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Soil Pollution and its effects on Agriculture

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***Abstract*— *Soil pollution can lead to the emergence of new pests and diseases by changing the balance of ecosystems and causing the disappearance of predators or competing species that regulate their biomass. It also contributes to the spreading of antimicrobial resistant bacteria and genes, limiting humanity's ability to cope with pathogens. Pollution can also cause the quality of soil to dwindle over time, making it harder to grow crops. Currently, the degradation of land and soils is affecting 40 per cent of the world's population. Soil has a key role to play through its ecosystem functions as it affects water regulation, nutrient recycling, food production, climate change and the biodiversity of terrestrial ecosystems. Transitioning from soil degradation to practices that restore soil is critical to ensure the food security and wellbeing of generations to come has now become a call of time..*

Keywords*— *Land degradation, heavy metal pollutants, pesticides, sustainable agriculture, soil fertility.

I. INTRODUCTION

The study of soil pollution is very important to many researchers and those interested in the environment, due to the great impact that the pollution of agricultural lands has on the lives of humans and animals alike. The chemical and physical changes in soil composition are caused by the entry of foreign bodies. Also, the use of pesticides and chemical fertilizers in large quantities, the fall of acid rain, as well as the dumping of solid and liquid waste from factories and others, contribute to the loss of soil fertility and organic materials. Also, volcanoes, fires and mining contribute significantly to soil pollution and losing its organic matter and fertility. Pesticides fungicides and chemical fertilizers affect soil and agricultural crops. The use of untreated wastewater to irrigate agricultural lands causes soil pollution through the growth of harmful insects and plants.

Soil pollution refers to the contamination of soil with anomalous concentrations of toxic substances. It is a serious environmental concern since it harbours many health hazards. For example, exposure to soil containing high concentrations of benzene increases the risk of contracting leukaemia. An image detailing the discolouration of soil due to soil pollution is provided.

It is important to understand that all soils contain compounds that are harmful/toxic to human beings and other living organisms. However, the concentration of such substances in unpolluted soil is low enough that they do not pose any threat to the surrounding ecosystem.

When the concentration of one or more such toxic substances is high enough to cause damage to living organisms, the soil is said to be contaminated. Environmental pollution is all the undesirable changes that occur in the environment, whether partial or total, due to the whole types of human activities. It is also known as the atmosphere that results from changes in the ecological environment created by humans, Environmental pollution can be considered as the cause of inconvenience, damage, disease, or death [1]. Soil pollution can be defined as the entry of foreign bodies into the soil that leads to a change in the chemical and physical composition. This often results from the use of pesticides and fertilizers, and acid rain that changes the pH of the soil, throwing off radioactive unions and others [2]. Also, it can be defined as the destruction that affects the soil layers causing a change in the natural characteristics of the main environmental elements due to the leakage of complex chemical compounds or artificial radioactive materials that raise the radioactive level in the soil, and impede its analysis. Pollution of agricultural land is defined as the corruption that affects agricultural land, and changes its natural, chemical or biological characteristics and properties. It makes it negatively affect, directly or indirectly, on the person, animal or plant living on its surface. Agricultural soil pollutants include agricultural residues such as plant residues and their weeds, roots left over from burning the ground, vegetable residues, crop stems, tree leaves, and fallen fruits before they ripen [3].

The origin of soil pollution may be natural or anthropogenic and therefore may have happened long ago or recently. Certain contaminants are often associated with specific activities, such as pesticide use in agriculture or radionuclides from nuclear power plants, while many others could result from a variety of sources of 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 anthropogenic sources of soil pollution are the chemicals used in or produced as byproducts of industrial activities; domestic, livestock and municipal wastes (including wastewater); agrochemicals; and petroleum-derived products.

