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Impact of Crops on Groundwater Remediation

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Abstract –This papier shows the impact of plants on a particular site remediation.
The purpose of this work is to present the phenomena that occure in the underground and the processes underlying the elimination or fixation of pollutans with crops. The framework is to define and to evaluate the phytoremediation.
This work supports the use of natural processes for remediation of contaminated sites, namely the processes that occure in nature and that can be applied to the target site. Suitable crops on a contaminated site lead to remediation of the area without using engineering methods
Keywords: phytoremediation, pollution, contaminated sites.

1. INTRODUCTION

Pollution has become a much dissussed problem after the population has noticed major changes in the environment. With the appearance of the idea of environmental and public health protection polution has been declared an hard to beat enemy.

So today when we are surrounded by sources of pollution problem becomes more pressing. Observing pollution, its spread and its effects, we concluded that soil, water and air have protective mechanisms against pollution. Detailed analysis showed that the processes taking place are self-cleaning, natural processes that occur without human intervention.

In this paper, we speak especially about the cleaning process of groundwater. In this field everybody knows that physical, chemical and biological remediation processes occur.

Our attention will turn to processes that occur because of crops, some plants that are on the contaminated site, or have been planted there to decontaminated the area.

2. PHYTOREMEDIATION

Phytoremediation is a technique for cleaning contaminated sites using the plant capacity of:

- Extracting contaminats from soil and groundwater
- concentrating contaminants by biotic and abiotic processes
- volatilizating contaminants, that have the ability to be volatilize
- degradating contaminants by biotic and abiotic processes
- transpiration that makes the switch of volatile contaminants into another medium, namely air
- Immobilizate contaminants in the root zone
- Hydraulic control of contaminated water
- Leakage, erosion and infiltration control by covering with vegetation.

Phytoremediation processes can be classified as:

- Phytoextraction
- Rhizofiltration
- Phytostabilization
- Phytodegradation
- Rhizodegradation
- Phyotovolatilization

Phytoremediation mechanisms have different target substances, so that metals are removed by phytoextraction, rhizofiltration and phytostabilisation while organic substances requires phytodegradation, rhizodegradation and phytovolatilisation.

2.1. PHYTOEXTRACTION

Plants have the ability to extract water from soil and also necessary nutrients for growth. This ability to extract substances can be used for removal of contaminants from soil and groundwater.

Fig. 1. Phytoextraction of contaminants from Groundwater and soil

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This requires knowledge of plant physiology because each plant extract different substances from the groundwater.

Contaminants are absorbed by the roots from the environment, then transported to the stem and leaves, where they are stored (fig. 1).

Plants that stored enough contaminants were harvested and then they are incinerated or stored. This method is cheaper than conventional methods because the amount of contaminated material that needs to be stored is much smaller, no matter that plants are stored or storing the ash resulting from burning.

Plants can extract from groundwater, true phytoextraction: Silver, Cobalt, Cadmium, Chromium, Copper, Mercury, Manganese, Molibdenum, Nickel, Lead, Zinc, Arsenic, Selenium, Strontium, Cesium, Uranium, Boron and Plutonium.

2.2. RHIZOFILTATION

Contaminated groundwater which is in contact with plant roots is absorbed, or pollutants from the contaminated water is adsorbed on the surface of the roots (fig. 2). In addition to contaminant that is stored in the plant or immobilized on the surface of the roots pollutant may precipitate and then deposited in the soil layer or aquifer.

Contaminants that can be subject for rhizofiltration are: Lead, Cadmium, Copper, Nickel, Zinc, Chrom, Uranium, Cesium and Strontium.

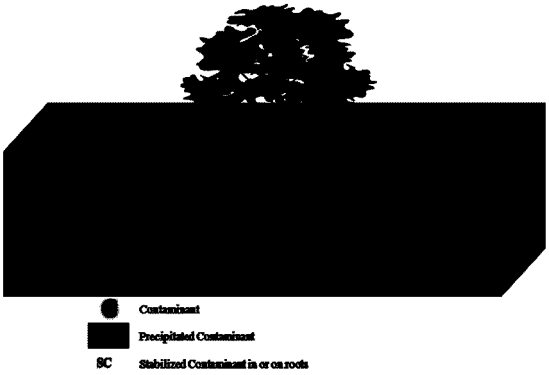

Fig. 2 Rhizofiltration of contaminated Groundwater (C-Contaminant; PC-Precipitated Contaminant, SC-Stabilized Contaminant in or on roots)

Plants that stored enough contaminants were harvested and then they are incinerated or stored.

2.3. PHYTOSTABILIZATION

Phytostabilizarea is the process by which plants adsorb on the surface of their roots contaminants from the groundwater and here they are immobilzed or transformed into water insoluble compounds. The process of phytostabilization is presented in fig. 2.

Phytostabiliztion prevents the migration of contaminants in soil and aquifer.

Phytostabilization can take place for contaminations with: arsenic, cadmium, chromium, copper, mercury, lead and zinc. For organic contaminants, phytostabilization has not been examined.

