Soil pollution and control

Definition of pollution and contamination

- **Soil pollution** is defined as the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and/or the ecosystem. In the case of contaminants which occur naturally in soil, even when their levels are not high enough to pose a risk, soil pollution is still said to occur if the levels of the contaminants in soil exceed the levels that should naturally be present.

Sources of soil pollution

- Agricultural soils can be contaminated with a wide range of compounds, from both direct inputs (point source pollution) such as the application of pesticides and fertilizers and indirect inputs (diffuse pollution) such as flooding and atmospheric deposition. Polluted soils also represent a secondary emission source of contaminants to surrounding air, surface waters, groundwater, and subsequently to oceans.
- The main sources of soil pollution in agricultural areas can be grouped as: i) pesticides; ii) mineral fertilizers; iii) organic fertilizers (manure and sewage sludge); iv) wastewater for irrigation; v) plastic materials such as films for mulching and greenhouses, drip irrigation tubes and empty packaging; vi) and rural wastes. Different contaminants are linked to each source.

Effects of chemical residues on soil

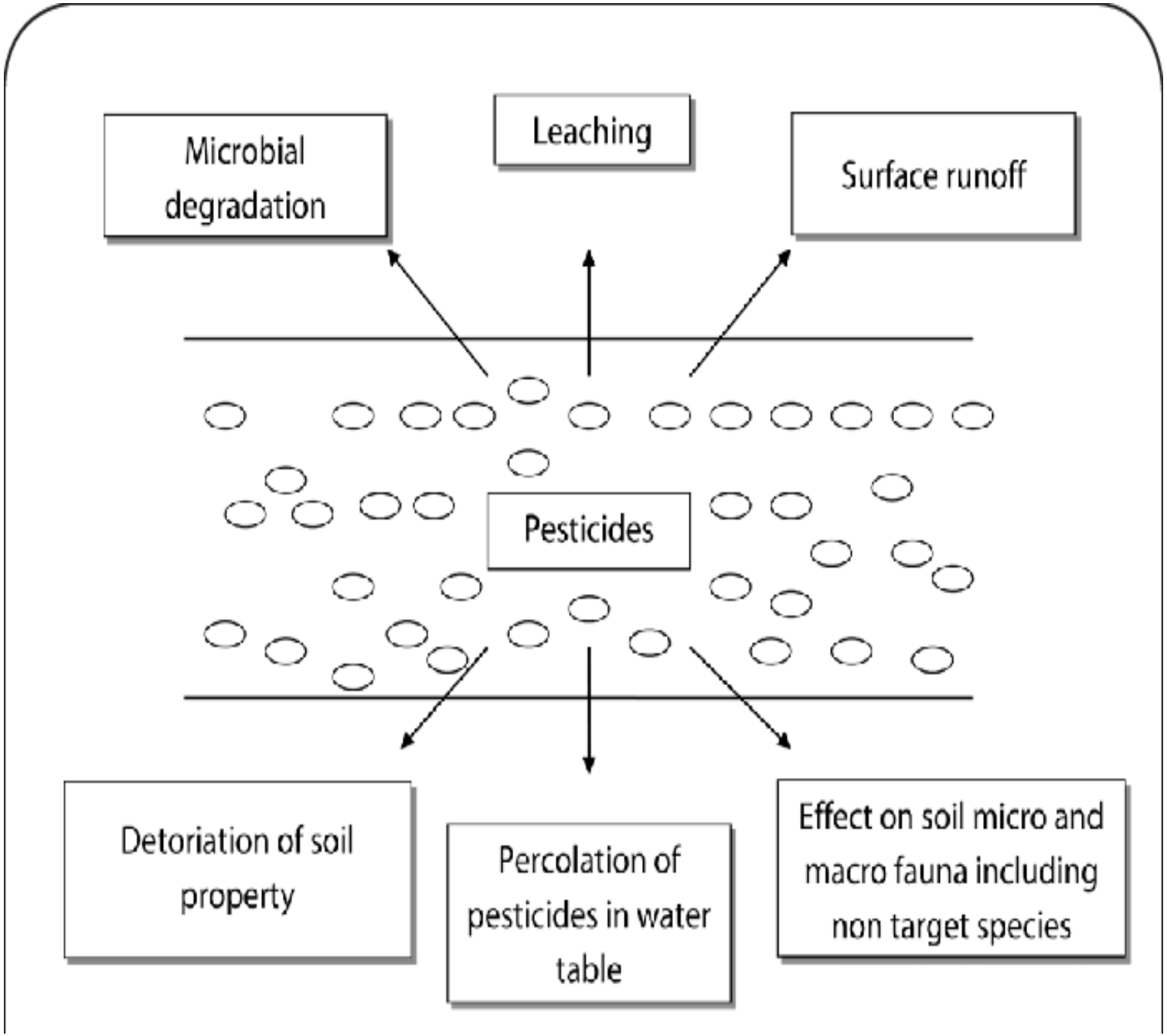
- CHEMICAL RESIDUE-

Chemical residues are **the traces of a chemical or its breakdown products that remain in or on treated produce**.