These chemicals are released to the environment accidentally, for example from oil spills or leaching from landfills, or intentionally, through use of fertilizers and pesticides, irrigation with untreated wastewater, or land application of sewage sludge. soil pollution has an adverse impact on food security in two ways –it can reduce crop yields due to toxic levels of contaminants, and crops grown in polluted soils are unsafe for consumption by animals and humans. It urged governments to help reverse the damage and encouraged better soil management practices to limit agricultural pollution.

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.

II. HEAVY METALS

The contamination of agricultural soils by heavy metals is one of the most important methods of soil degradation (EU Soil Thematic Strategy). Soil contamination by heavy metals presents many problems for soil functions, the environment, agriculture production, food chains or even human health [Adriano,]. The maintenance of a suitable state of soil load by heavy metals should be the interest of every society. The evaluation of soil load by heavy metals must be supported by the knowledge of heavy metals' background values, their inputs into soils, their behaviour and fate in the soil environment and their transfer into the plants or groundwater [Kabata-Pendias].

Pikula and Stepien [Pikula,] deal with heavy metals mobility in the soil profile. The behaviour of Cd, Cu, Pb and Zn depending on selected soil conditions was studied in a long-term microplot experiment. The mobility of heavy metals was defined for light texture soil and medium texture soil.

The transfer of Cd from soils with different Cd contents caused by agricultural techniques in the Amazonian area into cocoa plants was observed in the article of Rosales-Huamani et al.. The increased Cd load in cocoa beans complicates the husbandry of farmers in the area and the study shows the main principles of the problem. The content of Cd in the leaves of maize (Zea mays) was studied by Franič et al. The authors compared different maize genotypes and the effect of Cd on photosynthesis through chlorophyll fluorescence in selected plants.

Skála et al. observed the contamination of soil and plant by zootoxic elements (As, Cd and Pb) loaded by increased heavy metals contents in fluvial zones. The main soil characteristics influencing the transfer of risky elements from soil into selected plants, barley (Hordeum vulgare) and triticale (Triticosecale) or individual parts of the plant, shoots and grain of oat (Avena sativa) were defined using statistical tools. The single correlation analysis compared risky elements uptake by plants with its mobile fractions in soil (extracts by NH_4NO_3, $CaCl_2$ and Na_2EDTA).

Kuziemska et al. present a study focused on gentle remediation techniques. The organic soil amendments available in agriculture (cattle manure, chicken manure and spent mushroom substrate) were applied into soil contaminated by increased content of Cu to decrease phytotoxic effect.

Jakubus and Graczyk studied the immobilisation effect of compost and fly ash on Pb uptake by narrow-leaved lupine (Lupinus angustifolius), camelina (Camelina sativa) and oat (Avena sativa). The Pb contents in the soil and plants were used to calculate the risk assessment code (RAC), individual contamination factor (ICF), bioconcentration factor (BCF) and contamination coefficient level (CCL). The higher immobilisation effect of fly ash compared to compost was observed in the study.

III. PESTICIDES

The Pesticides are designed to kill bugs that are harmful to plants. Pesticides kill specific pests on plants such as slugs, beetles and flying insects. The chemicals used in most pesticides can kill more than just garden pests; they can kill the helpful organisms that live in the soil. Some of these chemicals can remain in the soil for years, effectively keeping necessary microorganisms from working the soil. Common chemical pesticides that are used in gardens and by large-scale crop producers include the following: • Basic Copper Sulfate • Silica Gel • Sodium Fluoride

The pesticides used in modern conditions allow not only to reduce crop losses from pests and maintain the resulting products quality [M.A. Daam, J. Gao, M. Hvězdová, E.M. John]. The soil-protective and minimal tillage is impossible without the pesticides use; it is possible to reduce the effectiveness of other measures, for example, the application of fertilizers and ameliorants [R. Kodešová, L. Zhichkina, S.-K. Lammoglia]. Insecticides and acaricides, nematicides, rodenticides, molluscicides, repellents, pheromones, fungicides, herbicides, desiccants, plant growth regulators - are pesticides [Q. Li, . A. Mudhoo, E. Pose-Juan, C. Qu, N. Rafique and V. Silva].

