Paper received: 22.10.2018. Journal of Agronomy, Technology and Engineering Management
Paper accepted: 19.12.2018. ISSN: 2620-1755 Bogoeva, I., 2018. Vol. 1(1): 39-44

Review paper

PRODUCTION OF SAFETY FOOD BY PHYTOREMEDIATION METHODS

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ABSTRACT: The production of pure and safety food, whether of plant or animal origin, requires a clean environment, for growing of plants, which serve as food for humans and livestock. The high development of the industry, as well as the use of many chemicals in the modern life and farming, are the main causes for the presence of toxic residues in nature and therefore – in the food. Among the main causes of soil and farmland pollution are heavy metals, pesticide residues and petroleum products. Modern environmental science is looking for ways to clean the soils from pollutants, which at the same time, to be ecologically and environmentally friendly. Traditional methods for cleaning the soil from different pollutants, such as excavation, etc., are very economically disadvantageous, but they also cause environmental damages. Because of the large economic costs, associated with the removal of soil contaminants through traditional physicochemical methods, this problem was overlooked for many years. Phytoremediation (mainly phytoextraction – absorption and concentration of environmental substances in the plant biomass) is a widespread and relatively new technology that uses plants to clean environmental pollutants by extracting them. This plant-based achievement is cost-effective and is due to the remarkable ability of plants to concentrate elements and compounds from the environment and to break down their molecules into their tissues. Using phytoremediation is possible to degrade, assimilate or detoxify toxic chemicals.

Key words: *pollution, chemicals, phytoremediation, environment, safety food*

INTRODUCTION

Soil pollution is a very important environmental issue that has attracted considerable public attention over the last decades. Increasing environmental pollution and especially this of soils, has caused large losses of arable land, due to the fact that they have become dangerous to wildlife and the human population (Alkorta and Garbisu, 2001). Pollution with toxic compounds is a major environmental problem, but the most conventional methods of purification and recovery of soil, do not provide an acceptable solution. The use of specially selected plants that are able to accumulate pollutants is an emerging environmental clean-up technology, called phytoremediation (Salt et al., 1995).

Among the main causes of soil and farmland pollution are heavy metals, pesticide residues and petroleum products. The first one are a result of the high industrial development in the last century and the second one are a consequence of the increasing use of chemical substances in agriculture. The modern science seeks ways to clean the soils from the pollutants, while at the same time, the purification of soils to be done ecologically and environmentally friendly.

DISCUSSION

Traditional methods for cleaning the soil from different pollutants, such as excavation etc., are too economically unprofitable, but also cause environmental damages. Because of the large economical costs, associated with the removal of soil pollutants through traditional physicochemical methods, the problem of soil recovery has been overlooked for many years. Bioremediation is a complex of methods for cleaning the soil, which offers an environmentally friendly and less expensive technology, by using plants (phytoremediation) or bacteria and fungi.

Phytoremediation is a method, which uses plants to degrade, assimilate or detoxify metals, hydrocarbons, pesticides and other pollutants. This achievement is cost-effective and is due to the remarkable ability of plants to concentrate environmental elements and compounds and break down their molecules into their tissues. Numerous trials and studies confirm the feasibility of applying different type of plants for cleaning the environment (Schnoor, 1995; Salt, 1998; Meagher, 2000). To remove these compounds from the soil, it is possible to use methods in situ, in vivo and in vitro (in place, in the living organism and outside the body).

Phytoremediation is a relatively new technology that promises an effective and inexpensive opportunity for purification of some hazardous waste. The effectiveness of this technology has been proven in a number of studies; it is suitable for soils where the pollution is shallow, less than 5 m depth. Phytoremediation can take more time, comparing to the traditional methods for cleaning the environment; it is also possible this process to be limited from the soil toxicity. As a whole, plants have better ability to survive in a higher concentration of hazardous waste, than most microorganisms, used in bioremediation.