- TYPES OF CHEMICAL RESIUE-
  - Pesticides
  - Fertilizers
  - Heavy metals

Effect of pesticides on soil

- Pesticide residues are the traces of pesticides compo unds that remain on or in the crop, water, soil and air after the application.



Effect of fertilizers on soil

- 1. All the major fertilizer nutrients, nitrogen is the main nutrient affecting soil pH, and soils can become more acidic or more alkaline depending on the type of nitrogen fertilizer used.
- 2. Nitrate-based products are the least acidifying of the nitrogen fertilizers, while ammonium-based products have the greatest potential to acidify soil.
- 3. Soil acidification due to use of phosphorus fertilizers is small compared to that attributed to nitrogen, due to the lower amounts of this nutrient used and the lower acidification per kg phosphorus. Phosphoric acid is the most acidifying phosphorus fertilizer.
- 4. Potassium fertilizers have little or no effect on soil ph.

Chemical Fertilizer

⇩

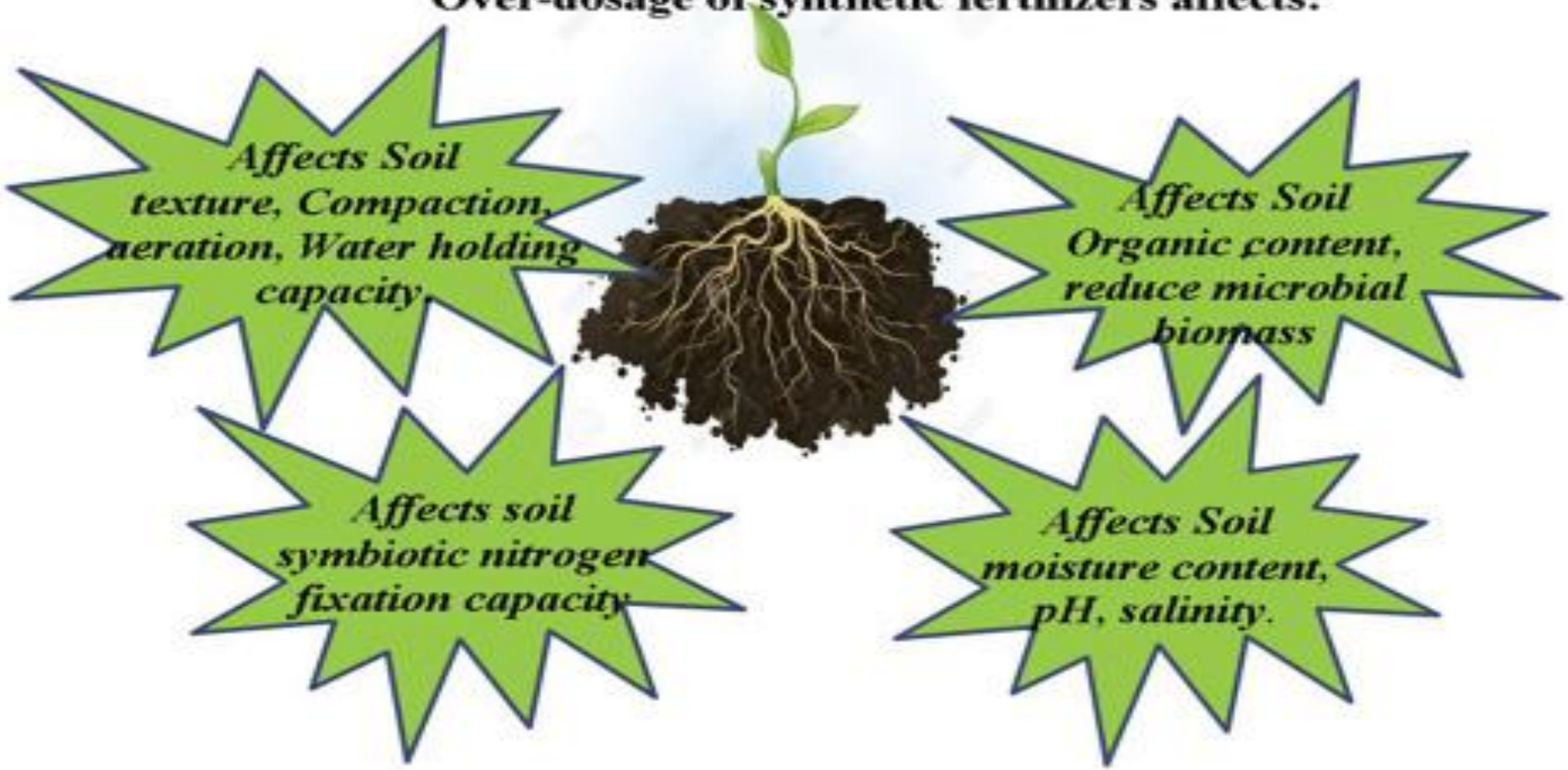
Supply Plant Nutrients

⇩

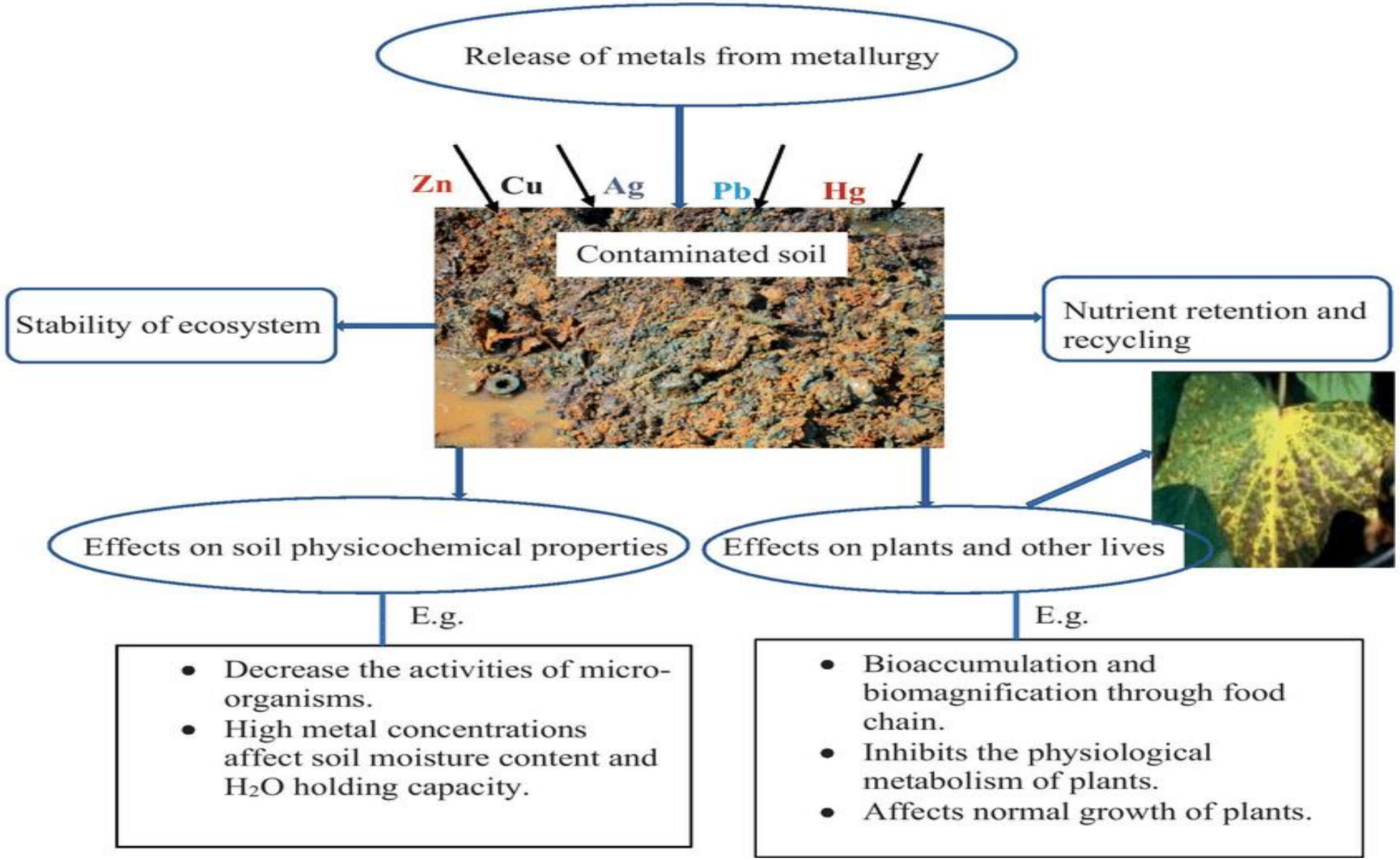
Improves Crop Productivity

⇩

Over-dosage of synthetic fertilizers affects:



Effects of heavy metals on soil



Soil pollution from nitrogen

- Nitrogen frequently increases root growth and foraging capacity for phosphorus. Some of the effects of nitrogen are related to the effect on increasing the growth of plant tops and concurrently increasing the absorption of phosphorus. The ammonium form of nitrogen frequently increases phosphorus absorption more than the nitrate form. Nitrogen additions affect plant metabolism and may change the ability of unit areas of root surface to absorb phosphorus. Nitrogen salts may influence absorption of phosphorus by plants by altering the phosphorus solubility in the soil. The residual acidity or alkalinity of added nitrogen may markedly change the phosphorus in solution and subsequent phosphorus absorption by plants.

