Review Paper

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Management of Increasing Soil Pollution in the Ecosystem

5 ABSTRACT

6 The present paper is a mini review of the increasing soil pollution in the environment and the possible 7 handy options available, to curb its rate. Soil being a non-renewable resource, must be protected from 8 all types of pollutants. The health of all life forms is associated with the health of soil. Any degradation 9 in the quality of soil can significantly produce many undesirable changes in the environment. Adoption 10 of suitable strategies to protect our motherland from contamination is must for all of us to save 11 ourselves and continuation of natural cycles in the ecosystem.

12 Keywords: Soil; pollution; pollutants; remediation measures.

13 1. INTRODUCTION

Soil is an important natural resource to sustain life on earth because of its diverse functions that it 14 15 play in the nature. It is the ultimate recipient of any waste that we throw or dispose as waste product 16 in the environment. The different layers of soil involved in physical (sieving), chemical (adsorption-17 precipitation) and biological filter (decomposition of organic wastes) is necessary to maintain a healthy 18 environment and reduce the pollution [1]. These buffering capacity of soil is limited and must be 19 managed properly to maintain the qualities of a healthy soil. Several human activities like agriculture, 20 industrial setup etc. pollute the soil with organic and inorganic substances (solid wastes, heavy 21 metals, solvents) [2]. Over the years, there is an increasing worldwide concern of environmental 22 pollution associated with soil because degradation of soil health increases the risk of health of all 23 forms of life [3]. The potential organic (e.g. pesticides) and inorganic (e.g. heavy metals) pollutants 24 released into the environment are toxic and persistent in nature [4]. They enter in the food chain and 25 accumulate within the tissues of animals (biological magnification) [5]. Soil helps in protecting the 26 groundwater by acting as a filter of these toxic compounds. This indicate pollution of soil can lead to 27 water pollution if the process is unchecked. Therefore, we must focus on prevention of our motherland 28 from contamination.

29 2. SOIL POLLUTION

The introduction of undesirable substances or contaminants in the environment is termed as pollution [6]. Soil pollution is the changes in properties of soil by addition of materials that adversely effects on its functioning and health of organisms living on it [7]. It may occur naturally or can be aggravated by the experiments of man. Soil pollution results in decrease of soil quality, disturbance in the soil's natural composition leading to erosion of soil, imbalance in the population of soil flora and fauna,
 contamination of groundwater, decline in productivity of crops etc.

36 3. TYPES OF SOIL POLLUTION

37 The different activities involved in the process of soil pollution are:

38 3.1 Agricultural Pollution

Various chemical compounds used in agriculture to enhance the crop yield are fertilizers, pesticides, insecticides, fungicides etc. contaminate the soil [8]. Surface runoff help in spreading of these chemicals. They penetrate deep inside the soil and poison the groundwater system. The organic compounds which resist degradation, bioaccumulate in terrestrial and aquatic ecosystem by transferring from one place to other and have potential to impact on the health of human and environment, are termed as persistent organic pollutants (POPs). Faulty irrigation practices and use of poor quality of water also help in degrading the soil [9].

46 **3.2 Industrial Pollution**

47 Disposal of industrial effluents from chemical industries, mining industries, paper industries, tanneries, 48 steel industries, pharmaceutical industries, food processing industries, cement industries, thermal 49 industries, nuclear power plants etc. in soil cause such type of soil pollution. These include mainly 50 heavy metals like lead, chromium, cadmium, mercury etc. [10]. Burning of fossil fuels, smelting and 51 processing of metals in factories dump the wastes in the soil. The heavy metals become toxic when 52 they are present at high concentration. Acid rain caused due to smoke released from the factories, act 53 as acidic pollutants in soil. Sulphur dioxide (SO₂) and nitrogen oxides (NO_x) act as a major sources of 54 acid rain.

55 3.3 Solid Wastes

56 Unscientific disposal of any type of waste (city/village waste, sewage, nuclear waste) will contaminate 57 soil. The municipal and domestic waste include garbage, paper, plastics, glass, metals, paints, 58 rubber, leather, textiles, varnishes etc. Leakage of stored waste from dumping site pollute soil and 59 groundwater [11]. Nuclear waste can cause mutation in the organisms. The problem of hospital 60 wastes and e-wastes generated in a day are dangerous urban waste and should be focussed on 61 recycling instead of dumping. Sanitary landfills are better than open burning. Improper management 62 of night soil can favour in spreading of harmful diseases.