Plants are able to remove organic pollutants through three main mechanisms – direct uptake of pollutants and subsequent accumulation of non-phytotoxic metabolites in plant tissues; secretion of enzymes that stimulate microbial activity and biochemical transformations; enhancement of mineralization in the rhizosphere (root-soil interaction). Vegetation (plants cultivation) also offers other benefits in polluted areas: phytoremediation increases the amount of organic carbon in the soil, which stimulates microbial activity. In addition, growing plants with a deep root system also helps to stabilize the soil. Plants also absorb significant amounts of water, which also contributes for soil cleaning.

Phytoremediation (mainly phytoextraction – uptake and concentration of environmental substances in plant biomass) is a relatively new but already widespread technology that uses plants to clean environmental pollutants by extracting them. This process is an appropriate alternative to currently applied physical methods which, in addition to being costly, act destructively on the environment.

Plants possess many genetic, biochemical and physiological properties that make them an ideal means of soil and water recovery. This method alleviates environmental and economic problems by eliminating the need to remove the pollutants by excavation (digging) from the soil and to transfer them to another location. This method, in addition to being economically unprofitable technology, also affects the soil and its characteristics and can cause environmental problems (Mccutcheon and Jorgensen, 2008).

After coming out of the positive results, showing the ability of plants to accumulate or break down certain elements and compounds in their organs, more and more specialists are involved in the phytoremediation campaign of various substances. This is because of the fact it seems a promising technology to remove soil contaminants. Significant progress has been made in this regard over the last years, through the use of native species of plants or genetically modified plants for soil remediation, for removing of the pollutants from the environment. Depending on the type of individual pollutants, there are different strategies for phytoremediation: for pollutants such as radionuclides and heavy metals, the focus is on hyperaccumulation (accumulation of large quantities of substances) in the organs of the plants, while organic pollutants are potentially possible to be completely mineralized by plants (Meagher, 2000; Alkorta and Garbisu, 2001).

Phytoremediation is a form of bioremediation and involves all chemical and physical processes that use plants to degrade and immobilize pollutants in soil and groundwater. There are six different types of phytoremediation (Alkorta and Garbisu, 2001):

1. Phytostabilization. Numerous different processes fall within this category, which may include root adsorption, production of biochemicals from the plants that are released into the soil or groundwater, adjacent to the roots and can retain, precipitate or otherwise block the operation of nearby pollutants.

2. Rhizodegradation / rhizophiltration. It can be used for cleaning of soils or underground waters, surrounding the roots of the plants in the immediate vicinity. Released from the plant specific fluids (exudates) stimulate the bacteria in rhizosphere (the root layer of the soil) and thus improve biodegradation of soil contamination.

3. Phytohydraulics. This is the use of plants with deep roots (usually trees) to collect, retain or degrade pollutants in underwater waters that come into contact with their roots (for example poplar trees are used for this purpose).

4. Phytoextraction. Also known as phytoaccumulation. Plants receive or hyperaccumulate pollutants through their roots and store them in the tissues of the leaves or stems. Pollutants do not necessarily have to be degraded but are removed from the environment when the plants are picked up. This is particularly suitable for removing metals from the soil and, in some cases, the metals can be recovered by plant incineration.

5. Phytoevaporation. Plants take volatile compounds through their roots and release the same compounds or their metabolites through leaf fluids and thus release them into the atmosphere.

6. Phytodegradation. Pollutants are taken up in plant tissues where they are degraded or bio-transformed. Biotransformation depends on the type of plant and can occur in the roots, stems or leaves.

Phytoremediation can be applied in places where soil or static water in the environment has been contaminated. Examples where phytoremediation has been successfully applied include the restoration of abandoned metal mines, the reduction of pollutants in soils, water or air. The impact of a number of pollutants such as metals, pesticides, solvents and explosives and crude oils has been alleviated through phytoremediation processes around the world.

Phytoremediation can be applied for cleaning the soil from different type of pollutants, like pesticides, heavy metals, etc.