Soil pollution from phosphorus

- The increase of available soil phosphorus associated with continuous additions of P fertilizer results, in the long term, in excessive phosphorus levels. The soil therefore becomes saturated in phosphorus.
- High P levels in the 0-15 cm surface soil layer are associated with high soil P saturation percentages. Under erosion conditions, potential risks are high for dissolved and sediment-attached phosphorus to get into watercourses. When phosphorus enters a watercourse, it contributes watercourse enrichment in phosphorus. This enrichment is also known as water eutrophication. Water eutrophication results in an increased growth and development of aquatic plants. More plants grow, produce, and die. It is the decomposition of those dead organic materials that then causes the depletion of dissolved oxygen and put the development of beneficial, aerobic aquatic life at risk.

Soil pollution from sulfur

- Sulphur deposition in soils contributes to their acidification. Adverse effects of Sulphur contamination of soils are shown by the fall in pH, an increase of phytotoxic aluminum concentration and by losses of Ca^{2+} and Mg^{2+} ions through leaching. These changes lead to soil degradation and the impact does not cease once the pollutant inputs stopped (carry-over effect). The carry-over effects of Sulphur contamination of soils is greater than the immediate impact. Disturbance in the relationships between Ca^{2+} and Al^{3+} ions caused by a long-term Sulphur deposition reduced crop yields and, in the case of sensitive crops, caused a total plant destruction soon after their emergence.

Soil pollution from micronutrients or trace elements

The main sources of trace elements are soil parent materials (rocks), fertilizers, biosolids, irrigation water, coal combustion residues, auto emissions, and metal-smelting industries. Even though some trace elements originate from rocks and some are essential for plant growth and development, when present in soils at elevated levels those same elements become toxic. Trace elements that have been taken up by plants, especially those grown on contaminated soils, could move up the food chain, some accumulating in the fatty tissue of animals and/or humans.

Some trace elements of potential concern as soil contaminants are: **arsenic (As), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), fluorine (F), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn)**.