63 3.4 Oil Pollution

With growing population, the consumption of fossil fuels has increased tremendously. Crude oil and hydrocarbon derivatives may pollute soil during its extraction, transportation, storage and use. Spilling and leaking of such oil products are the major threat to soil and water quality, and health of plants and animals [12]. These toxic compounds remain for very long time in soil, affecting the physical and chemical properties of soil. They reduce the available nutrient concentrations in the soil.

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69 Therefore, the common pollutants reaching the soil through different sources can be listed as (Fig. 1):

- i) Fertilizers and other salts
- 71 ii) Pesticides
- 72 iii) Heavy metals
- 73 iv) Organic waste materials
- v) Radionuclide
- vi) Acid rain

76 4. EFFECTS OF SOIL POLLUTION

77 Fertilizers can change reaction of soil. Excessive use of acid forming fertilizers (ammonium sulphate) 78 and basic fertilizers (sodium nitrate) may develop soil acidity and alkalinity respectively [13]. Leaching loss of nitrate (NO₃) can pollute groundwater. According to the World Health Organization (WHO), 10 79 mg NO₃⁻N/L water is safe for drinking water. Methemoglobinemia (blue baby syndrome) is seen in 80 infants if this limit of NO_3^{-} exceeds in water [14]. The adverse effects of nitrate poisoning are seen in 81 82 animals, particularly in ruminants because the rumen microbes fail to convert nitrite (NO_2) to 83 ammonia (NH₃), leading to accumulation of excess NO₂ [15]. Nutrient enrichment of nitrogen (N) and phosphorus (P) in water bodies cause algal bloom and natural aging of lakes (eutrophication) [16]. 84 85 The process is extremely costly to recover and takes long time in natural way. The NO₃ lost to the atmosphere in the form of N₂O gas by denitrification, contributes to greenhouse effect [17]. 86

Pesticides used to target specific pests may also kill beneficial organisms living in the soil (non-target 87 88 damage, extinction of species and habitat destruction) and the species which survive give rise to 89 highly resistant generations known as super pests and lead to outbreak of secondary pests. Several 90 diseases of skin, nervous system, respiratory system and other body organs are found in human as long term exposure to pesticides and these may even lead to cancer, Parkinson, Alzheimer etc. [18]. 91 92 Some of these chemicals remain in soil for years e.g. dichlorodiphenyltrichloroethane (DDT), aldrin, 93 triazine herbicides etc., while other pesticides like organophosphate insecticides (parathion, malathion), phenoxy herbicides [2,4-dichlorophenoxyacetic acid (2,4-D)], carbamate insecticides 94 95 persist only for few days or months. The potentially toxic elements (Cd, Cr, Hg etc.) are extremely 96 phytotoxic, accumulate in plant tissues and cause health hazards in humans and animals [19]. They 97 are also reported to cause nutrient imbalance in soil (soil infertility). Sewage sludge contain many pathogenic bacteria and form the basis of spreading many types of diseases. Radioactive elements 98 99 which enter in the food chain can cause abnormalities in animals. Acid rain leads to acidification of 100 soil, hampers in functioning of microbes, decreases enzymatic activities, reduces the vegetation 101 cover, and can even alter the composition of forest species [20].



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103	Fig. 1. Schematic representation of the sources and effects of soil pollution, and measures for
104	mitigation. (1), (2) and (3) express the adverse effects of the sources of urban/city, industrial
105	and agricultural wastes respectively, while (A), (B) and (C) are representatives of the mitigation
106	steps to control the soil pollution from the sources: (1), (2) and (3) respectively.

