic nutrient that is essential to the growth of plants. Excessive nitrate concentrations in surface waters encourage the rapid growth of microscopic plants called algae and excessive growth of algae degrades water quality.

Nitrates can enter the ground water from chemical fertilizers used in agricultural areas. Excessive nitrate concentrations in drinking water pose an immediate and serious health threat to infants under 3 months of age. The nitrate ions react with blood hemoglobin, reducing the blood's ability to carry oxygen and this produces a disease called ***blue baby*** or *methemoglobinemia.*

- An illness that arises when an infant's blood is unable to carry enough oxygen to body cells and tissue
- An infant with moderate to serious "blue baby syndrome" may have a brownish-blue skin tone due to lack of oxygen
- Child may be fussy, tired, have diarrhea or vomiting
- Severe cases can cause death

Excess Salts and Water

Irrigation water helps to produce more yield than rain fed land. Irrigation water contains dissolved salts and in dry season, water is in the form of saline solution evaporates leaving its salts such as NaCl in the top soil. This saline soil causes stunted plant growth, lower yield. Flushing out salts reduces the salinity but makes downstream irrigation water, saltier. Another problem is water logging.

Heavy metal pollution

Heavy metals include all metals with atomic numbers greater than 23 (with few exceptions) or more than 5 gm per ml. (eg. Hg, 70 gm ml^{-1}). Heavy metals are hazardous, not acceptable to biological system. They are toxic to man and other life forms. Most of them are slow poisons as they accumulate in the body and cause serious disorders. Mercury, lead, arsenic, chromium and cadmium are the five most common toxic heavy metals and they have serious effects on human health .

Effect of heavy metals on human health

S.No.	Heavy metal (forms)	Source	Effect
1.	Mercury: Hg^{++} (Mercuric) $C_6H_5Hg\ CH_3COO$	Methyl mercury fungicides, electrical and electronic industries, PVC, plastics, paints.	Irreversible neurological damage in man, Minamoto disease
2.	Lead Pb^{2+}, Pb^{4+}	Automobile exhaust of leaded petrol (50%), Batteries, Pipes, Soldiering.	Cause mutation in algae and bacteria, blackening in fish, gradual paralysis in man.
3.	Arsenic As^{+++} Arsenic trioxide, Sodium arsenate	Herbicide, fungicide, wood preservative – Agro chemicals (70%), industrial chemicals – paints, bullets (20%), glass and glass wares (5%).	Accumulate in hair, nail, skin lesions, act as oxidative uncoupler, cause damage to kidney, respiratory tract and nervous disorders.
4.	Chromium Cr^{+6} CrO_3	Tanneries, electroplating and metal finishing processes, Khaki dyeing in textiles.	Toxic to aquatic organisms, absorbed through intestinal tract in man.
5.	Cadmium (Cd)	Pigment and stabilizer for PVC, plastics, tires, rechargeable cells, electroplating, coal, oil and phosphate rocks.	Bones become brittle – Itai itai disease in Japan, gastro enteric distress and pain.

The unique physical, chemical and toxic properties of heavy metals have promoted their wide use in industrial processes and as biocides (fungicide and herbicide). As a result, higher concentration of these heavy metals accumulates in the environment, causing public health hazards and ecological problems. Removal of these metals is therefore a challenge to environmental management. The metals are generally removed by ion exchange and sorption to resins and precipitation as metal sulphides. Biodegradation of metals is not possible, because unlike organic pollutants, metals as elements cannot be mineralized to non-toxic compounds such as H_2O and CO_2. However, biomobilization is a valid concept in the management of metal pollution. Eukaryotic organisms detoxify heavy metals by binding to polythiols and bacteria have developed different and efficient mechanisms for tolerating heavy metals. They carry the genes controlling metal resistance on chromosome and plasmids, plasmids often contain genes resistance to several metals (Hg, Pb, As, Cr, Cd, Mo, U). As a result of biological action, metals undergo changes in valency and or conversion into organo metallic compounds.