Heavy metal pollution of soil

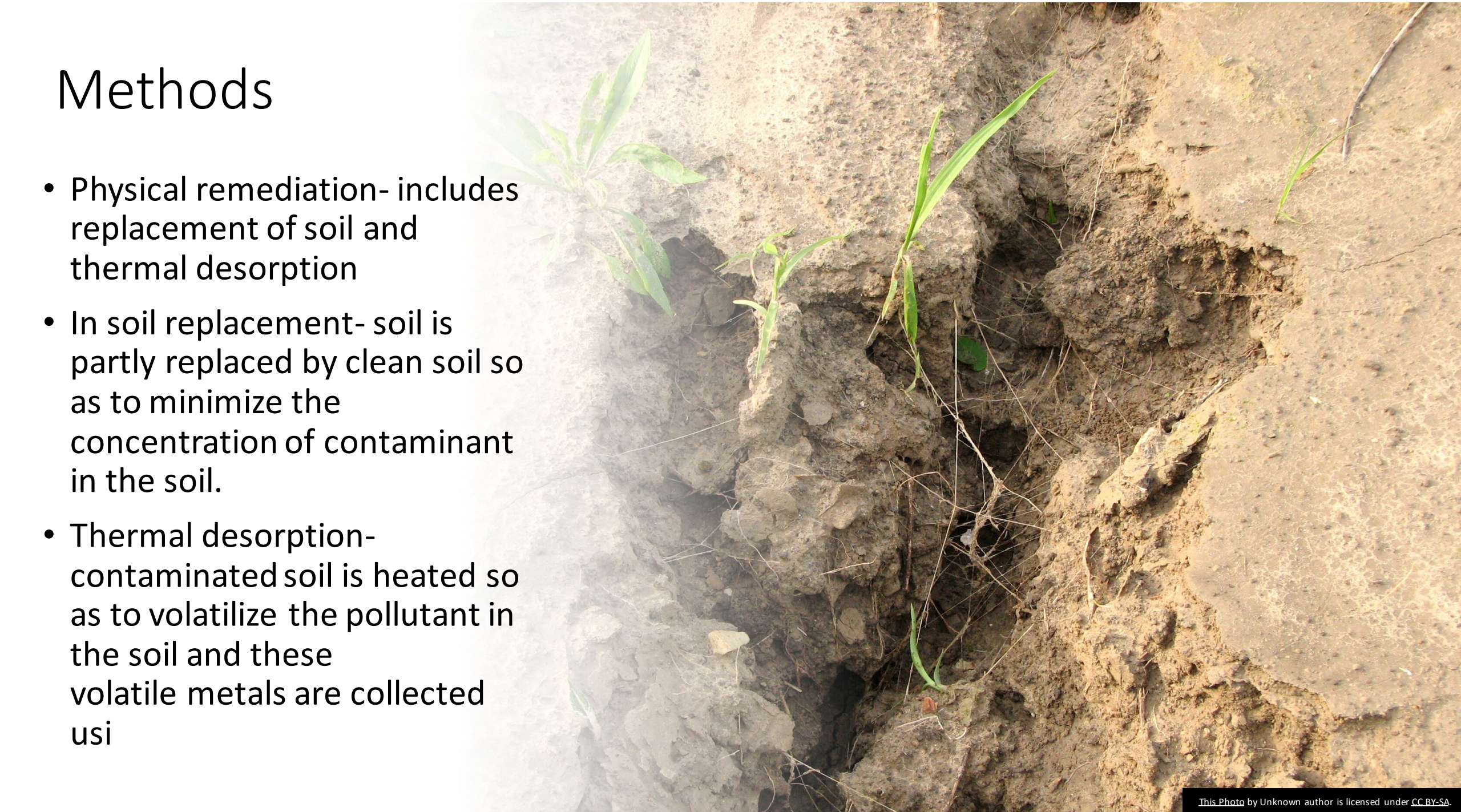
- Heavy metals are elements that exhibit metallic properties such as ductility, malleability, conductivity, cation stability, and ligand specificity. They are characterized by relatively high density and high relative atomic weight with an atomic number greater than 20 [2]. Some heavy metals such as Co, Cu, Fe, Mn, Mo, Ni, V, and Zn are required in minute quantities by organisms.
- Soil properties affect metal availability in diverse ways. Harter [9] reported that soil pH is the major factor affecting metal availability in soil. Availability of Cd and Zn to the roots of *Thlaspi caerulescens* decreased with increases in soil ph. Organic matter and hydrous ferric oxide have been shown to decrease heavy metal availability through immobilization of these metals . Significant positive correlations have also been recorded between heavy metals and some soil physical properties such as moisture content and water holding capacity.

Heavy metal remediation of soil

- Soil remediation is a term applied to various processes used to decontaminate the soil. The goal is to treat contaminated soil by removing and converting pollutants into less harmful products.
- Some of the pollutants that soil remediation addresses include:
- Heavy metals
- Cyanides
- Pesticides
- Creosote
- Semi-volatiles
- Petroleum and fuel residues
- Removing these pollutants from the soil prevents them from seeping into the groundwater, surface water, agricultural crops, and wild flora. In cases where they've already affected water sources, additional land remediation techniques are required.

Methods

- Physical remediation- includes replacement of soil and thermal desorption
- In soil replacement- soil is partly replaced by clean soil so as to minimize the concentration of contaminant in the soil.
- Thermal desorption- contaminated soil is heated so as to volatilize the pollutant in the soil and these volatile metals are collected usi



- CHEMICAL REMEDIATION-

The chemical leaching process involves the washing of contaminated soils with water, reagents, fluids and gases that helps the pollutant to leach out from the soil.

- Other methods are
  - chemical fixation
  - Electrokinetic remediation
  - Vitrification
  - Precipitation
  - Ion exchange
  - Membrane technologies

Biological remediation-

- Phytoremediation involves 5 strategies-

❖Phytoextraction- transfer of metals from the soil to the above

❖ground plant parts.

