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EFFECTS OF HEAVY METALS ON HEALTH INDEX OF SOIL, PLANTS, HUMAN & IT'S BIOREMEDIATION

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***ABSTRACT*:** Unplanned disposal of municipal waste, mining, use of intensive pesticides, insecticides, fungicides, and other agrochemicals uses are significant causes of environment pollution and causes of most concern. Heavy metals, like cadmium, copper, lead, chromium, manganese, iron and mercury are major soil pollutants, particularly in areas with high anthropogenic pressure. Heavy metal accumulation in soils is of concern in agricultural production because of the adverse effects on food safety, marketability and crop growth because of phytotoxicity, and environment health of soil organisms. Bioremediation is that the use of microorganisms and beneficial plants for the treatment of metal polluted soils. Heavy metals get transformed from one organic complex or oxidation number to a different and become either less toxic, easily volatilized, more water soluble and simply off from the polluted soils. Ayurvet Research Foundation undertakes various research initiatives to enhance soil health index and educates farmers of the region on ill effect of pesticides, insecticides, fungicides, over usage of chemical fertilizers on crop productivity and food safety. The Organization, time to time, demonstrates the methodology of organic farming, usage of fine quality of irrigation water, vermicompost and 0 tillage techniques for optimal crop productivity and environment sustainability.

***Keywords :-* Heavy metals, Soil, Bioremediation, Biochar**

INTRODUCTION

Soil health is that the continued capacity of soil to function as a significant living ecosystem that sustains plants, animals and humans. A healthy soil acts as a dynamic living system that delivers multiple ecosystem services, like sustaining water quality and plant productivity, controlling soil nutrient recycling decomposition, and removing greenhouse gases from the atmosphere. It's closely related to sustainable agriculture, because soil microorganism diversity and activity are the most components of soil health.

Heavy metals are significant environmental pollutants; their toxicity could be a problem of skyrocketing significance for ecological, evolutionary, nutritional and environmental reasons [1]. Abolition of metal pollution may be a challenging task thanks to its non-degradable nature allowing it to act soil for for much longer period than the opposite components of biosphere. Rapid industrialization and poor management of business effluents cause increased metal pollution altogether components of the environment [2]. Heavy metals are a gaggle of inorganic chemical and people most typically found at contaminated sites are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni) [3]. Soils are the main sink for heavy metals released into the environment by aforementioned anthropogenic activities and in contrast to organic contaminants which are oxidized to carbon (IV) oxide by microbial action, most metals don't undergo microbial or chemical degradation [4]. Ayurvet Research Foundation (ARF) a public trust, undertakes various initiatives for the sustainable integration of livestock and agriculture for the advantage of farmers and society at large. One in all the main objectives of the ARF is to grasp the health index of soil of agriculture land of varied districts of Haryana and educate farmers on ill effect of pesticides, insecticides, fungicides, over usage of chemical fertilizers on crop productivity and food safety. The Organization, time to time, demonstrates the methodology of organic farming, usage of fine quality of irrigation water, vermicompost and nil tillage techniques for optimal crop productivity and environment sustainability.

1. Source of heavy metals in soil:-

Heavy metals occur naturally within the soil environment from the pedogenetic processes of weathering of parent materials at levels that are thought to be trace (<1000mg/kg) and barely toxic. Thanks to the disturbance and acceleration of nature's slowly occurring geochemical cycle of metals by man, most soils of rural and concrete environments may accumulate one or more of the heavy metals above defined background values high enough to cause risks to human health, plants, animals, ecosystems, or other media [5]. The heavy metals essentially become contaminants within the soil environments because (i) their rates of generation via manmade cycles are more rapid relative to natural ones, (ii) they become transferred from mines to random environmental locations where higher potentials of direct exposure occur, (iii) the concentrations of the metals in discarded products are relatively high compared to those within the receiving environment, and (iv) the chemical form (species) within which a metal is found within the receiving environmental system may render it more bioavailable [6].

1.1 Fertilizers:- Large quantities of fertilizers are regularly added to soils in intensive farming systems to supply adequate N, P, and K for crop growth. The compounds accustomed supply these elements contain trace amounts of heavy metals (e.g., Cd and Pb) as impurities, which, after continued fertilizer, application may significantly increase their content within the soil [7].