IV. CONCLUSION

The study of effects of pollution on agriculture is indeed an urgent issue to work upon since it leads to a number of environmental effects like soil pollution, air pollution, water pollution and land pollution. With the advent of modern agricultural practices like use of high yielding variety seeds and eventually huge amounts of fertilizers is leading to degradation of land and desertification all over the country. The only solution to the above environmental problems is shifting towards green energy sources like manures, vermicomposts, biogas slurry and composting practices which are not only beneficial for crops but also helps in regenerating the degraded land. These organic alternatives are purely biodegradable and eco friendly.

REFERENCES

[1] Adhikari, P., Joshi, K., Singh, M., & Pandey, A. 2022. Influence of altitude on secondary metabolites, antioxidants, and antimicrobial activities of Himalayan yew (Taxus wallichiana. Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology, 156(1): 187- 195

[2] Ahmad, K. S., Hameed, M., Fatima, S., Ashraf, M., Ahmad, F., and Naseer, M. 2016. Morpho- anatomical and physiological adaptations to high altitude in some Avenue grasses from Neelum Valley, Western Himalayan Kashmir. Acta Physiol. Plantar. 38:93. doi: 10.1007/s11738- 016-2114-x.

[3] Amaral, J., Lobo, A. K., & Carmo-Silva, E. 2024. Regulation of Rubisco activity in crops. New Phytologist, 241(1): 35-51.

[4] Atkin, O. K., Scheurwater, I., & Pons, T. L. 2006. High thermal acclimation potential of both photosynthesis and respiration in two lowland Plantago species in contrast to an alpine congeneric. Global Change Biology, 12(3): 500-515.

[5] Bahuguna, R., Prakash, V., & Bisht, H. 2013. Quantitative enhancement of active content and biomass of two aconitum species through suitable cultivation technology. International Journal of Conservation Science, 4(1).

[6] Bano, A., and Fatima, M. 2009. Salt tolerance in Zea mays (L.) following inoculation with Rhizobium and Pseudomonas. Biol. Fertil. Soils 45: 405– 413. doi: 10.1007/s00374-008-0344-9.

[7] Bashyal, S. 2023. Plant functional traits of Aconitum Spicatum and Aconitum naviculare along the elevation gradients in central Nepal (Doctoral dissertation, Department of Botany.

[8] Bharali, S., Paul, A., Khan, M. L., & Singha, L. B. 2012. Survival and growth of seedlings of two Rhododendron tree species along an altitudinal gradient in a temperate broad-leaved forest of Arunachal Pradesh, India. International Journal of Plant Research, 2(1): 39-46.

[9] Chandra, S., & Lata, H. 2022. Effect of Altitude on Biochemical and Photosynthetic Characteristics of Aconitum balfourii and Podophyllum hexandrum: High Value Endangered Medicinal Herbs from Himalayas. International Journal of Tropical Agriculture, 40(3-4): 195-203.

[10] Chandra, S., Chandola, V., Singh, A., Singh, C. P., & Nautiyal, M. C. 2023. Responses of Herbaceous Species of Alpine Treeline to Elevated CO2. In Ecology of Himalayan Treeline Ecotone (pp. 439-453. Singapore: Springer Nature Singapore.

[11] Cui, G., Li, B., He, W., Yin, X., Liu, S., Lian, L., & Zhang, P. 2018. Physiological analysis of the effect of altitudinal gradients on Leymus secalinus on the Qinghai-Tibetan Plateau. PloS one, 13(9): e0202881.

[12] Deswal, R., & Sharma, B. 2014. Antifreeze proteins in plants: an overview with an insight into the detection techniques including nanobiotechnology. Journal of Proteins & Proteomics, 52.

[13] Gao, X., Zhang, Y., He, Z., & Fu, X. 2017. Gibberellins. [Li, JY, Li, CY, & Smith, SM (eds.)] Hormone Metabolism & Signaling in Plants. 4:107–160.

