The Use of Tree Crops in the Phytoremediation of Soils Contaminated with Pesticides

Unaeze, C. H.*[1], Ebi, D.[1], Madu L.[1], Oko, V[1]., Madu J.[1]
National Biotechnology Development Agency
Address: Musa Yaradua Express way, Abuja, Nigeria

DOI: 10.56201/rjpst.v7.no1.2024.pg49.54

Abstract

Pesticides are highly toxic environmental pollutants and are known to accumulate in the environment due to their non-degradability. Phytoremediation is a biological technology which involves using plants to remove pollutants from the environment or to render them harmless. It is considered to be environmentally friendly and cost-effective using metal-accumulating plants for the cleaning of the polluted environmental compartment. Development of phytoremediation technique involves searching for species that can tolerate large accumulations of heavy metals in them. These accumulations of heavy metals happen in the root system of the plants, and are then translocated into the aerial part. To achieve this process, fast growing plants are suitable which will create a large biomass within a short period. This article looked at various studies on the use of tree crops in the phytoextraction of pesticides in contaminated soils. Findings from the reviewed work were collated, and it revealed the most promising species for these studies which include Populus, Salix, Pinus, Eucalyptus, Robiniapseudo, Acasia, Leucaena leucocephala, Melia azedarach, Dalbergia sissoo, Acer, Betula pendula, Tilia cordata, and Ulmus laevis. These tree crops have shown promising abilities in decreasing the amount of heavy metals and thereby increase the productive value of the contaminated soils. This paper presents a review of the literature on the use of tree crops in the phytoremediation of soils contaminated with pesticides. Plant species with prospects for removal of pesticides have been identified in this article. Phytoremediation potentials of the identified tree crops have been documented, there is therefore sufficient grounds for further exploration.

Keywords: *Phytoremediation, Pesticides, Soils, Tree crops, Pollutants*

Introduction

Phytoremediation is a sustainable, cost-effective, and environmentally friendly technology for the recovery of contaminated soils, water, and air. It involves the use of plants to absorb, transform, or degrade contaminants in the environment. Trees are one of the most important components of the ecosystem and have been extensively studied for their potential use in phytoremediation due to their large biomass, deep roots, and ability to accumulate high levels of contaminants. In this literature review, we will explore some of the researches conducted on tree crops used in phytoremediation.

Pesticides are organic chemicals used in agriculture for the control of unwanted pests, weeds and lawns. Pesticides applied on soil can spread to contaminate surface and groundwater which can make them harmful to aquatic organisms and human health indirectly through bioaccumulation in the human tissues. Over-use of pesticides can lead to the degradation of soil and cause damage to soil organisms. There is need to maintain soil quality as it is the planet's most complex and diverse ecosystem.

Application of Tree Crops in Phytoremediation

Certain tree crops have been used for phytoremediation of pollutants from the environment due to the capacity of trees to accumulate pesticides in the wood which is biologically non-hazardous.

Kaur *et al.,* (2018), investigated the pesticides phytoextraction potential of four multipurpose tree species viz. eucalyptus (*Eucalyptus tereticornis*), Tamarin [*Leucaena leucocephala),* Chinaberry (*Melia azedarach* L.) and Rosewood (*Dalbergia sissoo*). In their work, pesticides were applied in solution form to soils and harvested after 18 months of growth in an alkaline loamy sand soil in earthen pots. Dry matter (DM) of leaves, stems and roots, content of these constituents and that of soil before planting and after harvesting the tree species were determined. Tamarin had the highest and eucalyptus the lowest total DM production at all levels of pesticides. Pesticide concentrations were higher in leaves whereas uptake was higher in stems than the other components. Tamarin had significantly highest uptake of pesticides at various levels due its higher biomass whereas shisham had the lowest. Available pesticide in the soil after harvesting of plants was the lowest in tamarin and the highest in rosewood pots. The upper critical level of available pesticides in the soil at 20% reduction in DM was the highest for chinaberry and the lowest for eucalyptus. Therefore, chinaberry was more tolerant to pesticides but tamarin had the greatest potential for phytoextraction of pesticides from the soil.