1.2 Biosolids and Manures:- The application of numerous biosolids (e.g., livestock manures, composts, and municipal sewage sludge) to land inadvertently ends up in the buildup of heavy metals like As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Mo, Zn, Tl, Sb, so forth, within the soil. Certain animal wastes like poultry, cattle, and pig manures produced in agriculture are commonly applied to crops and pastures either as solids or slurries. Heavy metals most typically found in biosolids are Pb, Ni, Cd, Cr, Cu, and Zn, and also the metal concentrations are governed by the character and so the intensity of the business activity, moreover because the design of process employed during the biosolids treatment [8].

1.3 Waste water:- The applying of municipal and industrial wastewater and now's a typical practice in many parts of the world. Farmers generally aren't bothered about environmental benefits or hazards and are primarily interested in maximizing their yields and profits. Although the metal concentrations in wastewater effluents are usually relatively low, long-term irrigation of land with such can eventually result in heavy metal accumulation within the soil [9].

2. Effects of heavy metals on soil:-

Soil contamination by heavy metals is of most important apprehension throughout the industrialized world. Heavy metal pollution not only end in adverse effects on various parameters bearing on plant quality and yield but also cause changes within the dimensions, composition and activity of the microbial community. Therefore, heavy metals are considered jointly of the foremost sources of soil pollution. Heavy metal pollution of the soil is caused by various metals especially Cu, Ni, Cd, Zn, Cr, and Pb. The adverse effects of heavy metals on soil biological and biochemical properties are well documented. The soil properties i.e. organic matter, clay contents and pH have major influences on the extent of the results of metals on biological and biochemical properties [10]. Some heavy metals like Co, Cu, Fe, Mn, Mo, Ni, V, and Zn are required in minute quantities by organisms. However, excessive amounts of these elements can become harmful to organisms. Other heavy metals like Pb, Cd, Hg, and As (a metalloid but generally stated as a major metal) do not have any beneficial effect on organisms and are thus considered the “main threats” since they're very harmful to both plants and animals. Plants grown in soil containing high levels of Cd show visible symptoms of injury reflected in terms of chlorosis, growth inhibition, browning of root tips and eventually death [11,12,13].

3. Effects of heavy metals on seed:-

Seed germination and seedling growth are important stages of growth in flora cycle because the quantity of healthy seedlings ensures greater crop exchange the sphere and thus higher production. Several studies indicate that the heavy metals reduce or inhibit the germination of the seeds by lowering the water uptake or causing death or damage to the embryo [6], and counting on the concentration of the metal, high concentrations affect germination, and low concentrations show no significant effect [7,8]. The effect of heavy metal toxicity on the expansion and development of plants differs in step with the particular heavy metal for that process. Nickel (Ni) is reported to be toxic to most plant species affecting amylase, protease and ribonuclease enzyme activity thus retarding seed germination and growth of the numerous crops. it has been reported to affect the digestion and mobilization of food reserves like proteins and carbohydrates in germinating seeds,[3] reducing plant height, root length, fresh and dry weight, chlorophyll content and enzyme carbonic anhydrase activity, and increasing malondialdehyde content (MDA) and electrolyte leakage. Lead (Pb) has been reported to strongly affect the seed morphology and physiology. It inhibits germination, root elongation, seedling development, plant growth, transpiration, chlorophyll production, and water and protein content, causing alterations in chloroplast, obstructing electron transport chain, inhibition of Calvin cycle enzymes, impaired uptake of essential elements, Mg and Fe, and induced deficiency of CO2 thanks to stomatal closure [4].

Copper stress ends up in reduced germination rate and induces biomass mobilization by release of glucose and fructose thereby inhibiting the breakdown of starch and sucrose in reserve tissue by inhibition within the activities of alpha amylase and invertase isoenzymes [8]. Proteomics studies has revealed that Cu toxicity inhibit seed germination by down regulating activity of alpha amylase. It has been reported to affect overall metabolism, water uptake and failure to mobilize reserve food [11]. Cadmium (Cd) has been shown to cause delay in germination, induce membrane damage, impair food reserve mobilization by increased cotyledon/embryo ratios of total soluble sugars, glucose, fructose and amino acids,[12] mineral leakage leading to nutrient loss,[13] accumulation in seeds and over accumulation of lipid peroxidation products [14,15] in seeds. It has been reported to chop back the germination percent, embryo growth and distribution of biomass, and inhibit the activities of alpha amylase and invertases.