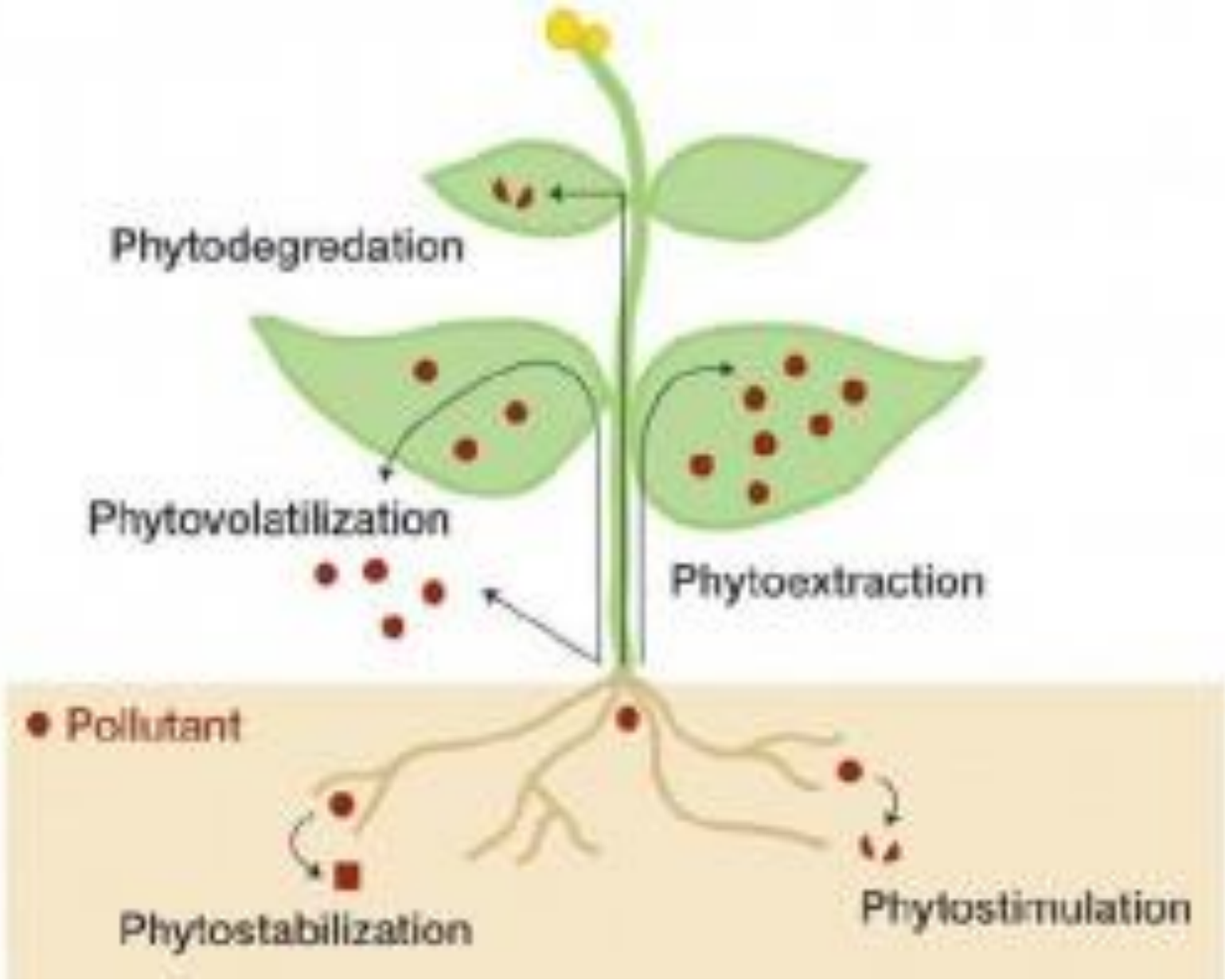
❖Phyto stabilization- use of plants to reduce mobility and

❖bioavailability of the metals in the soil

❖ Rhizo filtration- use of plant roots to remove toxic materials

❖ Phytovolatilization- absorption of contaminants from the soil by the plants, their upward movement and then release from the aerial parts.

❖Phytodegradation- use of plant roots and associated microbes to degrade the pollutants present in the soil.


Phytodegradation
Phytovolatilization
Phytoextraction
Pollutant
Phytostabilization
Phytostimulation

Methodologies of soil conservation

- Soil conservation is a **set of farming techniques and practices to avoid degradation, erosion and depletion in particular.**
- Soil conservation practices are tools the farmer can use to prevent soil degradation and build organic matter. These practices include: crop rotation, reduced tillage, mulching, cover cropping and cross-slope farming.
- Crop Rotation is a tool that enables farmers to increase soil organic matter content, soil structure and rooting depth. This is accomplished by growing secondary crops which enhance soil health.