Industrial Wastes: Indiscriminate dumping of untreated or inadequately treated domestic, mining and industrial wastes on and is an important source of soil pollution. Fall out of gaseous and particulate air pollutants from mining and smelting operations, smoke stacks etc. are the major source of soil pollutants in nearby areas.

Neyveli Lignite Corporation Limited (**NLC**) is a government-owned lignite mining and power generating company in India. NLC operates the largest open-pit lignite mines in India, presently mining 24 MT of lignite per year and has an installed capacity of 2740 MW of electricity and generates 2490 MW of power per year from three stations It operates three mines near the South Indian city of Chennai.

The power goes to the South Indian states of Andhra Pradesh, Karnataka, Kerela, Tamil Nadu, and Pondicherry. The company also provides consulting services in mine planning and construction and the renovation and life extension of old power stations. It also supplies a large quantity of sweet water to Chennai from the artesian aquifers in the lignite mines.

Open pit Coal mining at Garzweller, Germany

Urban Wastes : Millions of tones of urban waste are produced every year from polluted cities. The inadequately treated or untreated sewage sludge not only poses serious health hazards but also pollutes soil and decreases its fertility and productivity. Other waste materials such as rubbish, used plastic bag, garbage sludge, dead animals, hospital wastes, skins, tyres shoes etc. cause land and soil pollution. Suspended matter present in sewage can act as a blanket on the soil and interfere with its productivity.

Plastics

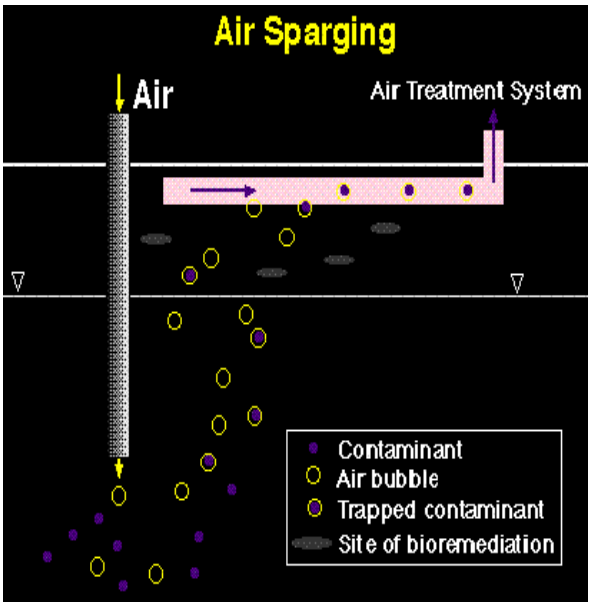
Plastics form a major part of global domestic and industrial waste. Not being biodegradable, waste plastic accumulates, adding to pollution. Using photodegradable plastic or biodegradable plastic can solve plastic pollution problem. Photodegradable plastic contains an element sensitive to UV rays. Under the effect of solar rays the element is activated and breaks the polymeric chain of the photodegradable plastic. It results in small fragments that are easily digested by microbes.

Control of Soil Pollution

Soil may be polluted and converted into acidic soil or alkaline soil. It should be corrected by suitable technology, before cultivation.

Methods of Soil treatment

Air sparging is an *in situ* remedial technology that reduces concentrations of volatile constituents in petroleum products that are adsorbed to soils and dissolved in groundwater. This technology, which is also known as "*in situ* air stripping" and "*in situ* volatilization," involves the injection of contaminant-free air into the subsurface saturated zone, enabling a phase transfer of hydrocarbons from a dissolved state to a vapor phase. The air is then vented through the unsaturated zone. Air sparging is most often used together with soil vapor extraction (SVE), but it can also be used with other remedial technologies.

