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# AMENDMENT OF HEAVY METAL POLLUTION IN AGRICULTURAL LANDS WITH PHYTOREMEDIATION TECHNIQUES*

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## ABSTRACT

Soil fertility has been reduced with intensive chemical fertilizers applied to soils. Besides, some physical, chemical and biological properties of soils were negative affected in this situation. On the other hand, soils were polluted by different industrial materials. Heavy metal pollution in the soil has been very important in recent years all over the world. On the other hand, phytoremediation technique is a new technology for improving of heavy metal pollution from agricultural lands. Phytoremediation technology is cheaper and more practical than other classical improving chemical and physicochemical technologies. Phytoremediation is the name inclined to a set of technology that use some hyper accumulator plants to clean heavy metal contaminated soils. Many agricultural techniques and some applications have been called phytoremediation methods, for example; Phytoextraction, Phytostabilization, Rhizofiltration, Rhizodegradation, Phytovolatilization, Phytodegradation, Vegetative Cover Systems, Hydraulic Control, Riparian Corridors/Buffer Strips. Some phytoremediation technologies were evaluated in this study.

**Keywords**: Heavy metal, phytoremediation, pollution, soil

## TARIM ALANLARINDA AĞIR METAL KİRLİLİĞİNİN FİTOREMEDİASYON TEKNİKLERİYLE GİDERİLMESİ

## ÖZET

Toprakların verimliliği yoğun bir kimyasal gübre uygulamaları ile birlikte azalmıştır. Ayrıca bu durum toprakların bazı fiziksel, kimyasal ve biyolojik özelliklerini de olumsuz bir biçimde etkilemiştir. Diğer taraftan topraklar çeşitli endüstriyel atıklarla da kirlenmiştir. Dünyada son yıllarda topraklardaki ağır metal kirliliği çok önemli bir sorun haline gelmiştir. Fitoremediasyon teknolojisi klasik kimyasal ve fizikokimyasal yöntemlere göre daha ucuz ve daha pratik olmaktadır. Bu ıslah yönteminde bazı hiper akümülatör bitkiler yardımı ile topraklar ağır metallerden temizlenmektedir. Fitoremediasyon teknikleri ve uygulamlaları çeşitli olup hepsine fitoremediasyon yöntemi adı verilmekte olup bu yöntemlerin bazıları şu şekildedir, fitoekstraksiyon, fitostabilizasyon, rizofiltrasyon, rizodegredasyon, fitovolatilizasyon, fitodegredasyon, vejetatif örtü sistemleri, hidrolik kontrol, riparian buffer strips. Bu çalışmada bazı fitoremediasyon teknolojileri değerlendirilmiştir.

**Anahtar Kelimeler:** Ağır metal, fitoremediasayon, kirlilik, toprak.

## 1. Introduction

For soil pollution, which has increasingly been a universal problem, the best solution would certainly be the preventive studies. In our developing country however, it is a truth that precautions are insufficient and studies about polluted soils are below the expected standards. First of all, it is required to detect potential areas for pollution and possible regions for treatment. Next step should be to carry out laboratory measures and feasibility studies regarding a large number of factors such as geographical features, polluting characteristics, hydro-geological specifications and economic relevance and the appropriate biological treatment method should be selected with reference to them. The soil is polluted by activities such as chemical fertilizers, pesticides, the use of soil amendments and hormones, discharge of solid and fluid wastes, waste mud applications, the use of wastewater in agricultural irrigation, atmospheric sedimentation and atomic fallouts which are carried out to improve the quality and amount of agricultural production. As a result, the capacity limits of soils to be used effectively and problem-free get narrow and this problem keeps on increasing gradually.

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On the other hand, asbestos and other free pollutants existing in natural structures of soils are another source of soil pollution. The pollutants mingling with soils due to natural and man-made activities, which cause soil pollution, might be categorized in general as organic (pesticides, hormones) and inorganic compounds (heavy metals, etc.) and atomic fallouts

Physical and chemical treatment methods used for the control of heavy metal, which comprises the most significant environment polluting group in terms of soil pollution, are not widely preferred due to their high costs and the difficulty in final dispelling of those pollutants brought about by that treatment. Therefore, *phytoremediation* method, which is defined as the dispelling of heavy metals and some other sorts of pollutants by the help of plants, has become a more widespread method because of its economical feature and its ecologically preferred usage.

Transforming heavy metals in soil to a form able to be taken in by the plant roots is the major factor affecting the success of phytoremediation method. Structurally complex chelats, used for that purpose, have been identified as increasing the take-in capacity of metals by plants (Martens et.al., 1994). While many plants exhibit toxicity symptoms in a Zn storage of approximately 100 ppm, the most widely known metal hyperaccumulator of *Thlaspi caeruledcens* might sustain a storage of over 26 000 ppm. in its body (Lasat, 2000).