Crop rotation

Maize

Potato

Sugarcane

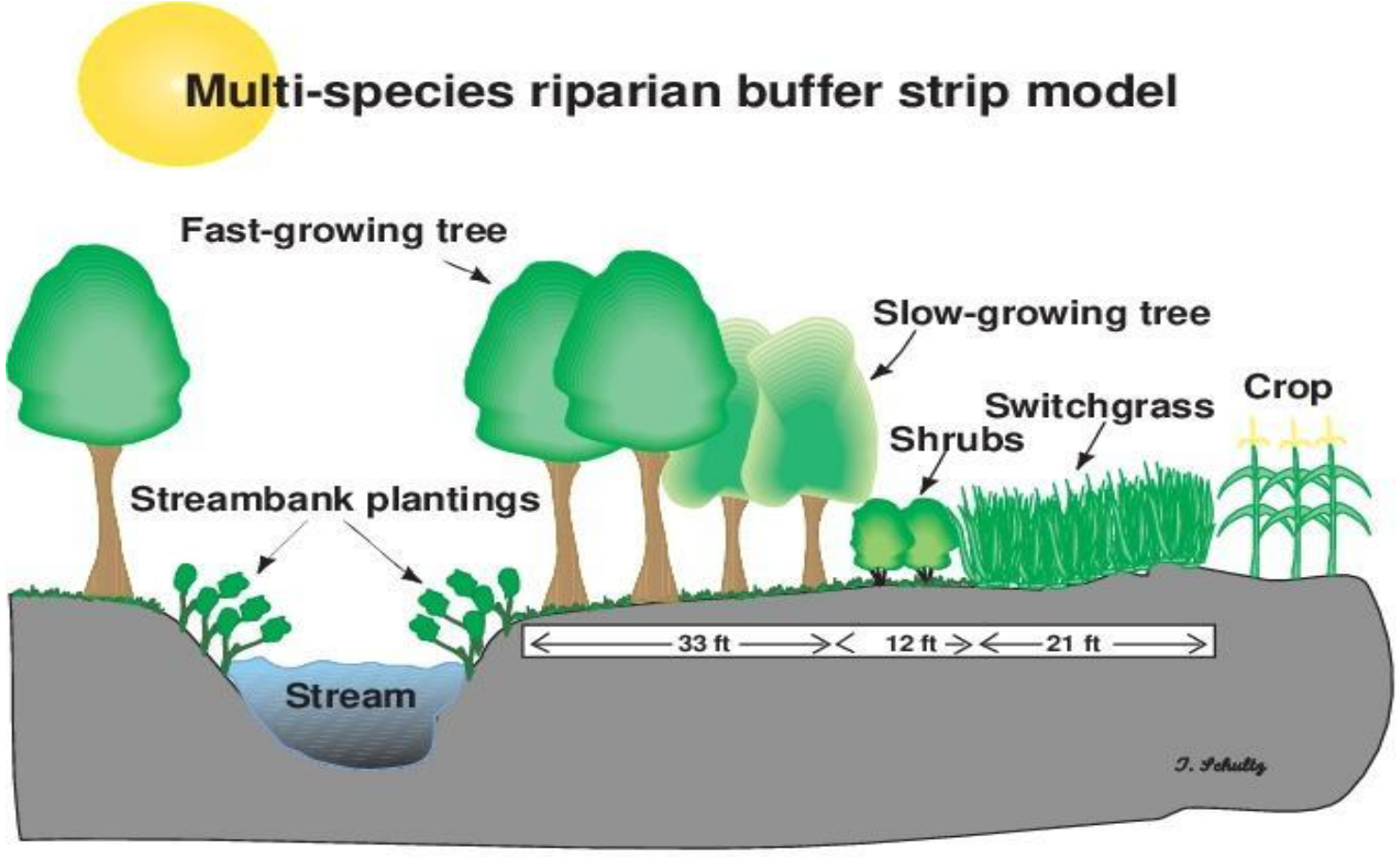
visit: newagriindia.com

- Cover Cropping and Mulching are effective at reducing soil erosion by leaving a cover over the soil which reduces soil displacement associated with the impact of raindrops hitting soil particles. They also reduce the volume and velocity of runoff over the soil.
- Mulching consists of applying organic material over the exposed soil. Hay makes the best mulch, but it is important to ensure that the hay is harvested before weeds are mature. Straw can also be used.

- Conservation Tillage is field operations aimed at preserving soil aggregates, organic matter and surface residue from previous crops.

- Cross slope farming Is the practice of conducting field operations perpendicular to field slope.

- Buffer strips- are vegetative areas that separate field boundaries from watercourses. They are efficient at preventing soil and contaminants from entering watercourses by providing an area for field runoff to collect.



