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SOILS POLLUTION CONTROL METHODS

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Abstract: This paper presents various methods of soil pollution control, which are globally used. Among these methods, I have mentioned physico-chemical pollution control methods, biotechnological methods and the use of plants for pollution control. Taking into account the fact that no method allows full pollution control of contaminated soil, several methods must be combined.
Keywords: source pollution, pollutants, pollution control methods, biotechnologies, physico-chemical methods

1. INTRODUCTION

Soils are subjected to various impacts due to natural phenomena and anthropogenic processes which lead to soil properties changes.

Modern ecology considers that soil pollution represents any action that results in the disturbance of the soil's normal function, dysfunction manifested in the deterioration of the soil's physical, chemical and biological properties, reducing thus soil productivity.

The total area of Earth is 51 billion hectares of which 1.5 billion hectares are used in agriculture. United Nations Food and Agriculture Organization (FAO) found that agricultural land is 1.1 hectares for each inhabitant, respectively 0.3 hectares of arable land.

Table 1. Areas affected by pollution in Europe (2001)

Polluting process	Affected area (million ha)	Percentage of total agricol area of Europe (%)
Erosion by water	115	12
Wind erosion	42	4
Acidification	85	9
Pesticides	180	19
Nitrates and phosphates	170	18
Compact	33	4
Loss of organic matter	3,2	0,3
Salinization	3,8	0,4
Excess moisture	0,8	0,1

The basic functions of soil (part of the biosphere, support for food production and world population, the main means of plant production, nutrient source for plants, renewable energy resource) are endangered by inappropriate land use processes and especially by anthropogenic processes.

The most severe soil pollution processes in Europe, in terms of their irreversibility and the affected area are presented in Table 1.

The most important soil degradation processes in our country are: erosion and surface runoff, landslides, alkalization and acidification, pollution with heavy metals, with pesticides, excess or deficiency of nutrients, compaction, and inadequate waste disposal, damage by mining, salinisation and excess moisture.

The effects of soil pollution are assessed through the synthetic index, whose value is given by the ratio between the quantitative and qualitative aspect of the harvest obtained in conditions of pollution as compared to the one obtained in normal conditions.

In assessing the degree of impairment of soil quality not only the status of the soil quality, but also the pollution degree are taken into account. (table 2)

Soil pollution analysis must take into account not only the determination of the pollutant factor, but also its quantity and the manner it penetrates the soil as well as the physical, chemical, biological and biochemical reactions that it produces into the soil. (fig.1)

Pollutant removal action on the soil represents a long and complex activity. Soil pollution control represents the return to characteristics and fertility considered before the creation of pollution, so the factor pollutant removal does not require concomitant soil pollution control, too.

The degree of soil pollution is assessed based on the quantitative and qualitative reduction of crop production in terms of pollution reported to that obtained by unpolluted soil, in normal weather and technological conditions by the formula:

$$R = (Pp/Pn)\ 100 \qquad (\%)$$

Where: R - Production reducing (%)
PP - Production after pollution (tons/ha)
Pn - Production before pollution (t /ha)

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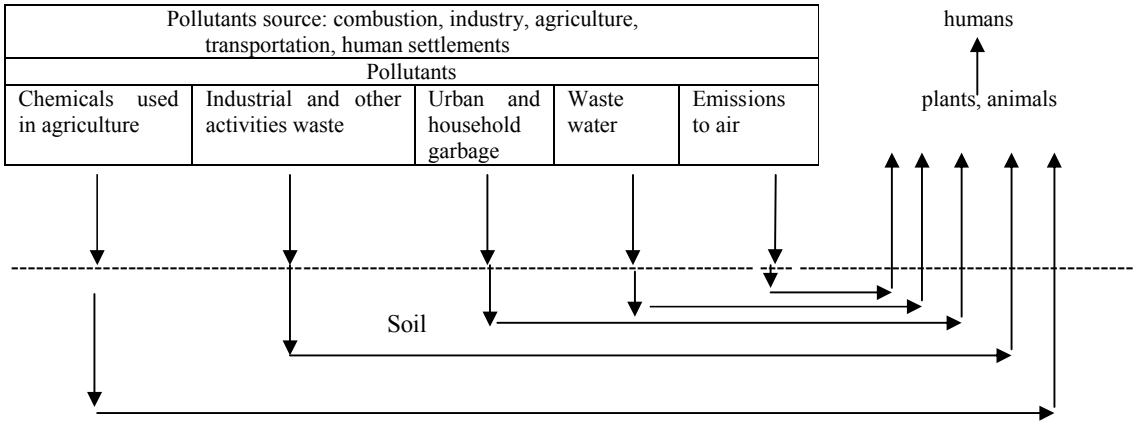

Fig.1. Soil accumulator of pollutants

Table 2.The degree of soil pollution

Symbol	Assessment	Production reducing (%)
0	Unpolluted	<5
1	Weakly polluted	6-10
2	Moderately polluted	11-25
3	Heavily polluted	26-50
4	Very heavily polluted	51-75
5	Excessively polluted	>75

2. POLLUTION CONTROL METHODS

The action of soil control pollution of an area comprises several stages:

- immediate danger decrease;
- activity history, geological and hydrological study, soil mapping and analysis;
- risk assessment;
- determination of the objectives and methods of pollution control;
- actual work of pollution control;
- monitoring and restrictions on land use.