In their research for the amendment of polluted soils through phytoremediation method with the use of radish and canola plants, Marchiol et.al. (2004) identified radish to be more effective in dispelling pollution of Pb, Cr, Ni, Cu, Cd and Zn than canola. For the same study, they applied 0 and 10 mmol/kg of EDTA to increase the activity of pollutants. The researchers found out that the heavy metal concentrations in the roots of both plants were more than those in their over-the-soil mechanisms.

Esringü (2005) revealed in a study that the Zn, Cu, Pb and Cd pollution in soil could be dispelled by canola and mustard plants. The researcher came to a conclusion that mustard would be more effective than canola in that sense.

Phytoremediation method isn't considered as the final method of removing or dispelling pollution. Final removal or dispelling can be actualized by burning up the plants coming out of phytoremediation or storing them in a relevant storage area.

In a study by Vanlı (2007), the soils polluted by Pb, Cd and B elements were tried to be treated by phytoremediation method. The researcher studied the phytoremediation of soils having the addition of Pb, Cd and B elements by the use of corn, sunflower and canola plants. He decided that above mentioned pollutant elements could be removed from the soil by using corn, sunflower and canola. He also indicated that the most effective plant was canola.

Some phytoremediation technologies were evaluated in this study with related references.

## Phytoremedation Methods

Phytoremediation is a general name given to the technology of amending pollutants by plant use. There are a large number of technologies called after this name. These technologies can be categorized as phytodegradation, phytoextraction, phytovolatilization, phytostabilization, rhizofiltration, rhizodegradation, hydraulic control, riparian buffer strips and vegetative cover systems.

Some of most common ones, Phytoextraction, Phytodegradation, Vegetation and Riparian Corridors/Buffer Strips were evaluated below.

## Phytoextraction Method

This method is a technique born out of some plants' absorption of organic or inorganic pollution elements in soil into their roots or shoots, and is mostly used for the amendment of polluted soils by heavy metals. It is a convenient method to remediate polluted areas in a scattered manner and pollution elements are removed by pruning or uprooting the plant with high capacity of dispelling, on the polluted area. Re-use of those harvested or pruned parts is an important advantage. Because, this type of plants keep up to 100 times more of pollution elements than other types do. Harvested parts might be benefited as fertilizers while other heavy metals involved can be re-obtained (EPA, 2000).

This technology takes more time than other techniques and it is hard to apply it to areas with intensive pollutants. Therefore, a plant type existing in the local ecosystem should be selected. The plants mustn't be seasonal as they will be harvested. If additives are planned to be used in soil to enable the heavy metal intake, extra precautions are needed to prevent the movement before plant intake. Plant assimilation cannot dispel organic pollutants directly from the soil, however root systems supported by microbiological activity might realize it (EPA, 2000).

In phytoextraction, by adding chelator, which accelerate metal intake to soil, heavy metal might be adsorbed by the plant in a shorter time interval. For example, the use of chelats such as EDTA relatively increases metal mobility. As a result of experiment, soil pollutants like Pb, Cd, Cr, Cu, Ni and Zn have been detected to be stored in *Brassica juncea* (Indian mustard) and *Helianthus annuus* (sunflower) in considerably large amounts. The capability of other metal chelats such as EDDHA, CDTA, DTPA, EGTA and NTA in scaling up the metal storage has been assigned in various plant types (Arlı, 2006).

### Phytodegradation Method

Phytodegradation, which is also known as plant degradation, is the technique of taking pollutant elements into the plant and changing them during the metabolic processes. Degradation process may also occur out of the plant through the compounds given out by itself. In phytodegradation process, the plant must take in the pollutant element (EPA, 2000). For instance, *trichloroethylene* (TCE), which is a major water and soil pollutant, has been found to be taken in by hybrid poplar tree or *Populus deltoides x nigra* and been decomposed into its metabolic components. TCE and other chlorine solvents can be dissolved into carbondioxide, chloride ions and water forms. Root secretions of *Datura innoxia* and *Lycopersiconperuvianum* consist of peroxidase, laccase and nitrilase, which can decompose soil pollutants. They may also decompose and destroy nitroeductase and laccae as well as HMX, TNTand RDX (Arlı, 2006).