[14] García-Plazaola, J. I., Rojas, R., Christie, D. A., & Coopman, R. E. 2015. Photosynthetic responses of trees in high-elevation forests: comparing evergreen species along an elevation gradient in the Central Andes. AoB Plants, 7, plv058.

[15] Geange, S. R., Briceño, V. F., Aitken, N. C., Ramirez-Valiente, J. A., Holloway-Phillips, M. M., & Nicotra, A. B.

2017. Phenotypic plasticity and water availability: responses of alpine herb species along an elevation gradient. Climate Change Responses, 4(1): 1-12.

[16] Gruwez, R., De Frenne, P., De Schrijver, A., Leroux, O., Vangansbeke, P., & Verheyen, K. 2014. Negative effects of temperature and atmospheric depositions on the seed viability of common juniper (Juniperus communis. Annals of Botany, 113(3): 489-500.

[17] Guo, Q. Q., Li, H. E., & Zhang, W. H. 2016. Variations in leaf functional traits and physiological characteristics of Abies georgei var. smithii along the altitude gradient in the Southeastern Tibetan

[18] Plateau. Journal of mountain Science, 13:1818- 1828.
He, M., Yang, B., & Bräuning, A. 2013. Tree growth– climate relationships of Juniperus tibetica along an altitudinal gradient on the southern Tibetan Plateau. Trees, 27: 429-439.

[19] Hou, D., Shu, G., & Ren, Z. 2006. Effect of nitrogen, phosphorus, and potassium on several nitrogen metabolism enzymes of Aconitum carmichaeli Dexb. (Ranunculaceae. Southwest China Journal of Agricultural Sciences, 19(5): 857-862.

[20] Jamloki, A., Singh, A., Chandra, S., Shukla, V., Nautiyal, M. C., & Malik, Z. A. 2023. Population structure, regeneration potential and leaf morphological traits of Rhododendron campanulatum D. Don along an altitudinal gradient in Western Himalaya. Plant Biosystems- An International Journal Dealing with all Aspects of Plant Biology, 157(1): 159-174.

[21] Jiang, Y., CHENG1ϕ, X. I. A. O. M. A. O., Zi, H., & Huang, X. 2021. Physiological and ecological responses of an alpine plant picea likiangensis at different altitudinal gradient Sn. Pak. J. Bot, 53(6): 2233-2240.

[22] Kammer PM, Steiner JS, Schöb C. 2015. Arabis alpina and Arabidopsis thaliana have different stomatal development strategies in response to high altitude pressure conditions. Alp Bot. 1252:1–12. Kessler, M., Siorak, Y., Wunderlich, M., & Wegner, C. 2007. Patterns of morphological leaf traits among pteridophytes along humidity and temperature gradients in the Bolivian Andes. Functional Plant Biology, 34(11): 963-971.

[23] Kumari, M., & Kumar, R. 2024. Functional trait correlation network and proteomic analysis reveal multifactorial adaptation mechanisms to a climatic gradient associated with high altitude in the Himalayan region. Plant, Cell & Environment.

[24] Landi, M., Tattini, M., & Gould, K. S. 2015. Multiple functional roles of anthocyanins in plant- environment interactions. Environmental and Experimental Botany, 119, 4-17

[25] Li, R., Luo, T., Tang, Y., Du, M., & Zhang, X. 2013. The altitudinal distribution center of a widespread cushion species is related to an optimum combination of temperature and precipitation in the central Tibetan Plateau. Journal of Arid Environments, 88: 70-77.

[26] Li, X., Yang, Y., Ma, L., Sun, X., Yang, S., Kong, X., ... & Yang, Y. 2014. Comparative proteomics analyses of Kobresia pygmaea adaptation to environment along an elevational gradient on the central Tibetan Plateau. PloS one, 9(6): e98410.