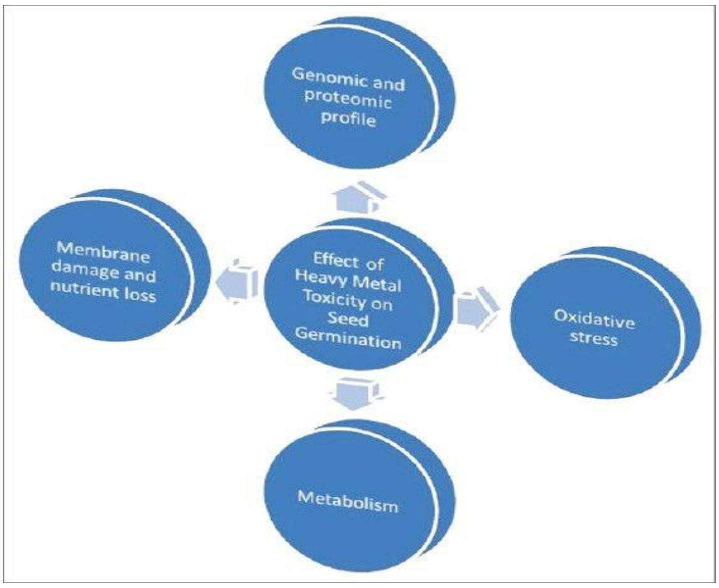

Figure 1:- Different effects of heavy metals on seed germination

4. Effects of heavy metals on plants:-

Some of these heavy metals i.e. As, Cd, Hg, Pb or Se don't seem to be essential for plants growth, since they're doing not perform any known physiological function in plants. Others i.e. Co, Cu, Fe, Mn, Mo, Ni and Zn are essential elements required for normal growth and metabolism of plants, but these elements can easily end in poisoning when their concentration greater than optimal values. Among the heavy metals, lead (Pb) is reported to bio-magnify in animal body through contaminated crops other than morpho-physiological and oxidative damage in plants with higher transfer factor of cadmium from soil to plants, cadmium concentration is found predominantly high in fruits and vegetables [18]. The use of compost to spice up agricultural yield without caring with possible negative effects may possibly be a problem since the waste composts are most applied to boost soils accustomed grows vegetables. Considering the edible an element of the plant in most vegetable species, the possibility of transference of heavy metals from soil to humans can be a matter of concern. Uptake of heavy metals by plants and subsequent accumulation along the natural phenomenon may be a possible threat to animal and human health. The absorption by plant roots is one all told the foremost routes of entrance upon many factors which include temperature, moisture, organic matter, pH and nutrient availability of heavy metals within the natural phenomenon. Heavy metal accumulation in plants depends upon plant species and also the efficiency of varied plants in absorbing metals is evaluated by either plant uptake or soil to plant transfer factors of the metals. Elevated Pb in soils may decrease soil productivity, and a very low Pb concentration may inhibit some vital plant processes, like photosynthesis, mitosis and water absorption with toxic symptoms of dark green leaves, wilting of older leaves, stunted foliage and brown short roots. Heavy metals are potentially toxic and phytotoxicity for plants resulting in chlorosis, weak plant growth, yield depression, and may even be among reduced nutrient uptake, disorders in plant metabolism and reduced ability to fixate molecular nitrogen in leguminous plants [19].

5. Effects of heavy metals on human health

The plant uptake of heavy metals from soils at high concentrations may cause an honest health risk taking into consideration food-chain implications. Utilization of food crops contaminated with heavy metals is also a serious natural phenomenon route for human exposure. The food plants whose examination system relies on exhaustive and continuous cultivation have great capacity of extracting elements from soils. The cultivation of such plants in contaminated soil represents a possible risk since the vegetal tissues can accumulate heavy metals. Heavy metals become toxic once they don't seem to be metabolized by the body and accumulate within the soft tissues. Chronic level ingestion of toxic metals has undesirable impacts on humans and so the associated harmful impacts become perceptible only after several years of exposure. Cadmium (Cd) might be a well known heavy metal toxicant with a specific gravity 8.65 times greater than water. The target organs for Cd toxicity are identified as liver, placenta, kidneys, lungs, brain and bones. Reckoning on the severity of exposure, the symptoms of effects include nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. Severe exposure may cause pulmonary odema and death. Pulmonary effects (emphysema, bronchiolitis and alveolitis) and renal effects may occur following subchronic inhalation exposure to cadmium and its compounds. The Itai-itai disease in Japan brought the risks of environmental Cd to world attention. Cd has been associated to a lesser or greater extent with many clinical conditions including anosmia, cardiac failure, cancers, cerebrovascular infarction, emphysema, osteoporosis, proteinuria cataract formation within the eyes. Yet, it has been difficult to tie down obvious links of environmental exposures with morbidity and mortality [15]. Zinc is taken into consideration to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction. The clinical signs of zinc toxicosis are reported as vomiting, diarrhea, bloody urine, icterus (yellow mucus membrane), liver failure, nephrosis and anemia. Copper (Cu) is a vital element in mammalian nutrition as a component of metallo enzymes during which it acts as an electron donor or acceptor. Conversely, exposure to high levels of Cu may find your self during variety of adverse health effects. Exposure of humans to Cu occurs primarily from the consumption of food and drinkable.