There are several pollution control methods namely:

2.1. Physico-chemical pollution control methods

These methods have high costs, reason for which they are avoided, but also have the advantage that they quickly solve the problem. The mostly used physico-chemical pollution control methods are:

- the excavation method which is very expensive because of transport and storage of polluted soil;
- the method by nitrogen air or steam injection, that will capture the pollutants;
- the flotation method, by which soil is mixed with water and surfactants agents and air injected into this mixture captures the pollutants;
- the electrical extraction method, which is based on creating an electric field through a pair of electrodes.

This method is used for the extraction of acetic acid, phenol, zinc, lead and copper;

- the extraction by heating is a process through which soil is excavated, chopped and heated at 600-800^{0}C;
- the cleaning by solvents is indicated for pollution caused by heavy hydrocarbons products such as tar and pesticides;
- the washing with water is used for soils polluted with heavy metals and mineral oils.

2.2. Biotechnological methods of pollution control

The most widely used biotechnologies for soil pollution control are:

- the soil pollution control using bacteria. Bacteria are microorganisms, with length of 0,1 to 100μ, are thickness of 0,1 to 1μ, and the most common exercise the most important activity in comparison with other microorganisms.

They degrade the nitrogenous and non-nitrogenous organic matter, cause nitrification, denitrification, sulfur and phosphorus release from organic combinations, etc. The number of bacteria in the soil ranges from 2-3 million to 2-3 billion per gram of soil, which means about 5-6 tons of bacteria in a hectare of arable layer of soil rich in bacteria. For normal soils, the quantity of bacteria is 0.5 to 5 tons, 1-2 tons for uncultivated soils and for the soils planted with leguminous plants of 5-10 tons. Of these only 5% are known and can be isolated and grown in the laboratory.

The spread of the bacteria in soils is due to their great capacity for adaptation. Thus, they may use very different nutrients, and some can use atmospheric nitrogen. Also, their ability of sporulation is a condition for their persistence in environments which are usually unsuitable for the development of life, the endospores being resistant to high temperatures and prolonged dehydration.

Bacteria are used in most wastewater treatment plants in Europe, they can digest and remove pollutants. Also, household waste deposited in landfill emits methane as a result of anaerobic bacteria activity.

Bacteria degrade phenol, hydrocarbons, pesticides, and help eliminate arsenic and heavy metals. The biodegradation process starts once the bacteria take their nutrition from organic compounds, mineral compounds and light.

Thus, sulpho-reducing bacteria are used to clean ground water containing heavy metals which have serious effects on animal and human health. Chromium is converted by bacteria from the state of the soluble pollutant, dangerous to health and cancer producing, to the slightly soluble state, less toxic even

in small doses necessary to health. Similarly, arsenic is transformed from a toxic form into a naturally form that is less dangerous.

These biotechnologies are used to identify mineral resources (cobalt, copper, silver) especially in Central Europe and Scandinavia ores.

The European Programme BIODEPOL classified bacteria according to the pollution in Table 3.

Table 3. Classification of bacteria

Bacteria	Objective
Bacteria that oxidize sulfur compounds in aerobic conditions (Thiobacillus)	- Bio-hydro-metallurgical processes implementation to recover metals from mineral resources - mine drainage
Oxidizing or reducing bacteria of arsenic in aerobic or anaerobic conditions (Thiobacillus, Rhizoctonia)	- Treatment procedures implementation of wastewater, effluent and soil contaminated with arsenic. - mine drainage
Heterotrophic bacteria that degrade organic compounds in aerobic and anaerobic conditions (Ralstonia eutropha)	- Pollution control procedures implementation of effluent, waste and soil
Sulphates reducing bacteria in anaerobic conditions (Saccharomyces, Rhizopus, Chlorella, Thiobacillus, Zoogloea	- use of biological treatment of mining and industrial acids effluents contaminated with heavy metals
Bacteria that produce hydrogen and marsh gas	- degradation of organic matter in reducing conditions such as bio- treatment of organic waste and energy gas recovery
Bacteria which mineralized carbon in carbonates	- fixation of carbon dioxide in mineral form

It was observed that the inappropriate use of bacteria can lead to the generation of more toxic products and more mobile than the original products.

Bacteria are mostly used to treat soils contaminated with hydrocarbons such as gasoline and conventional diesel. One method is the „ex – situ" method. This procedure takes about six months, and after the land pollution control, could be used as agricultural land. The method is however limited by soil type and has the disadvantage that the land must be excavated from polluted area and brought to the treatment center.