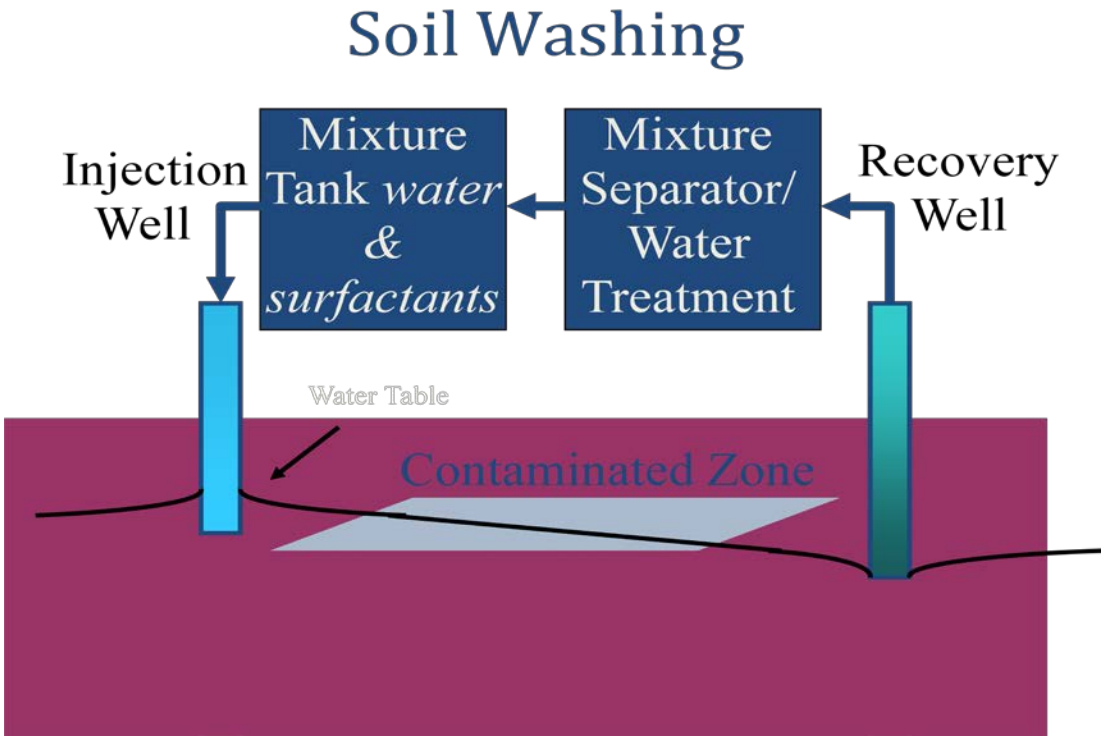


Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. The process removes contaminants from soils in one of the following two ways:

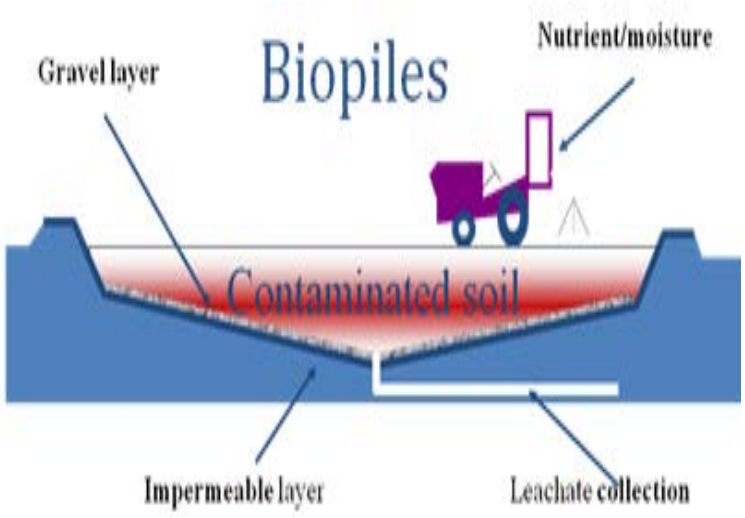
- By dissolving or suspending them in the wash solution (which can be sustained by chemical manipulation of pH for a period of time); or
- By concentrating them into a smaller volume of soil through particle size separation, gravity

separation, and attrition scrubbing (similar to those techniques used in sand and gravel operations).

