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DECONTAMINATION OF SOIL USING AMARANTHUS AND ITS ENERGETIC EXPLOITATION

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ABSTRACT: The aim of presented experimental work was to test possibility and effectiveness of the soil decontamination using Amaranthus plants and subsequent exploitation of that plant as phyto-energetic fuel of biomass for energetic purposes.
Article is focused on analysis of the soil decontamination using cultivation of the plant Amaranthus caudatus. Effectiveness of this method of decontamination is studied using reference samples of various types. Moreover, exploitation of the plant as a fuel material produced of vegetable biomass and its energetic value is analyzed.
KEYWORDS: biomass, decontamination, combustion

❖ INTRODUCTION

One of the most important menaces of heavy metals contamination is connected with its spreading in soils that works as water flow reservoir. Circulating streams of surface and subsurface water distribute heavy metals in interaction of the erosion processes from surrounding terrain and from processing plants by ores flotation [1].

Velocity deceleration of the water flow in trough of a river, backwaters, tributary river from the dam and series of consecutive level changes due to ice are some of the factors that create the conditions for contaminating of the soil by heavy metals by sedimentation [2, 3].

One of the possibilities to remove heavy metals from the soil is method of growing plants with ability to absorb some portion of it [4, 5]. Contamination is thus removed from soil into the plant which can be subsequently utilized as a phyto-energetic fuel [6].

Main aim of presented research is to perform study on the soil decontamination by planting Amaranthus with subsequential analyze of its exploitation as a fuel.

❖ MATERIAL AND METHODOLOGY

Samples of contaminated soil were taken at the river Hornad close to the mouth of the river Hnilec into Hornad, just above limekiln in Margecany. The samples were taken from the right bank of the river bottom with profile 15- 20 cm and mass of 80 kg.
Soil showed marshy character with corresponding humidity of water content. For sowing plants, soil properties were changed by replacing indoors in order to acquire physical properties convenient. Soil contamination of particular samples was studied using analyzing of the heavy metals content. Analyses were performed in accredited laboratory of ecology in Spisska Nova Ves.

For the purposes of the experiment, three variants were differentiated:

- K-1: variant with contaminated soil;
- K-2: variant with contaminated + soil without contamination in ratio 1:1;
- K-3: variant with soil without contamination (reference sample).

Seeds of Amaranth have been acquired from the Slovak University of Agriculture in Nitra. Soil was transported in PE packaging with walls and bottom coated by impermeable foil that not allowed the soil egesting. Experiment was realized in laboratory conditions at the Faculty of Manufacturing Technologies of Technical University of Košice with a seat in Prešov at the Department of Manufacturing Processes Operation.

During growing plants before harvesting their height was monitored and balancing production of the plants mass. For variant K-1, root part of the plants was separated for analyzing of heavy metals. After harvesting, the plants were dried and subsequently the soil and plants were analyzed. The variants K-2 and K-3 were not analyzed being used as a reference samples for a comparison of growth and plants mass production. Plants from variant K-1 were further analyzed for combustion, heating capacity and heavy metals content in ash. Appointed indices are of major importance in the assessment of the plants exploitation as phyto-energetic fuel [7, 8].

❖ RESULTS AND DISCUSSION

Determination of the plants height is important for use mechanization technology of harvesting. For particular variants it was observed:

- Variant K-1 – average plants height 39.0 cm, dispersed from 12 to 168 cm;
- Variant K-2 – average plants height 40.2 cm, dispersed from 13 to 82 cm;
- Variant K-3 – average plants height 28.7 cm, dispersed from 10 to 74 cm.

Wide dispersion of the plants height is affected by conditions in which the plants were grown. For the purpose of mechanized harvesting are more suitable plants with higher growth. Plantations with larger number of plants that reach greater height per unit of surface are preferable for mechanical harvesting. For purposes of the production of vegetable substance the final number is important as it determines production of phyto-energetic fuel from the unit of surface [9].

For particular variants, the biomass production is summarized below (Table 1):

Table 1. The production of biomass

Variant	Production for the variant (ton)	Production from 1 ha (ton)
K-1	750	37.5
K-2	460	23
K-3	407	20.3

Results of the experimental cultivation proved that the Amaranthus provides fair quantity of biomass per surface unit; it is suitable for the mechanized harvesting and provides material for the phyto-energetic fuel production.