Another method is the „in situ" one. This involves the sampling of polluted soil, then the correction of the soil pH and the addition of nitrogen and phosphorus because bacteria grow optimally when the ratio C/N/P is 100/10/1. The bacteria are sprayed, in liquid form, at the soil surface or injected into soil. They lead to the degradation of the pollutant. The method has limitations on soil permeability, the local weather conditions, hydrocarbon type and its concentration and depth of pollution. To accelerate biodegradation plowing (by which microorganisms are brought into contact with hydrocarbons), soil moisture and pH also contribute. The cost of pollution control by this method is 5 times lower than when using physical-chemical methods.

2.3. The use of plants

Plants have been used since ancient times to treat diseases or to destroy parasites. The European Union has established a research program of phyto-remediation in which seven countries participate to agree on pollution control methods and costs.

Phyto-remediation is done through two mechanisms: - active remediation that destroys pollution;

- passive remediation which stabilizes pollution.

The techniques of pollution control with plants are of four types - phyto-stabilization

- phyto-extraction

- rizo-degradation

- phyto-volatilization

a). Phyto-stabilization is a technique that uses plants with developed roots so they reduce the mobility of pollutants contained in the soil. They come from dust, particles that are carried by water, or from fauna. Roots fix the pollutants by limiting their horizontally and vertically movement. Featured plants are the gramineous plants. This method is used for soils polluted with metals, pesticides, solvents, explosives, oil and derivatives. For this method to be effective certain conditions must be met:

- pollutants are not easily migrating into soil;

-pollutants are not easily accessible to wild herbivores and insects;

-plants will be chosen so as to be able to fix pollutants, but not to accumulate pollutants;

- polluted area to be monitored, the toxicity threshold must be controlled so that the plants stay alive.

b). Phyto-extraction is a method of decontamination of soil from heavy metals (copper, silver, gold, mercury, cadmium, lead). The method is based on crop production that has a tolerance and a greater capacity for accumulation of heavy metals. These plants can accumulate up to 1% of the pollutant, to their dry matter.

Plants used for this method will be chosen depending on the nature of pollutants, climate and biomass so that it can accumulate large amounts of pollutants.

After harvesting the plants are incinerated and the ashes will be stored in a secure environment. Culture may be renewed up to an acceptable low concentration of metals in soil.

Phyto-extraction can be of two kinds:

- continuous phyto-extraction which contains used plants that accumulate up to 1% metal and cannot live without them. These plants are called metalofite (pansies)

- induced phyto-extraction, which is based on plants that have molecules called "chelator" which have the capacity to deliver metals that are not soluble in water and accumulate them. Plants used for this type of pollution are mustard and tobacco. Experimentally, it was found that by this procedure, 20% zinc, 40% lead and 60% cadmium were extracted from the deposit.

Plants cannot solve the overall problem because plants can absorb only a fraction of heavy metals found in soil. Therefore successive harvests must be made until the area is completely pollution-controlled.

Worldwide heavy metal accumulator plants are more than 320 and were classified as:

- type I plants that accumulate Al, Ag, As, Be, Cr, Cu, Mn, Hg, Mo, Pb, Se, Zn;
- type II plants that accumulate Ni;
- type III plants that accumulate radionucleide, hydrocarbons, organic solvents.

c). Rizo-degradation is a measure used more for treating pollution with hydrocarbons. Plants and microorganisms that live mostly in roots are used. The method is based on the ability of microorganisms that live in plant roots to degrade hydrocarbons embedded in soil. Microorganisms used in this method are bacteria (Pseudomonas, Xanthomonas, Micrococcus) and fungi (Aspergillus, Penicillium). They take their food from these organic compounds after they were decomposed. The effectiveness of microorganisms increases if certain plants are grown on the polluted soil.

d). Phyto-volatilization is based on plants that can absorb pollutants, so that they can destroy them in their cells and repel them into the atmosphere. Thus, nitrogen and selenium after transformations suffered in plants are evaporated into the atmosphere through the leaves. One of the most prominent trees that have this property is the poplar.

e). Rizo-filtering is used for the organic pollution control of waste water using plants that develop a large rizosphere. Such a plant is the reed.

f).Phyto-remediation allows landscape preservation and an agricultural activity after the end of the pollution control, being a more advantageous method than the others from an economic point of view. This method presents certain disadvantages and requires at least 10 years in order to pollution control a contaminated soil. The investment is small, but the long mobilization of the land can lead to an economic problem.

3. CONCLUSIONS

No method allows full pollution control of a contaminated soil. In order to have effective results, several methods must be combined.

Polluted land will never regain their previous status, which is why it is better not to pollute than to pollution control a polluted land.

It requires that environmental pollution problems are solved through international cooperation, which will lead to responsible and expeditious resolution of pollution problems, taking into account the experience of each state.

To ensure global population with agricultural products and industry with raw materials it must be protected all soil resources and recovered fully, with greater efficiency and greater economic efficiency. It is therefore necessary to ensure the best soils management measures, to prevent and combat their degradation phenomena, to maintain or even increase fertility, respectively their productive capacity.

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