2.4. PHYTODEGRADATION

Phytodegradation is a complex process.

In the first step of phytodegradation, contaminants are absorbed thru roots, as in previous case, and here begins the actually decay process, inside the plant.

The contaminant is transported in the plant cells where enzymes break down substances using them to form new fibres, that lead to plant growth, or to produce energy. Fig. 3 is a presentation of phytodegradation with production of new plant fibres.

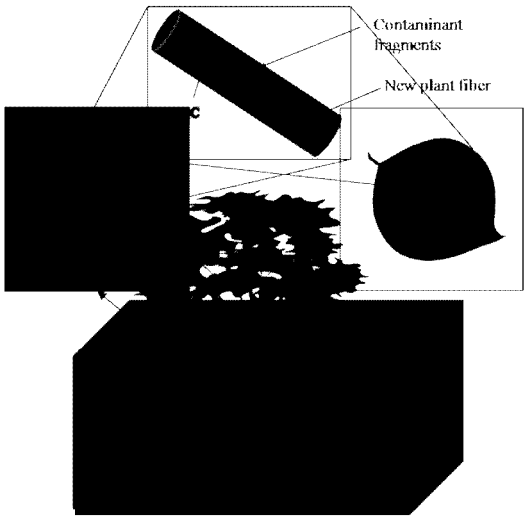

Fig. 3. Phytodegradation (E-Enzymes; C-Contaminant, CF – contaminant fragments)

Thru phytodegradation generaly are transformed organic contaminants such as: chlorinated solvents, herbicides, insecticides, munitions, phenols but also inorganic nutrients like nitrates.

2.5. PHYTOVOLATILIZATION

Plants takes solid or liquid contaminants from the groundwater and transforms it to a vapor. Contaminants can be vaporized in the pure form or they can be metabolized before vaporization. Plants vaporizes contaminants through metabolism or transpiration.

Phytovolatilization has been applied with succes for groundwater.

Thru phytovolatilization contaminants can be transformed to less toxic form, and this is the major avantege of this process.

Fig. 4 shows in a very simple way how phytovolatilization takes place.

At this moment phytovolatilization was examined only for organic contaminants such as gasoline and diesel. [3]

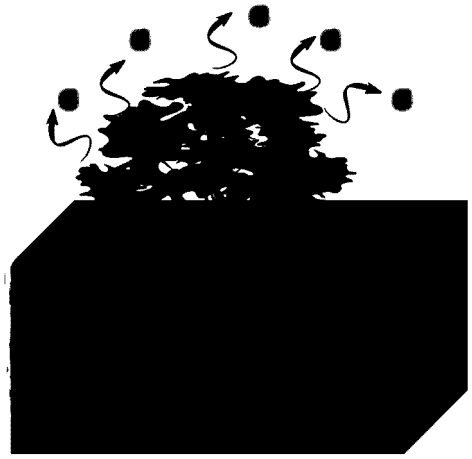

Fig. 4 Phytovolatilization (C-Contaminant)

2.6. RHIZODEGRADATION

Rhizodegradation is also known as plant-assisted degradation, and it is the breakdown of organic contaminants trough microbial activity. We speak here about microorganisms that live in the root zone.

Plant roots released a exudate that contains sugars, amonio acids and organic acid, enzymes and other compounds. This exudate favores the growth of microorganisms in the root zone.[4]

Fig. 5 shows microorganisms that live in the root zone. Microbes extract contaminants from groundwater, integrating them into their cell and transform them to cellular compounds or energy.

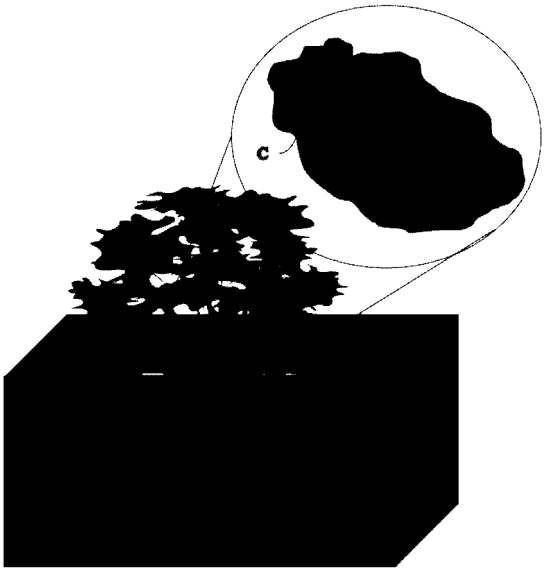

Fig. 5 Rhizodegradation (E- Enzyme, C-Contaminant, DF-Degraded contaminant)

Rhizodegradation is known for contaminants such as: TPH (total petroleum hydrocarbons, PAH (polycyclic aromatic hydrocarbons), BTEX (Benzen, Toluen, Etylbenzene, Xilenes), pesticides, chlorinated solvents, PCP (pentachlorophenol), PCB (polychlorinated biphenyls), surfactants – LAS (alkylbenzen sulfonate), -LAE (alcohol ethoxylate)

3. PLANTS

Plants metabolize, volatilize or accumulate different kind of pollutants and therefore we must know which plant has the capability to remediate which contaminant

Transformed or removed contaminants are presented in Table 1, second column, and in the first column are plants that have the ability to remediate groundwater or soil.