Acute Cu toxicity is usually associated with accidental ingestion; however, some members of the population is additionally more susceptible to the adverse effects of high Cu intake thanks to genetic predisposition or disease. Excessive human intake of Cu may leads to severe mucosal irritation and corrosion, widespread capillary damage, hepatic and renal damage and central system irritation followed by depression.

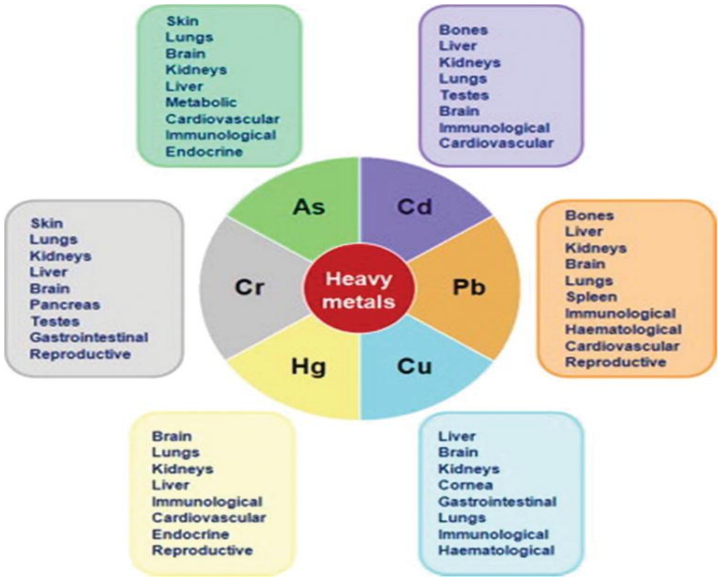

Figure 2:- Impacts of heavy metals on the environment

Severe gastrointestinal irritation and possible necrotic changes within the liver and kidney can also occur. The implications of Ni exposure vary from skin irritation to interrupt to the lungs, system, and mucous membranes. Lead (Pb) is physiological and neurological toxic to humans. Acute Pb poisoning may finishes up during a dysfunction within the kidney, reproduction system, liver and brain resulting in sickness and death. Pb heads the threats even at extremely low concentrations. A notably serious effect of lead toxicity is its teratogenic effect. Plumbism also causes inhibition of the synthesis of hemoglobin; vascular system and acute and chronic damage to the central nervous system (CNS) and peripheral nervous system (PNS) [19].

5. Bioremediation

Methods of Heavy Metal Remediation

Bioremediation is that the utilization of microorganisms and beneficial plants for the treatment of metal polluted soils. It is a broadly usual method of soil remediation because it's clear to occur via natural processes. It is a value effective and non disturbing method of soil remediation, it used for the treatment of heavy metal polluted soils. Heavy metals can't be degraded during bioremediation but can only be transformed from one organic complex or number to a unique. because of a change in their oxidation condition, heavy metals are often transformed to become either less toxic, easily volatilized, more water soluble can removed through leaching whereas less water soluble is precipitate and easily far away from the polluted soils. For bioremediation of heavy metals polluted soils combination of both microorganisms and plants is employed [20,21]. Several microorganisms especially bacteria (Bacillus subtilis, Pseudomonas putida, and Enterobacter cloacae) are successfully used for the reduction of the high toxicity of Cromium to the less toxic Cr (VI to III). Bacillus thuringiensis are shown to increase extraction of Cd and Zn from Cd-rich soil and soil polluted with effluent from metal industry. It's assumed that the assembly of siderophore (Fe complexing molecules) by bacteria may have facilitated the extraction of these metals from the soil; and reproduce the assembly of siderophore and this consequently affects their bioavailability. Bioremediation may occur indirectly through bioprecipitation by sulphate reducing bacteria (Desulfovibrio desulfuricans) which converts sulphate to hydrogen sulphate which subsequently reacts with heavy metals like Cd and Zn to form insoluble sorts of these metal sulphides. The controversies surrounding genetically modified organisms and thus the indisputable fact that the heavy metal remains within the soil are major limitations to the current approach for bioremediation.

