TECHNOLOGY SOLUTION OF DECONTAMINATION PROCESS OF SOIL

Juraj Ruzbarsky, Tomas Duranik, Andrej Ulicny
Technical University of Košice, Slovak Republic
juraj.ruzbarsky@tuke.sk, tomas.duranik@tuke.sk, andrej.ulicny@tuke.sk

Abstract. The article solves the scientific problem of decontamination of the soil using biomass. The investigation was subjected to decontaminate the soil against the elements like Cu, Pb, Hg and As. As significant consumer of heavy metals, Amaranth plant was chosen.

Keywords: soil decontamination, Amaranth plant, biological decontamination.

Introduction

The largest holder of contaminated soil is water. With erosion it moves contaminated soil in parts of water areas where no water flow is, like a dam. Subsequently contaminants are collected in soil with gradual sedimentation. Therefore, it is necessary to extract the soil from the dam. With excavated soil the dam restores the volume and can fulfil the original purpose of the collection of water and produce energy. The article discusses the possibilities of soil decontamination with a proposal to receive energy from contaminated phytomass with combustion. An investigation of the metals like copper, lead, arsenic and mercury was made. As a potential hyperaccumulator plant amaranth plant was used. After carrying out the experiments the levels of heavy metals in the soil before planting and after harvest of the mentioned hyperaccumulator were measured [1].

Because the excavated soil is contaminated, decontamination can be done by several methods [2; 3]:

- physical method;
- physic-chemical method;
- biological method.

The most preferred method appears to be the biological. The technological process of biological decontamination is the usage of plants otherwise called hyperaccumulators. Plants with their root system absorb from the substrate heavy metals, which are stored in different parts of the plants.

According to the findings, most pollutants are concentrated in the roots, footstalk and leaves. Minimum content of pollutants is in the seeds.

Materials and methods

A sample of contaminated soil was taken from the water flow of river Hornad near the city of Margecany, from estuary river Hnilec into river Hornadu.

Samples of soil were taken from the bottom of the river right bank in 15-20 cm profile in quantities approximately 80kg. The soil showed characters of mud, what matches the humidity for our experiment. For sowing Amaranth, an adjustment of soil moisture is needed so that advisable physical properties for processing and sowing seeds are acquired. A part of the sample soil was given to analyze the content of heavy metals. For analysis of soil samples biological accredited laboratory is used.

For foundation of the experiment three variants with marking were created:

- K-1 variant with only contaminated soil
- K-2 variant with contaminated + not contaminated soil in ratio 1:1
- K-3 variant with not contaminated soil, as control variant.

Sowing was made in a plastic crate. The walls and bottom of the plastic crate were coated with impermeability foil for the egesting of soil. The attempt was realized in laboratory conditions at the Faculty of Manufacturing Technologies with the seat in Presov at the Department of Technology Systems Operation.

We monitored the growing of plants since the incipiency of growth till gathering. At gathering the height of the plants and the vegetable production were measured. From variant K-1 we separated the root part for individual representations of heavy metals. Following the vegetable substance was dried and the soil and plant from variants K-1 were given to analyze. The variants K-2 and K-3 were not passed through analyses, these variants served as control samples at comparison of growth and vegetable substance production. From variant K-1 analysis for the content of combustion, heating capacity and content heavy metals in ash was further made.

Results and discussion

1. Monitoring of plants height is important for plant collection technology with mechanization devices.

The data of the examination variants are shown in Table 1.

Table 1

Data about height of plants in sample variants

Variant	Average plants height, cm	Range, cm
K-1	39	12-168
K-2	40,2	13-82
K-3	28,7	10-74

High range of plant height was affected by conditions that the plants were grown in laboratory conditions. For mechanical harvesting plants with higher rise are better. It is possible to influence the plant height with growth organization. The vegetable substance production is an important index, because it determines utilization of fytoenergetic fuel from the unit of surface.

Individual variant vegetable substance productivity is shown in Table 2.

Table 2

Vegetable substance productivity

Variant	Productivity of variant, g	Productivity from 1 ha, t
K-1	750	37,5
K-2	460	23
K-3	407	20,3

The results of productivity prove that Amaranth provides sufficient vegetable biomass from unit surface. Amaranth is able to be harvested with machines and provides production of fytoenergetic fuel.

2. Results of testing soil.

Analysis of the soil from variant K-1 is shown in Table 3 [4; 5].