Tabel 1. Plants and contaminants which can be remediated[2]

Plant	Contaminant
Arabidopsis thaliana (mouse-ear cress)	Mercury
Silene vulgaris (Bladder campion)	Zinc Copper
Brassica sp. • Brassica juncea (indian mustard) • Brassica oleracea var. italic (broccoli)	Selenium Sulfur Lead Cadmium Chromium Nickel Zinc Copper Cesium strontium
Buxaceae family (boxwood)	Nickel
Compositae family	Cesium Strontium
Euphorbiaceae family	Nickel
Solanum licopersicum (tomato)	Lead Zinc Copper
Populusgenius (poplar, cottonwood)	Pesticides Antrazine Trichlorethylene Carbon tatrachlorid Nitrogen compounds 2,4,6-trinitrotoluen (TNT) Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
Pondweed (acvatic plants and green algae) Maranta arundinaceae (arrowroot) Ceratophyllum (coontail)	2,4,6-trinitrotoluen (TNT) Hexahydro-1,3,5-trinitro-1,3,5-triatine (RDX)
Thlaspi sp. (pennycress)	Zinc Cadmium
Lolium sp. (perennial rye grass)	Polychlorinatedphenyls Polyaromatichydrocarbons

Plants that can be used for phytoremediation of groundwater must have some special features:

- Grow quickly
- Consume large quantities of water
- Remediate more than one pollutant

4. ADVANTAGES AND DISADVANTAGES

Advantages of phytoremediation are:

- Produces less waste because contaminated plants are burned and the ash has a small volume that must be stored.
- Relatively inexpensive, it cost less than other

remediation methods.

- Phytoremediation has a low impact of the environment.
- In this case we have a in situ remediation
- Contaminants can be reused – contaminants stored in the biomass can be transported to an area with deficite of the same compound.
- In case of phytostabilization disposal is not required.
- Plants are able to grow in areas with high concentration of contaminants
- Contaminants could be transformed to less toxic forms

As we shown here phytoremediation has many advantages but also a lot of disadvantages and we can´t go over them. So the disadvantages are:

- Remediation of groundwater is only possible if we have a plant with deep roots or shallow groundwater.
- The toxicity of pollutants go over to the plants.
- A limited number of plants can be used, because not every plant has the ability to extract or transform contaminants from groundwater or soil.
- Phytoremediation needs a large period of time.
- The process depends on season, because in winter we can´t grow plants.
- The risk posed to consumers of plants because plants are storage for contaminants.
- In case of phytostabilization the contaminant remain in place[5]

After we present the advantages and disadvantages, now it´s time to show some possibilities to reduce the disadvantages.

5. REDUCING DESADVANTIGES

A possibility to reduce disadvantages is genetic engineering. Genetic engineering is the science which makes possible the modification the organisms.

The European legislation do not alow to grow genetic modify plant on field, but genetic engineering have a large area of application.

Genetic engineering makes possible the passage of a desired character at a plant that is adapted to the environment in which to be planted. More precisely, if we have a deep aquifer and plants that have the ability to absorb contaminant have a shallow root system, then by genetic engineering methods we can introduce gene responsible for contaminant uptake in the genome of a plant that has a deep root system and make phytoremediation possible.

As already mentioned, in Europe in field cultivation of genetically modified plants is banned, but this technique has advantages for phytoremediation. Through genetic engineering techniques can be removed most of the disadvantages posed by phytoremedation.

6. CONCLUSION

Plants have the ability to remediate the contaminated site. If we speak about aquifer the situation is more complicated, because here you have to ensure that the roots are deep enough that they can enter the aquifer. Phytoremediation can be applied with good results also where groundwater is at shallow depths and thus can easily enter into contact with plant roots.

Phytoremediation can be made directly by the plant, but mostly it is done through the activity of microorganism that live in plant rhizosphere.

Microorganisms have in the rhizosphere an intense activity because the plant roots remove substances that are used by microbes as nutrients.

The most suitable plants for groundwater phytoremederea are trees because they have roots that penetrate deep into the soil, and one species must be mentioned here, the poplar tree, whose root system extends over an area of 40 m from the trunk.

If the method of choice is phytoremediation for groundwater pollution it must be known which contaminant will be removed in order to choose the right crop, I mean that we must choose the plants that assimilated pollutants in large amounts.

The final conclusion would be that we need a revision of the attitude toward genetic engineering, because it can bring benefits to phytoremediation techniques, and should not be applied to consumer crops, to be justified the fear of danger that plants can have on human health.

7. ACKNOWLEDGMENT

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[3] http://www.rtdf.org (8.12.2010)

[4] http://www.cluin.org/download/remed/introphyto.pdf

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