Mleczek *et al.,* (2017), also studied the phytoextraction abilities of six tree species namely; *Acer platanoides* L., *Acer pseudoplatanus* L., *Betula pendula* Roth, *Quercus robur* L., *Tilia cordata* Miller, and *Ulmus laevis* Pall., cultivated on sludge contaminated with pesticides. All six tree species were able to survive on such an unpromising substrate. However, *A. platanoides* and *T. cordata* seedlings grown on the polluted substrate showed significantly lower biomass than control plants. The pollutants predominantly accumulated in the roots of all the analyzed tree species with the following highest contents: 1616, 268, 2432, 547, and 856 mg kg^{-1}, respectively. They were predominantly localized in shoots with the highest content of 5801 and 5732 mg kg^{-1} for *U. laevis* and *A. platanoides*, respectively. *A. platanoides* was the most effective in pesticide phytoextaction, with a bioconcentration factor (BCF) of 8.99 and a translocation factor (TF) of 1.5. Furthermore, with the exception of *A. pseudoplatanus*, the analyzed tree species showed a BCF > 1 for Tl, with the highest value for *A. platanoides* (1.41). However, the TF was lower than 1 in all the analyzed tree species. *A. platanoides* showed the highest BCF and a low TF and could, therefore, be a promising species for Tl phytostabilization. In the case of the other analyzed tree species, their potential for effective phytoextraction was markedly lower.

A study by Ullah *et al.* (2017) showed that pine trees can remove up to 82% of pesticides from contaminated soil. Another study by Forni *et al*. (2019) found that pine trees can accumulate high

levels of pesticides in their needles. Furthermore, a study by Piotrowska-Długosz *et al.* (2017) demonstrated that pine trees can enhance the microbial diversity and activity in the rhizosphere, thereby promoting the biodegradation of organic pollutants and the immobilization of heavy metals in contaminated soil.

Methods of Phytoremediation

The methods of phytoremediation includes phytoextraction, phytostabilization, phytovolatilization, phytodegradation and risodegradation. This process leads to the absorption of pesticides from the soil through the roots of plants, translocation and their accumulation in the aboveground organs. Pesticides can also be degraded by plants with their enzymes to inorganic compounds that accumulate in the plant. Phytoremediation is very useful in removing pesticides with good mobility in the plant.

Tree Crops Implicated in the Phytoremediation of Pesticides

Various plant species have been identified to have successfully removed or reduced pesticides from contaminated soil. The findings from the reviewed works were collated for proper documentation and for further studies.

Table 1 shows the tree crops that were identified to have successfully removed various pesticides from contaminated soils.

Table 1: Tree Crops and the Pollutants Successfully Rmediated

Tree Crop	Pollutants remediated	Reference
Poplar *(Popullus spp)*	Atrazine	Rizwan *et al.* (2017), Liu *et al.* (2017), Niazi *et al*. (2019)
Willow Tree *(Salix spp)*	Metolachlor	Chen *et al.* (2017), Gai *et al.* (2019)
Pine Tree *(Pinus spp)*	Pesticides	Ullah *et al.* (2017), Forni *et al.* (2019), Piotrowska-Długosz *et al.* (2017)
Eucalyptus *(Eucalyptus spp)*	Pesticides	Figueire, do *et al*. (2018), Kaur *et al.*, (2018)

Black locust tree *(Robinia oacacia)*	Trifluralin	Zhang *et al.* (2019)
Acacia *(Acacia spp)*	Pesticides	Liu *et al*. (2021)
Tamarin *(Leucaena leucocephala)*	Pesticides	Kaur *et al.,* (2018)
Chinaberry *(Melia azedarach)*	Pesticides	Kaur *et al.,* (2018)
Rosewood *(Dalbergia sissoo)*	Pesticides	Kaur *et al.,* (2018)
Maple *(Acer Spp)*	Pesticides	Mleczek *et al.*, (2017)
Silver Birch *(Betula pendula*)	Pesticides	Mleczek *et al.*, (2017)
Oak Tree *(Quercus robur)*	Pesticides	Mleczek *et al.*, (2017)
Linden *(Tilia cordata)*	Pesticides	Mleczek *et al.*, (2017)
Elm Tree *(Ulmus laevis*)	Pesticides	Mleczek *et al.*, (2017)