Gram-negative bacteria are capable of resisting and accumulate Cd from the contaminated sites. The biomass of the P. aeruginosa strain was reported to be highly efficient for the recovery and removal of Cd, Pb, and Cu from a polluted soil. Also, the genetically engineered P. aeruginosa effectively removed Cd. It absolutely was also observed that the strains from the Pseudomonas have the potential to induce obviate Cd thanks to its good biosorption efficacy. Most of the microorganisms use many strategies to counter the heavy metal stress which include active efflux of metals; metal ions sequestration, Cd accumulation, and enzymatic detoxification. Chemical methods are often available for elimination of chromium in majority from industrial effluent but they often fail to satisfy the environmental regulations. In chemical treatment very harmful chemicals are discharged which are toxic moreover as harmful to environment. So microbial treatment of CTLS is additionally better alternative compared with chemical treatment for this purpose because the chemical agents raise the environmental pollution [22]. Microbial treatment involves all kinds of microbes like bacteria, fungus & some species of bacteria like Pseudomonas, Bacillus and Arthrobacter for reducing the quantity of chromium. In polluted sites, chromium obtainability is influenced by processes like complex formation, oxidation-reduction, precipitation, which successively rely upon microbial activities. Though, exposure to chromium for an extended time can reduce microbial diversity, population and activity. Many bacterial species surviving in presence of chromium for years in contaminated sites are found to be highly proof against chromium and are measured as important for removal of chromium.

5.1 Physicochemical Methods

Physicochemical methods include processes that employment to urge eliminate heavy metals from any contaminated environment. They're going to be applied within the type of particulate of metals or metal-containing particles. This remediation is conducted through physical and chemical processes like process, precipitation, reverse osmosis, evaporative recovery, solvent extraction, filtration, chemical oxidation, chemical leaching, electrokinetics land filling, electrochemical treatment, electrodialysis, ultrafiltration, solvent extraction, chemical precipitation, chemical reduction, and isolation (mechanical) separation of metals [23].

5.2. Biological Methods

Biological remediation or biodegradation constitutes many sorts of methods involved within the removal or degradation of heavy metals through biological activity. These biological treatments may either include aerobic (presence of oxygen) or anaerobic (absence of oxygen) processes and may well be used for heavy metal removal.

(5.2.1) In-situ Bioremediation

In situ bioremediation methods treat the contamination at the situation without removing soil. The use of these specific methods depends on many factors: the realm contaminated, properties of the compounds involved, concentration of the contaminants, and time required to end the bioremediation [24]. This process is usually recommended because it requires moving fewer materials and may be a smaller amount expensive.

(5.2.2) Ex-Situ Bioremediation

Ex situ bioremediation means excavating and treating soil before returning the soil to its original state. If the contaminated material is excavated, it'll be treated on or off site, which is often a more rapid method of decontaminating the globe. Ex situ bioremediation is categorized into solid phase and slurry phase systems. The foremost important techniques include land farming, composting, biopiles, and bioreactors [25].

5.3 Biochar

It is one organic material that's currently being exploited for its potential within the management of heavy metal polluted soils. The effect of varied biochar amendments depends on the provision of heavy metals present in soil. Further, more research is required so on grasp the effect of biochar on soil microorganisms and also the way the interaction between biochar and soil microbes influences remediation of heavy metal polluted soils because such studies are rarely found within the literature.

Conclusion:-

Heavy metals are significant environmental pollutants; their toxicity could be a problem of skyrocketing significance for ecological, evolutionary, nutritional and environmental reasons. Abolition of metal pollution may be a challenging task thanks to its non-degradable nature allowing it to move soil for for much longer period than the opposite components of biosphere. Plants growing on heavy metal polluted soils show a discount in growth because of changes in their physiological and biochemical activities. Plants employ different mechanisms within the remediation of heavy metal polluted soils. Phytoextraction is that the commonest method of phytoremediation used for treatment of heavy metal polluted soils. It ensures the whole removal of the pollutant. Bioremediation is that the use of microorganisms and beneficial plants for the treatment of metal polluted soils. It's a broadly usual method of soil remediation because it's clear to occur via natural processes. It is a value effective and non disturbing method of soil remediation, it used for the treatment of heavy metal polluted soils.

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