The concept of reducing soil contamination through the use of particle size separation is based on the finding that most organic and inorganic contaminants tend to bind, either chemically or physically, to clay, silt, and organic soil particles. The silt and clay, in turn, are attached to sand and gravel particles by physical processes, primarily compaction and adhesion. Washing processes that separate the fine (small) clay and silt particles from the coarser sand and gravel soil particles effectively separate and concentrate the contaminants into a smaller volume of soil that can be further treated or disposed of. Gravity separation is effective for removing high or low specific gravity particles such as heavy metal-containing compounds (lead, radium oxide, etc.). Attrition scrubbing removes adherent contaminant films from coarser particles. However, attrition washing can increase the fines in soils processed. The clean, larger fraction can be returned to the site for continued use. Soil washing is generally considered a media transfer technology. The contaminated water generated from soil washing are treated with the technology(s) suitable for the contaminants. The duration of soil washing is typically short- to medium-term.



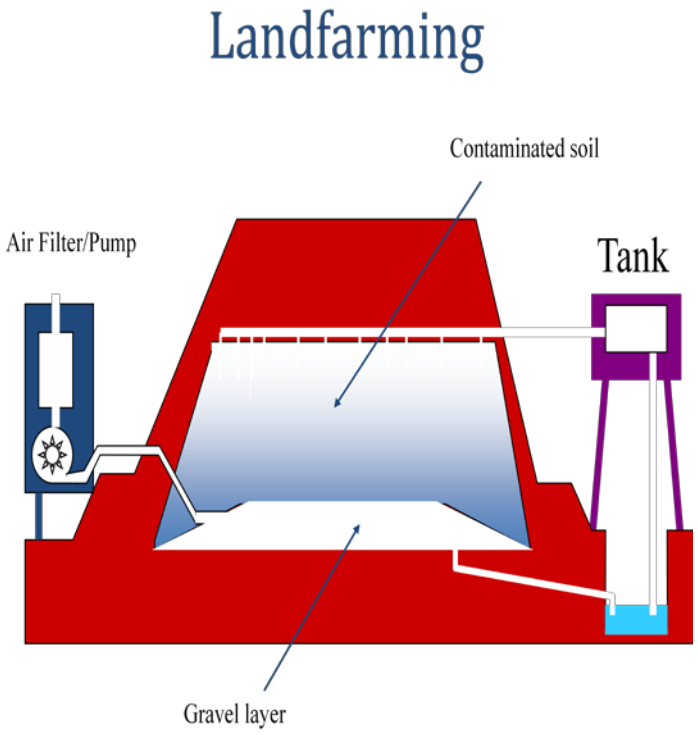
Biopile treatment is a technology in which excavated soils are mixed with soil amendments and placed on a treatment area that includes leachate collection systems and some form of aeration. It is used to reduce concentrations of petroleum constituents in excavated soils through the use of biodegradation. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation.



The treatment area will generally be covered or contained with an impermeable liner to minimize the risk of contaminants leaching into uncontaminated soil. The drainage itself may be treated in a bioreactor before recycling. Vendors have developed proprietary nutrient and additive formulations and methods for incorporating the formulation into the soil to stimulate biodegradation. The formulations are usually modified for site-specific conditions.