Conservation of arable land

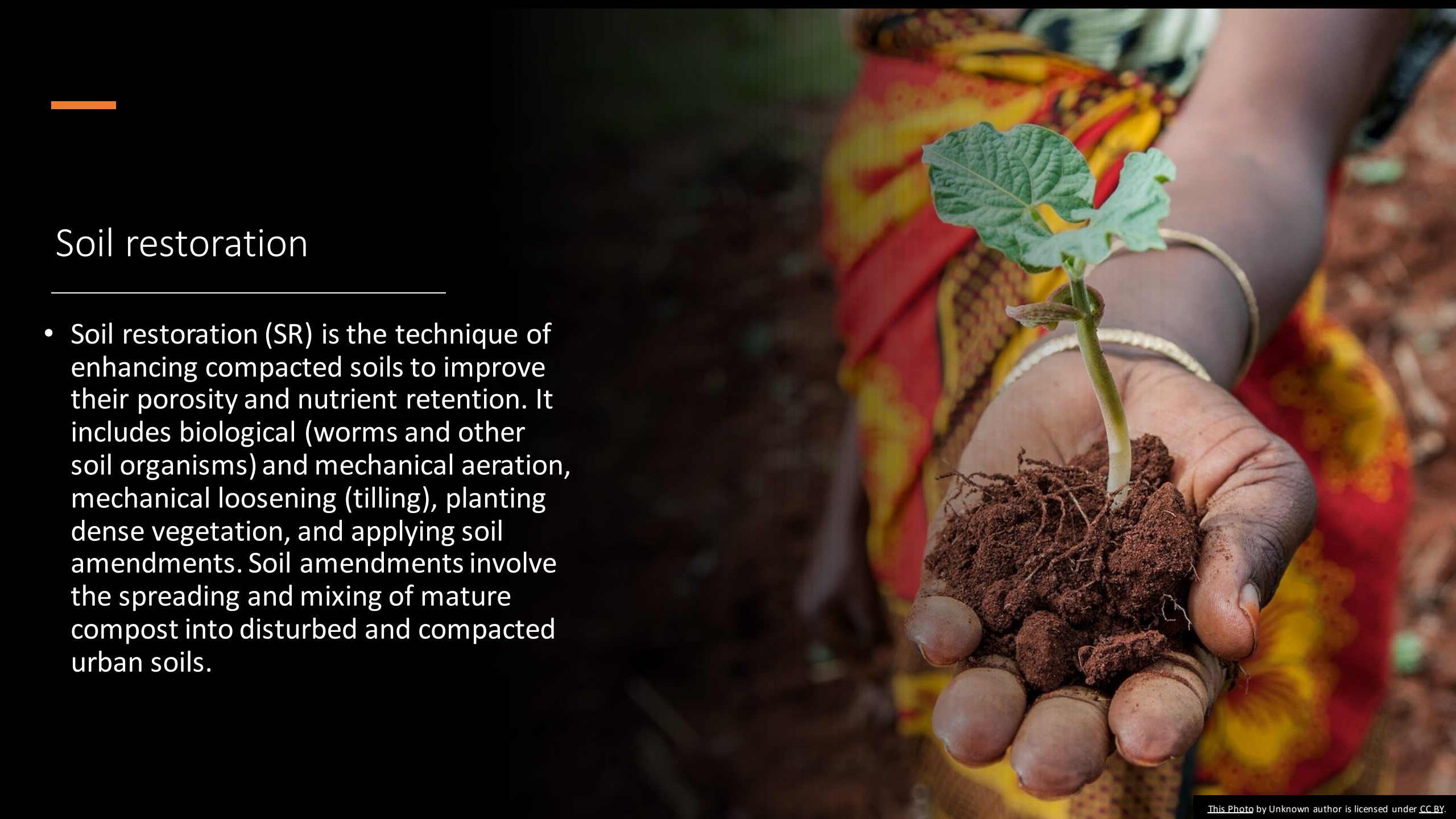
- Arable land is any land capable of being ploughed and used to grow crops.
- **CONTOUR CULTIVATION**
- Cultivation is done along the contours. This forms the mini barriers across the flow path of the runoff, which conserves rain water in situ & check soil erosion. Effectiveness of contour cultivation varies with slope, crop cover and soil.
- **SHELTER BELTS**
- It consists of plantation of grasses, shrubs and trees across the wind direction on the field boundary to form a vegetative barrier to protect the lands from fast blowing wind.
- **SAND DUNE STABILISATION**
- Shifting sand dunes pose serious threat to the productive agriculture lands so these need to be stabilized. Etc.

Soil reclamation and restoration

- ***Soil Reclamation*** is the process of reclaiming the soil's quality like lost fertility, minerals, nutrients and moisture to make it fit for intensive use again. The reclamation of soil, its nutrients and fertility are done with an objective to increase further land use and enhance agricultural activities like cropping and irrigation.
- This process in combination with Land reclamation is being employed widely for the creation of national parks and wildlife sanctuaries for enhancing wilderness and forest life by a combined process called ***Pedogenesis.***
- Pedogenesis, also known as ***soil development, soil evolution, soil formation,*** and ***soil genesis,*** is the process of soil formation as regulated by the effects of place, environment, and history.

Soil restoration

- Soil restoration (SR) is the technique of enhancing compacted soils to improve their porosity and nutrient retention. It includes biological (worms and other soil organisms) and mechanical aeration, mechanical loosening (tilling), planting dense vegetation, and applying soil amendments. Soil amendments involve the spreading and mixing of mature compost into disturbed and compacted urban soils.




Thank you