Pesticides are chemical pollutants, most of which are persistent in the environment and fall into it due to improper application, such as non-compliance with the dose or the timing of their application. A promising possibility for their detoxification is the application of technology such as phytoremediation, in combination with other methods – physical and chemical. Phytoextraction is one of the most ecological and cost effective methods for decontamination and detoxification of the environment in the case of pesticide pollution. It is necessary to be developed strategies, regarding the choice of phytoremediation technology, which examine the advantages and disadvantages of environmental components, contaminated with pesticides (Gavrilescu, 2005).

The process of phytoremediation should be specific to each individual object that will be purified by this technology. This method has the potential to provide the most cost-effective and resource-conservative approach, to clean areas, contaminated with different types of hazardous chemicals. Phytoremediation can be applied anywhere, if the soil or static natural water basins have been permanently contaminated. An example of successful implementation of this method is the recovery of abandoned metal mines by reducing the impact of pollutants in soils, water or air (Susarla et al., 2002).

Of a great importance for successful phytoremediation is the proper selection of the crops to be planted, in particular their tolerance to the pollutants (the plants to remain unaffected), the development of large biomass and, last but not least, the need to obtain unpolluted production of contaminated areas. Phytoremediation is based on the natural ability of some plants, called hyperaccumulators, to accumulate substances in high concentrations, in their plant biomass by destroying or disposing of pollutants in soil and water; moreover, when the pollutants are distributed in the biomass of plants, their concentration decreases and can reach safe levels. Numerous plants such as mustard, hemp, corn, etheric-oil crops have been proven successful in the hyperaccumulation of pollutants in places with toxic waste. Technical crops (flax, cotton, hemp) are also suitable because they are not used for food purposes. Besides cultural, for the purpose of phytoremediation, wild plants can be successfully used, especially tree species; plants such as willow, poplar, eucalyptus, acacia, mulberry, etc., are particularly suitable due to the rapid development and the growth with large biomass.

When considering the advantages and limitations of phytoremediation, it can be concluded that this process must be specific to each individual object that will be purified by this technology. However, this method has the potential to provide the most cost-effective and resource-conservative approach for cleaning sites, contaminated with different types of hazardous chemicals (Susarla et al., 2002).

In addition to being a process of reducing soil concentrations of pollutants through plants that can help clean up many types of pollutants, phytoremediation is also effective in terms of plant protection also from wind and rain, plants prevent the fall of pollutants in groundwater. Phytoremediation works most successfully in areas with low to medium pollution levels. When fed into plants, chemicals can be stored in the roots, stems or leaves where they can be transformed into less dangerous compounds inside plants; chemicals can also be converted into gases that are released into the air by breathing of the plants (U.S. Environmental Protection Agency, 2001).

One of the main benefits of phytoremediation is that the environmental cleaning is carried out at the place of pollution. But its main disadvantage is that it requires a long-term commitment, as the process is dependent on the ability of plants to grow and develop in an environment that is not suitable for their normal growth. Other advantages of this method are: the cost of phytoremediation is lower than that of traditional purification processes; monitoring of plants is easily feasible; this is the safest method, possible because of using living organisms and protects the environment in a natural and ecologically sound way.

Apart from the advantages, phytoremediation has some limitations: it extends to the depth of the root system of the used plants; slow growth and low biomass require a long process run; through the phytoremediation process it is not possible to completely prevent leakage of pollutants into groundwater, so the pollution problem is not fully addressed; the survival of plants is affected by the toxicity of the contaminated area and the general condition of the soil; the bioaccumulation of pollutants in plants that subsequently can pass into the food chain, requires the safe destruction of the affected plant material.

CONCLUSIONS

Despite of some limitations, phytoremediation is a modern method for cleaning the environment from hazardous wastes that uses natural processes and does not contradict the natural state of ecosystems and does not disturb their normal functioning. Phytoremediation is a natural approach to achieving clean agricultural production, free of chemical pollutants, which is a serious achievement in terms of ensuring safe and healthy food for the consumers.

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