Soil piles and cells commonly have an air distribution system buried under the soil to pass air through the soil either by vacuum or by positive pressure. The soil piles in this case can be up to 20 feet high (generally not recommended, 2-3 meters maximum). Soil piles may be covered with plastic to control runoff, evaporation, and volatilization and to promote solar heating. If there are VOCs in the soil that will volatilize into the air stream, the air leaving the soil may be treated to remove or destroy the VOCs before they are discharged to the atmosphere. It is a short-term technology. Duration of operation and maintenance may last a few weeks to several months.

Land Farming is a bioremediation treatment process that is performed in the upper soil zone or in biotreatment cells. Contaminated soils, sediments, or sludges are incorporated into the soil surface and periodically turned over (tilled) to aerate the mixture. This technique has been successfully used for years in the management and disposal of oily sludge and other petroleum refinery wastes. In situ systems have been used to treat near surface soil contamination for hydrocarbons and pesticides. The equipment employed in land farming is typical of that used in agricultural operations. These land farming activities cultivate and enhance microbial degradation of hazardous compounds.



Soil conservation

Soil conservation is the protection of soil against excessive loss of fertility by natural, chemical, or artificial means. It encompasses all management and land-use methods protecting soil against degradation, focusing on damage by erosion and chemicals. Soil conservation techniques can be achieved through crop selection and rotation, fertilizer and lime application, tilth, residue management, contouring and strip cropping, and mechanical methods (e.g., terracing).

- **Biological methods**

1. Agronomic practices
   - Contour farming
   - Mulching
   - crop rotation
   - Strip cropping
2. Dry farming
3. Agrostological methods
   - Lay farming
   - Retiring of land to grass

- **Mechanical methods**

1. Basin listing
2. Contour terracing

- **Other methods**

1. Gully control
2. Afforestation

Terracing – increases the amount of land used for cultivation on steep slope and mountains and reduces erosion

Soil Amelioration

1. **Soil Amelioration**

Amelioration of Acidic Soil: Soil acidity is due to the accumulation of H^+ ions over OH^- ions. Limiting material – are neutralization of H^+ ions such as

- *Quicklime*- oxide of lime is usually known as burned lime or quicklime.
- *Slaked lime*-can be obtained by adding water to quick lime.
- *Blast furnace slag*- a byproduct during the manufacturer of pig iron viz, calcium silicate.
- *Basic Slag*- is a byproduct of the basic open heart method of producing steel from pig iron,
- *Electric furnace slag*- is produced from the electic furnace reduction of phosphate rock during preparation of phosphorous. The product is manly the calcium silicate.

The other methods which could result in amelioration of acidic soil are:

- Use of basic fertiizers such as sodium nitrate reduces the soil acidity.
- Proper soil and water management.

- Usage of corall shell, chalk, woodash, press mud, byproduct material of paper mills, sugar factories, fly ash and sludge etc.

Amelioration of Saline and Alkali Soil

Saline soil- they contain an excess of soluble salts. *Saline soil reclamation can be achieved by:*

- Providing proper drainage
- Using salt free irrigation water
- Use of acidic fertilizers-such as ammonium sulphate
- Use of organic fertilizers
- Use of organic manures.

Alkaline soil-they contain appreciable amounts of soluble salts. *Alkali soil reclamation* may be achieved by the following practices:

- Application of gypsum
- Use of sulphur
- Addition of organic matter
- Addition of molasses.

2. ***Prevention of solid waste dumping***
   Open dumping of solid waste should be segregated and recyclable materials could be recycled. Other garbage can be conveted into organic manure by suitable technology.
3. **Usage of bio-fertilizers and bio-pesticides.**
4. **Following the concept of Integrated Plant Nutrient System (IPNS).**

Organic / Sustainable Agriculture

Organic farming is a holistic approach which aims for the production of quality and safe agriculture products for consumption. This system requires less financial and external inputs and provides sustainable income to the farming community. Organic farming aims at production of quality and safe agricultural products which contain no chemical residues due to the adoption of eco-friendly production methods and farming systems that restore and maintains soil fertility.