- 107 5. REMEDIATION MEASURES
- 108 Approaches to be developed to minimise soil pollution as pre and post contamination management 109 strategies are:
- Generation of eco-friendly approaches (organic farming, regenerative agriculture, permaculture etc.) for farming system, where we focus more on the benefits of crop rotations, crop residues, organic manures, legumes, green manuring etc. than the use of chemical fertilizers and pesticides [21].
- Biopesticides: Formulations made from natural ingredients either derived from animals 114 115 (nematodes) and plants (Chrysanthemum spp., Azadirachta spp. etc.) or microorganisms (Bacillus thuringiensis, Trichoderma spp. etc.), and even include living organisms (natural 116 by-products 117 enemies), their products (phytochemicals, microbial products) and (semiochemicals) for controlling the problem of pests by non-toxic mechanisms, and 118 119 maintained in an environment friendly manner [22].
- Analysis of soil samples (soil testing)
- 121 i) Assessment of soil quality and development of soil health report.
- 122 ii) Evaluation of levels of heavy metals and other contaminants present in soil.
- 123 iii) Fertiliser recommendations and site-specific nutrient management.
- Physico-chemical measures

- i) Soil vapour extraction: This is used for treatment of volatile organic compounds
 (VOCs), where vacuum is applied to soil and activated charcoal is used for filtration or
 adsorption [23].
- ii) Soil washing: The toxic compounds are removed by dissolution in water or waterbased solution. This is used for organic as well as inorganic pollutants (metals,
 radioactive substances, etc.) [24].
- Recycling and recovery of useful materials from the wastes.
- Promotion of jute/paper bags and exclusion of plastic bags (especially those below 20 microns thickness).
- Proper treatment of industrial effluents and sewage before releasing them to soil.
- Composting is an economically and environmentally suitable method for recycling
 biodegradable wastes in developing countries having limited resources [25]. Nutrient rich
 manures produced with the help of macrofauna (earthworm) and microflora (bacteria, fungi
 and actinomycetes) will help in restoring the soil conditions.
- Sanitary landfilling is a good option for disposing municipal solid waste (MSW). Solid wastes are disposed in thin layers, compacted, and covered with liners made of suitable earth material (clay) or plastic foam as protective measures against pollution of surface or groundwater, dust, wind-blown litter, stink, fire exposure, bird menace, pests or rodents, greenhouse gas emissions, slope instability, and erosion [26]. The leachate is sent for treatment and the methane produced in the decomposition, can be used in electricity generation.
- Humic substances (HS) are ubiquitous in natural environment, having high stability, can be
 used for remediation of soils contaminated with heavy metals, as they bind with metal ions
 and change their speciation forms in soils [27].
- Government policies focussing on plantation, social, agroforestry and watershed
 programmes.
- Awareness in public about adoption of conservation agriculture, crop rotation, conservation
 tillage, livestock production etc. practices.
- Application of participatory rural appraisal (PRA) techniques for discussion with the local people about the problems of the area and suggesting them the proper solutions with the use of existing local knowledge so as to promote the dwindling indigenous technical knowledge 156 (ITK) practices.
- Improved scheduling of irrigation i.e. supply of water as per demand, minimizing leaching and
 use of good quality water in agricultural fields.
- Adverse effect of N can be minimized by application of optimum dose of N in split doses in time and use of slow release fertilizers (sulphur coated urea, neem coated urea etc.) [28].
- Proper collection of solid waste and use of appropriate techniques for disposal.
- Use of on and off-farms residues and organic manures in the fields.
- Bioremediation and/or biotransformation:

- i) Phytoremediation: Use of plant species (hyperaccumulators) for remediation of soil
 contaminants. Plants belonging to the family of Asteraceae, Brassicaceae,
 Caryophyllaceae etc. are reported for such type of actions [29].
- 167 ii) Micro-remediation: Use of microbes (*Trichoderma* spp., *Pseudomonas* spp. etc.) for
 168 remediation of soil contaminants.
- 169 iii) Vermi-remediation: Use of earthworms (*Eisenia fetida*, *Eudrilus eugeniae* etc.) for
 170 remediation of soil contaminants.

171 These are soft bioengineering techniques which can be used not only for cleaning the 172 polluted lands but also for stabilizing the eroded lands and check the problem of soil erosion 173 [30].

174 6. CONCLUSION

More studies and researches should be carried out in pollution remediation of soil resources. Regionspecific, eco-friendly and cost effective technologies should be identified. Biological measures has gained worldwide attraction due to its environment friendly nature but selection of appropriate species

178 (plant or microorganisms) is the new challenge associated with it. Soil and crop management

- 179 practices should be dealt more scientifically with judicious use of the toxic inorganic chemicals so that
- 180 their continuous flow in soil-plant-animal system is reduced.

181 COMPETING INTERESTS

182 Authors have declared that no competing interests exist.

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