❖ RESULTS OF THE SOIL ANALYSIS

Results of analysis of the heavy metals content in the soil performed before sowing and after a harvesting of Amaranthus are summarized in Table 2.

Table 2. Content of heavy metals in the soil

Element	Soil contamination before amaranthus sowing (mg/kg)	Soil contamination after harvesting of the plants (mg/kg)	Limit values for the content of the element in soil (mg/kg)
As	50	25.9	25
Cu	321	300	60
Hg	1.24	1.18	0.5
Pb	66	30.1	70

It is clear that limit values for heavy metals content are exceeded for three elements namely As, Cu, and Hg. The soil contamination exceeds limits before and also after harvesting of the plants. Nevertheless, the substantial decrease in the harmful elements contents after the planting clearly proves its reasonability of the soil decontamination.

❖ CONTENT OF HEAVY METALS IN THE PLANTS

The contamination of the plants with heavy metals is summarized in the Table 3. The analysis of the plants cultivated using non-contaminated soil, contaminated soil and separated roots of the plants cultivated in the contaminated soil was performed.

The analysis revealed considerable capturing of the heavy metals in plants cultivated using contaminated soil in comparison with reference plants cultivated using not contaminated soil, particularly in roots.

This result raises the issue of the harvesting the whole plant with root because it is different from harvesting the plants which is technically solved. Therefore will be necessary to solve technology of harvesting the whole plants, which requires individual solution, because this concerns with plants that differ from the other plants that are usually harvested with roots. Moreover, if the root remains in soil and only above-ground part of the plants is harvested, the decontamination of the soil is unsolved. On the contrary, heavy metals released from the dead root returns back into the soil.

Table 3. Content of heavy metals in the plants in mg/kg

Element	Sample		
	Cultivated using not contaminated soil	Cultivated using contaminated soil	Roots of plants from contaminated soil
As	0.03	0.06	1.68
Cu	8	31	25
Hg	0.05	0.06	1.12
Pb	0.5	1.11	3.59

Decontamination of the soil using cultivating the Amaranthus encounters a problem of root harvesting, which is at present not technically solved. The possible solution is to use known techniques after some technical modifications. Technology of the Amaranthus harvesting should be oriented at a production of packages burnable in boiler; or briquettes or pellets burnable in other types of boilers.

For the purposes of presented research, production of briquettes in laboratory conditions using Heckert EU 40 hydraulic facility and subsequently their testing was performed by calorimetric analysis of the samples. Measured and calculated parameters for briquettes are as following:

- Density – 0.956 (kg/m^3)
- Pressure – 321.5 (MPa)
- Work – 2144.4 (kJ/kg)
- Combustion heat – 13.56 (MJ/kg)
- Heating capacity – 12.72 (MJ/kg)
- Calculated heat of combustion – 12.96 (GJ/kg)
- Calculated heating capacity – 12.16 (GJ/kg)

Heating capacity is lower in comparison with coal and is comparable with wood. For combustion of biomass from Amaranthus it is shown that more effective is to combust it in the form of pressed packages, because of the lower heating capacity in the case of pellets or briquettes and their manufacturing substantially raises expenses and unfavourably influences production economy of the phyto-energetic fuel from Amaranthus.

ANALYSIS OF ASH

The ash is a final link in chain rocks – water – soil – plant – fuel – ash wherein are contained heavy metals. Contents of heavy metals in ash determined using the laboratory analysis is (mg/kg):

- As - 2.25
- Cu - 304.00
- Pb - 8.00
- Hg - 0.20

Analysis proved that the ash contains high portion of heavy metals and thus has character of contaminated material.

CONCLUSION

The aim of presented experimental work was to test possibility and effectiveness of the soil decontamination using Amaranthus plants and subsequent exploitation of that plant as phyto-energetic fuel of biomass for energetic purposes.

Recommendations resulting from the research can be formulated as following:

- Amaranthus absorbs heavy metals from soil and thus allows its partial decontamination.
- For the heat production using Amaranthus as phyto-energetic fuel from biomass it is preferable combustion in the form of pressed packages.
- After burning, heavy metals remain in ash. The ash being the final product of this chain and so should be processed in accordance with its character of contaminated material.

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