Organic farming is a production method which does not pollute the soil and ground water with chemical residues and provides safe and quality food for consumption. It also increases the biological diversity of plants and animals that helps to maintain the natural eco balance. This approach also aims to recycle only the natural resources and restricts the use of external inputs which indirectly helps to reduce the energy consumption in the farming system considerably.

The vision of organic farming in India has necessitated the government to launch the National programme for organic production (NPOP) during 2000. By National accreditation policy and programme, the government has also implemented the National standards for various organic farming

activities. Hence organic farming has to be promoted in a big way to provide quality and safe food to the growing population and also to protect the environmental degradation.

Concepts of Organic Farming

Organic farming aspires to a complex mix of agronomic, environmental, agricultural and processing and are based on a number of principles. They are:

- To produce food of high quality and safety
- To interact in a constructive and life-enhancing way with natural systems and cycles
- To consider the wider social and ecological impact of the organic production and processing system
- To encourage and enhance biological cycles within the farming systems, involving microorganisms, soil flora and fauna, plants and animals
- To develop a valuable and sustainable aquatic ecosystem
- To maintain and increase the long term fertility of soils
- To promote the healthy use and proper care of water, water resources, and all life therein
- To use, as far as possible, renewable resources in locally organized production systems
- To create a harmonious balance between crop production and animal husbandry
- To minimize all forms of pollution
- To process organic products using renewable resources
- To produce fully biodegradable organic products.

These principles are given equal importance as that of other economically viable production technologies.

Organic Farming Requirements

Achieving the above mentioned principles of organic farming needs a holistic farming system with integrated approach in all aspects. The basic principle of organic farming in enhancing the soil fertility can be achieved through proper recycling of organic wastes, versatile crop rotation and cropping systems, a wide range of biological methods for control of pests, diseases and weeds and to avoid the use of synthetic fertilizers, chemical pesticides and herbicides. Habitat development is the key factor in restoring the natural eco-system which in turn facilitates the symbiotic co-existence of fauna and flora apart from promoting natural predators, parasites etc.

a. Maintaining soil fertility

Depletion of soil organic matter under intensive cropping system is the key factor in altering biological equilibrium of the soil ecosystem. It is essential to maintain the soil food web, where all the soil organisms viz, bacteria, fungi, actinomycetes, protozoa, earthworms etc, and they flourish in population in the presence of sufficient amount of soil organic matter. In order to maintain the soil fertility, the following farming practices are recommended.

- Increased use of organic manures, green manures
- Enriched vermicompost and bio composts

- Use of bio fertilisers
- Crop rotation with high and low biomass crops
- Avoiding the use of chemical fertilizers

b. Plant Protection methods

Indiscriminate use of chemical pesticides and herbicides leads to soil and ground water contamination which causes health problems in living systems. The accumulation of toxic residues in the food products has created considerable awareness among the producers and consumers. The reports on the pesticides residue in food products revealed that, most of the food products from conventional agriculture contain more than 70 per cent residues. In addition, it also impairs the soil microflora that is essential to maintain soil fertility. These problems can be solved by adopting organic farming practices which uses only the natural bio pesticides for plant protection. Generally bio pesticides, bio control agents, plant extracts etc are used for controlling the pest and disease problems.

c. Animal husbandry

The basis for including animal husbandry in the system is to respect the physiological and ecological needs of animals. This is achieved by providing sufficient quantities of good quality organic fodder, Shelters according to their behavioral needs and also by proper veterinary treatment. Animals are an important part of organic system because they act as the agents for recycling of byproducts with value addition. Further contribute to complete the nutrient cycle and maintaining soil fertility. They also contribute draught energy for agricultural operations and provide essential manure for soil nutrition and urine for pesticides.

d. Processing of organic products

The basis of processing organic products is that as far as possible the vital qualities of the products are maintained throughout each step of the process. This is achieved by choosing and developing methods which are adequate to the specifications of the ingredients and by developing standards which emphasize careful processing methods, limited refining, energy saving technologies, minimal use of additives and processing aids etc. The production and handling of organic products in a safe way can be achieved by adopting existing standards or by developing new standards, which define the safe methods of waste management in the form of products besides packing systems and energy saving systems in processing and transport.