[27] Liu, W., Zheng, L., & Qi, D. 2020. Variation in leaf traits at different altitudes reflects the adaptive strategy of plants to environmental changes. Ecology and Evolution, 10(15): 8166-8175.

[28] Ma L, Yang L, Zhao J, Wei J, Kong X, Wang C, Zhang X, Yang Y, Hu X. 2015. Comparative proteomic analysis reveals the role of hydrogen sulfide in the adaptation of the alpine plant Lamiophlomis rotata to altitude gradient in the northern Tibetan plateau. Planta. 241(4):887–906.

[29] Magaña Ugarte, R., Escudero, A., & Gavilán, R. G. 2019. Metabolic and physiological responses of Mediterranean high-mountain and alpine plants to combined abiotic stresses. Physiologia plantarum, 165(2): 403-412.

[30] Mangral, Z. A., Islam, S. U., Tariq, L., Kaur, S., Ahmad, R., Malik, A. H., ... & Dar, T. U. H. 2023. Altitudinal gradient drives significant changes in soil physico-chemical and eco-physiological properties of Rhododendron anthopogon: a case study from Himalaya. Frontiers in Forests and Global Change, 6, 1181299.

[31] Maxime, C., & Hendrik, D. 2011. Effects of climate on diameter growth of co-occurring Fagus sylvatica and Abies alba along an altitudinal gradient. Trees, 25(2): 265-276.

[32] Musarella, C. M., Brullo, S., & Del Galdo, G. G. 2020. Contribution to the orophilous cushion-like vegetation of central-southern and insular Greece. Plants, b(12): 1678.

[33] Nataraj, N., Hussain, M., Ibrahim, M., Hausmann, A. E., Rao, S., Kaur, S., ... & Olsson, S. B. 2022. Effect of altitude on volatile organic and phenolic compounds of Artemisia brevifolia Wall ex Dc. from the Western Himalayas. Frontiers in Ecology and Evolution, 10, 864728.

[34] Noctor, G., Mhamdi, A., & Foyer, C. H. 2014. The roles of reactive oxygen metabolism in drought: not so cut and dried. Plant physiology, 164(4): 1636- 1648.

[35] Ortiz, P. L., Arista, M., & Talavera, S. 2002. Sex ratio and reproductive effort in the dioecious Juniperus communis subsp. alpina (Suter) Čelak. (Cupressaceae) along an altitudinal gradient. Annals of botany, 89(2): 205-211.

[36] Rahman, I. U., Afzal, A., Iqbal, Z., Hart, R., Abd_Allah, E. F., Alqarawi, A. A., ... & Bussmann, R. W. 2020. Response of plant physiological attributes to altitudinal gradient: Plant adaptation to temperature variation in the Himalayan region. Science of The Total Environment, 706, 135714.

[37] Rahman, I. U., Hart, R., Afzal, A., Iqbal, Z., Alqarawi, A. A., Abd_Allah, E. F., ... & Calixto, E. S. 2019. Ecophysiological plasticity and cold stress adaptation in Himalayan alpine herbs: bistorta affinis and Sibbaldia procumbens. Plants, 8(10): 378.

[38] Rathore, N., Thakur, D., & Chawla, A. 2018. Seasonal variations coupled with elevation gradient drives significant changes in eco-physiological and biogeochemical traits of a high-altitude evergreen broadleaf shrub,Rhododendron anthopogon. Plant Physiology and Biochemistry, 132, 708-719.