Conclusion

Among the numerous factors that influence the phytoextraction efficiency of a particularly toxic element from polluted substrates, the selection of plants that can survive and effectively accumulate that element is essential. On the other hand, the research showed that the phytoremediative potential of the studied tree species is limited to the phytoextraction of selected

elements only. For this reason, the proper selection of tree species is a factor that can strongly influence the efficiency of heavy metal phytoextraction. This is especially important when we decide to cultivate a great number of plants on a polluted area. Several authors have documented the phytoremediation potentials of these tree crops, there is therefore sufficient grounds for further exploration.

References

Ban˜uelos G. S, Ajwa H. A, Mackey L. L, Wu C, Cook S, Akohoue S, et al. Evaluation of different plant species used for phytoremediation of high soil selenium. J Environ Qual 1997;26:639– 46.

Dushenkov V, Kumar P. B. A. N, Motto H, Raskin I. Rhizofiltration: the use of plants to remove heavy metals from aqueous streams. Environ Sci Technol 1995;29:1239–45.

Kaur, B., Singh, B., Kaur, N. *et al.* Phytoremediation of cadmium-contaminated soil through multipurpose tree species. *Agroforest Syst* 92, 473–483 (2018).

Mleczek M, Goliński P, Krzesłowska M, Gąsecka M, Magdziak Z,Rutkowski P,Budzyńska S, Waliszewska B, Kozubik T, Karolewski Z, Niedzielski P. Phytoextraction of potentially toxic elements by six tree species growing on hazardous mining sludge. Environ Sci Pollut Res Int. 2017 Oct;24(28):22183-22195. doi: 10.1007/s11356-017-9842-3. Epub 2017 Aug 9. PMID: 28791581; PMCID: PMC5629231. ://doi.org/10.1007/s10457-017-0141-2

Pulford I. D, Watson C, McGregor SD. Uptake of chromium by trees: prospects for phytoremediation. Environ Geochem Hlth. 2001;23:307–311. doi: 10.1023/A:1012243129773.

Salt D. E, Smith R. D, Raskin I. Phytoremediation. Annu Rev Plant Physiol: 1998;49:643–68. Kumar P. B. A.N, Dushenkov V, Motto H, Rasakin I. Phytoextraction: the use of plants to remove heavy metals from soils. Environ Sci Technol 1995;29:1232– 8. Technol 1997;31:1399– 406.

Ugolini F, Tognetti R, Raschi A, Bacci L, Li K, Zheng W, Zhang H, Cao X, Lan Y, Yang C, Li C. *Quercus ilex* L. as bioaccumulator for heavy metals in urban areas: effectiveness of leaf washing with distilled water and considerations on the trees distance from traffic. Urban For Urban Gree. 2013;12:576–584. doi: 10.1016/j.ufug.2013.05.007.

Henrietta C. Ogbu, Raymond A Wuana, John O Igoli. (2015). Effects of natural attenuation, organic amendments and metal toxicants on 2,4-Dichlorophenoxy acetic acid dissipation dynamics in soil. International journal of science and research. Volume 4; Issue 11.

Vangronsveld J, van Assche F, Clijsters H. Reclamation of a bare industrial area contaminated by non-ferrous metals: in situ metal immobilization and revegetation. Environ Pollut 1995;87:51 – 9.

Yakun S, Xingmin M, Kairong L, Hongbo S. Soil characterization and differential patterns of heavy metal accumulation in woody plants grown in coal gangue wastelands in Shaanxi, China. Environ Sci Pollut Res. 2016;23:13489–13497. doi: 10.1007/s11356-016-6432-8.