The Indian domestic market being quite large, there is ample opportunity for marketing the products especially the organic products in the country. Greater opportunities are also available for exporting certified organic products to counties like USA, Japan and European Union. Although some farmers are practicing organic agriculture, their awareness on certification is limited and they are yet to recognize the importance of certification.

Lecture 10 Causes, effects and control of soil pollution.

1	Heavy metal pollution in soils through application of chemical fertilizers is regarded as ---------- source of pollution	
	a)Point	**b) Non point**
	c) Degradable	d) Non Degradable
2	_____ is a practice of solid waste disposal.	
	a) Land fill	b) Landscape
	c) Landslide	d) None of the above
3.	The process of enrichment to remove pollutant in soil is called ----------	
	a) Biostimulation	b)Bioaccumulation
	c) Biosorption	d) All the above
4	The most obvious toxic product of combustion of plastic is -------	
	a)PHB	b)Toluene
	c)PHA	**d)Dioxins**
5	The main problem associated with management of solid waste in Inida is	
	a)Exceesive moisture	**b) Segregation ,**
	c) Collection ,	d) Management techniques
6	The persistent molecules that fail to be metabolized are called as	
	a)Recalcitrant	b) resistant
	c) hard substances	d) biodegradable
7	The process of destruction of solid waste in high temperature is	
	a) burning	**b) Pyrolysis**
	c) Incineration	d) Biomethanation
8	Biostimulation is nothing but	
	a**) Addition of nutrients**	b)Addition of microbes
	c)Addition of wood chips	d) Do nothing
9	Bioaugumentation is	
	a)Addition of nutrients	**b) Addition of microbes**
	c)Addition of aeration	d) Do nothing
10	Incineration of municipal solid waste releases which toxic material of significant concern?	
	a) HCl gas	**b) dioxins**
	c) Heptachlor	d) Methyl mercury
11	While building a landfill, it should be ensured that it is	
	a. above the groundwater table	b. below the groundwater table
	a. level with groundwater table	d. in sandy terrains
12	Which heavy metal acts as oxidative uncoupler	
	a)Chromium	b)Nickel
	c)Arsenic	d)Lead

13	Biodegradation of metals is not possible, but ---------- is a valid concept in the management of metal pollution	
	a)Bioaugumentation	b)Phytodegradation
	c)Biostimulation	**d) Biomobilization**
14	Seed treatment mercuric fungicides are found to be inhibitory to	
	a)*Rhizobium*(nodulation and nitrogen fixation),	b)*Nitrosomonas* (nitrification).
	c)*Nitrobacter* (nitrification)	**d)All the above**
15	---------- contains an element sensitive to UV rays,under the solar rays the element is activated and breaks the polymeric chain of the photodegradable plastic.	
	a)Photodegradable plastic	b)Biodegradable plastic
	c)Recalcitrant plastic	d)None of the above
16	Acidic soils can be ameliorated by	
	a)adding quick lime	b)adding slaked lime
	c)adding basic slag	**d)all the above**
17	The usage of coral shell, chalk, wood ash, press mud helps to ameliorate	
	a)acidic soil	b)saline soil
	c)sodic soil	d)all the above
18	Soil polluted with excess soluble salt is known as	
	a)saline soil	b)sodic soil
	c)acidic soil	d)latritic soil
19	Application of gypsum reclaims	
	a)saline soil	**b)alkaline soil**
	c)acidic soil	d)all the above
20	An approach that does not pollute the soil, ground water and quality food for consumption is	
	a)Jhum cultivation	b)industrial agriculture
	c)organic farming	d)all the above