[39] Rawat, J. M., Rawat, B., Mishra, S., Negi, R., Mishra, S. N., Chandra, A., & Nautiyal, S. 2014. Altitudinal and seasonal variation in bioactive compound aconitine in Aconitum

violaceum, a threatened medicinal plant of Indian Himalayan region. International Journal of Advanced Research, 2, 981-988.
[40] Sedej, T. T., Erznožnik, T., & Rovtar, J. 2020. Effect of UV radiation and altitude characteristics on the functional traits and leaf optical properties in Saxifraga hostii at the alpine and montane sites in the Slovenian Alps. Photochemical & Photobiological Sciences, 19, 180-192.
[41] Senica, M., Stampar, F., Veberic, R., & Mikulic- Petkovsek, M. 2017. The higher the better? Differences in phenolics and cyanogenic glycosides in Sambucus nigra leaves, flowers and berries from different altitudes. Journal of the Science of Food and Agriculture, 97(8): 2623- 2632.
[42] Shen, N., Xu, W., Guo, F., Cui, Y., Chen, Y., & Su, X. 2023. Effect of fertilizer and harvesting stage on growth and bioactive compounds content of Rheum tanguticum. Journal of Plant Nutrition, 46(18): 4462-4476
[43] Shi, S., Shi, R., Li, T., & Zhou, D. 2022. UV-B Radiation Effects on the Alpine Plant Kobresia humilis in a Qinghai-Tibet alpine Meadow. Plants, 112(2): 3102.
[44] Shi, Z., Liu, S., Liu, X., & Centritto, M. 2006. Altitudinal variation in photosynthetic capacity, diffusional conductance and δ13C of butterfly bush (Buddleja davidii) plants growing at high elevations. Physiologia Plantarum, 128(4): 722-731.
[45] Stiles, E. A., Cech, N. B., Dee, S. M., & Lacey, E. P. 2007. Temperature-sensitive anthocyanin production in flowers of Plantago lanceolata. Physiologia Plantarum, 129(4): 756-765.
[46] Streb, P., & Cornic, G. 2011. Photosynthesis and antioxidative protection in alpine herbs. In Plants in Alpine Regions: Cell Physiology of Adaption and Survival Strategies (pp. 75-97. Vienna: Springer Vienna.
[47] Streb, P., Aubert, S., Gout, E., & Bligny, R. 2003. Reversibility of cold-and light-stress tolerance and accompanying changes of metabolite and antioxidant levels in the two high mountain plant species Soldanella alpina and Ranunculus glacialis. Journal of experimental botany, 54(381): 405-418
[48] Streit, K., Siegwolf, R. T., Hagedorn, F., Schaub, M., & Buchmann, N. 2014. Lack of photosynthetic or stomatal regulation after 9 years of elevated [CO2] and 4 years of soil warming in two conifer species at the alpine tree line. Plant, cell & environment, 37(2): 315-326.
[49] Thapliyal, J., & Shukla, V. 2022. The elevational effect on soil parameters and biochemical constituents of Rheum emodi Wall. exMeisn: an important medicinal plant of Garhwal Himalaya.
[50] Wang, Y. Y., Qi, D. H., Liu, W. S., & Liang, W. B. 2016. Comparison on leaf phenotypic and anatomical structures of Polygonum paleaceum along altitudinal gradients at Yulong Mountains. Acta Botanica Boreali-Occidentalia Sinica, 36, 70–77.
[51] Wani, Z. A., Negi, V. S., Bhat, J. A., Satish, K. V., Kumar, A., Khan, S., et al. 2023. Elevation, aspect, and habitat heterogeneity determine plant diversity and compositional patterns in the Kashmir Himalaya. Front. For. Glob. Change 6:1019277. doi: 10.3389/ffgc.2023.1019277.
[52] Ye, L. J., Möller, M., Luo, Y. H., Zou, J. Y., Zheng, W., Liu, J., ... & Gao, L. M. 2023. Variation in gene expression along an elevation gradient of Rhododendron sanguineum var. haemaleum assessed in a comparative transcriptomic analysis. Frontiers in Plant Science, 14, 1133065.
[53] Zhai, B., Hu, Z., Sun, S., Tang, Z., & Wang, G. 2024. Characteristics of photosynthetic rates in different vegetation types at high-altitude in mountainous regions. Science of The Total Environment, 907, 168071.