Table 3

Analysis of heavy metals from soil from variant K-1

Element of heavy metals	Contaminated soil before sowing Amaranth, $mg \cdot kg^{-1}$	Contaminated soil after the collection of Amaranth, $mg \cdot kg^{-1}$	Limited attributes of danger elements in soil, $mg \cdot kg^{-1}$
As	50.0	25.9	25.0
Cu	321	300	60
Hg	1.24	1.18	0.50
Pb	66.0	30.1	70.0

In comparison with limited attributes of danger elements in soil in three cases their content is highly exceeded. These elements are namely arsen, copper, and mercury. From the data in Table 3 the soil contamination decreases after using the Amaranth plants.

3. Content of heavy metals in the plant.

The utilization of Amaranth plant for soil decontamination is mentioned in Table 4.

Analysis of the plant proves absorption of heavy metals, where the highest content of pollutants is included in the root of the plant.

The result that the root is mostly contaminated makes a harvesting problem of the plant, because it is different from collection of cultural plants which is technically solved. Therefore, there will be a need to solve technology of collecting whole plants [6]. The problem of harvesting requires individual solution.

Table 4

Content of heavy metals in different variants

Element of heavy metals	Sort of sample		
	Above-ground not contaminated plant	Above-ground contaminated plant	Root of contaminated plant
As	0.03	0.06	1.68
Cu	8	31	25
Hg	0.05	0.06	1.12
Pb	0.50	1.11	3.59

If the root stays in soil and we collect only the above-ground part of the plant, the decontamination of the soil will be unsolved. The dead root could release heavy metals into the soil and it goes backwards and the soil will contaminate again [7; 8].

The decision is to use the known techniques of harvesting plants.

4. Evaluation analysis of ash.

Ash is final existence, wherein there are heavy metals contained. The content of heavy metals in ash is shown in Table 5.

Table 5

Content of elements of heavy metals in ash

Element of heavy metals	Content of elements in ash, $mg \cdot kg^{-1}$
As	2.25
Cu	304
Pb	8
Hg	0.2

Analysis proves that the ash includes large quantities of heavy metals.

Conclusion

The target of this article was to find out a possibility and effectiveness of decontamination of soil through plant Amaranth, and exploitation of that plant as a fytoenergetic type of biomass for heating.

According to the findings and results from the research topics we can state that:

1. Plant Amaranth removes heavy metals from the soil and causes its decontamination.
2. For heat production as fytoenergetic fuel from biomass, it shows preferable and economically preferable burning in packages [9].
3. After burning heavy metals are contained in ash. The contained heavy metals in ash are the end product after burning. After Solidification method of ash, the heavy metals can be eliminated.

References

1. Bédi, E. Obnoviteľné zdroje energie. Fond pre alternatívne energie. Bratislava: SZOPK. 2001
2. Dedrna, Z. Pôda. Bratislava: Príroda. 1984.
3. Groda, B. Technika zpracování odpadů. Brno. Mendelova zemědělská a lesnická univerzita. 1995.
4. Uličny, A., Duraník, T. Návrh na riešenie dekontaminácie zeminy. In: Situácia v ekologicky zaťažených regiónoch Slovenska a Strednej Európy : 19. vedecké sympózium s medzinárodnou účasťou : zborník : 21.-22. október 2010, Hrádok. - Košice : Slovenská banícka spoločnosť ZSVTS, 2010 pp. 222-223. ISBN 978-80-970034-2-5.
5. Slovak Innovation and Energy Agency [online] [31.03.2012.]. Available at: www.sea.gov.sk.

6. Müller M., Hrabě P., 2012. Overlay materials used for increasing lifetime of machine parts working under conditions of intensive abrasion. Res. Agr. Eng., 59, pp. 16-22.
7. Drzimala, Z. at al. Preglad mechaniczny-Organ glowny towarziszenia inžinierow I mechanikov Polskich- PL ISSN, 1998.
8. Neubauer, K. at al. Poľnohospodárske stroje. Bratislava: SVPL. 1964.
9. Viglaský, I. Tepelný zdroj na biopalivo. In: Zborník prednášok zo 4. Medzinárodnej konferencie a výstavy ENEF. Bratislava, 2000.
10. Hraško, J. Rozbory pôd. Bratislava. SVPL. 1962.
11. Rajčaková, Ľ. at al. Vplyv kontaminácie pôdy ťažkými kovmi na ich prijem rastlinami. In: Zborník z medzinárodného sympózia "O ekológii vo vybraných aglomeráciách Jelšavy – Lubeníka a Stredného Spiša" Hrádok, Košice, 2002.
12. Sladký, V. Využití fytomasy k vytápění zemědělských objektu. Praha: Ústav vědeckotechnických informaci pro zemědělství. 1992.