### Vegetative Cover Systems

Being a long-lasting and renewable structure, vegetative cover systems grow up inside or over the materials having environmental risks and they require minimum care. Vegetative cover is of two kinds; the first one is about preventing water loss by vaporization and the second one of amending type. In the first type, plant minimizes water loss in soil and maximizes its capacity to keep water so that pollutant elements can't be reduced to wash-out formation or they can't become immovable. In the second type, which has the purpose of green amendment, plant minimizes water filtration as a cover and provides with the degradation of pollution on the inferior layer. In this mechanism, water intake occurs through microbiology around the root as well as plant metabolic factors. Various green amendment categories including hydraulic control also take place in this system. In the applications, vegetative cover is usually formed as barriers preventing the dispersal of pollution.

Vegetative covers might be generally established either in areas with polluted surface soil or mud, or around units spreading specific pollution or where dirty waterholes are found (EPA, 2000).

Estimates of cost be a sign of savings for an evapotranspiration cover up compared to a conventional cover design to be 20 to 50%, dependent on accessibility of the soil (RTDF1998).

The most significant disadvantage of this method is the need for sustaining long-term maintenance and control required to ensure the suitable vegetation. This is because some plant types may become more dominant than others by the time (EPA, 2000; Pivetz, 2001).

### Riparian Corridors/Buffer Strips

Riparian Corridors/Buffer Strips method is a process of cultivating suitable plants as buffer strips at the banks of watercourses along the stream, generally in order to dispel pollutants in underground waters or surface waters pouring into the watercourse (Gabor et.al., 2001).

This amendment method is undertaken not to allow the pollution to spread around or to mix with ground waters. Soil erosion is also got under control and sediment is reduced through this method. Studies in Canada have displayed that application of this method decreased soil erosion at 90% and the flow of herbicides at 42-70%. Moreover, sediment level in water might decrease by 71-91% and nitrogen by 67-96%, phosphorus 27-97%, pesticides by 8-100% and fecal coliform by 70-74 % by the help of this method (Gabor et.al., 2001).

This method is mostly used for the amendment of pollution caused by fertilizers and pesticides from soil. Poplar trees are the widely used plants for this purpose (EPA, 2000).

## Conclusion

On the developing world, as a result of the mankind's urge for having a more comfortable life; natural resources, soil, water and the environment have being polluted day by day. Among pollution types, the main one is chemical and heavy metal pollution. Thus, precautions should be definitely taken so as to reduce or prevent this type pollution. Due to high costs of advanced chemical and physico-chemical methods and particularly due to their below-the-average capacity to overcome heavy metal pollution, it seems a compulsion to extend the use of phytoremediation method. Phytoremediation method should be preferred because of its low cost and having no damage on natural resources as well.

## References

**Aralı, S., 2006**. Removal Of Heavy Metals By Plants In Sewage Sludge. Sakarya Üniversity, Institute of science, master thesis.

Esringü, A., 2005. Toprakta Kirliliğe Sebep Olan Bazı Ağır Metallerin Kanola (*Brassica nopus*) ve Hardal (*Brassica juncea*) Bitkileri İle Uzaklaştırılması. Atatürk Üniversitesi Fen Bilimleri Enst. Toprak Anabilim Dalı, Yüksek Lisans Tezi.

Lasat, M.M., 2000. Phytoextraction of metals from contaminated soil: A review of plant/ soil/ metal interaction and assessment of pertinent Agronomic Issues. Journal of Hazardous Substance Research, 2(5), 1-25.

Marchiol, L., Assolari, S., Sacco, P. ve Zerbi, G., 2004. Phytoextraction of Heavy Metals by Canola (*Brassica napus L.*) and Radish (*Raphanus sativus L.*) Grown on Multicontaminated Soil. Environmental Pollution, 132: 21-27.

Martens, S.N., and R.S. Boyd., 1994. The ecological significance of nickel hyperaccumulation: A plant chemical defense. Oecologia 98:379–384.

Gabor, T. S., North, A. K., Ross, L. C. M., Murkin, H. R., Anderson, J. S. ve Turner, M. A., 2001. "Beyond The Pipe: The Importance of Wetlands and Upland Conservation Practises in Watershed Management : Function and Values for Water Quality and Quantity" Ducks Unlimited Canada. 52 p.

EPA, 2000. Environmental Protection Agency, "Introduction To Phytoremediation"Epa/600/R–99/107, Cincinati, Ohio, U.S.A, p 72, www.clu–in.org

Pivetz, B.E., 2001. Phytoremediation Of Contaminated Soil And Ground Water At Hazardous Waste Sites" U.S Environmental Protection Agency EPA, 540/S-01/500, pp: 36 .

RTDF., 1998. Summary of the Remediation Technologies Development Forum Alternative Covers Assessment Program Workshop. February 17-18, 1998, Las Vegas, NV. http://www.rtdf.org.

Vanlı, Ö., 2007. Removal Of Pb, Cd, B Elements From Soıl By Chelate Assısted Phytoremediation Method .İTÜ, Institute of science, master thesis.