Aspects of Rehabilitation of Waste Dumps Using Herbaceous Plants

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Abstract

There are many arguments that underlie research on rehabilitation of large areas of land that were set aside from the agricultural circuit and became heaps of storage for inert waste materials like bottom and boiler slag and fly ash. On the other hand result of biological materials with potential for land recycling *i.e.* sewage sludge. On the dumps of boiler slag composed of particles of 2-3 mm was gradually installed a layer of grass with the help of sewage sludge as a fertilizing agent and microbial activity stimulating agent, based on an extract of brown seaweed EKO GEA Slovenia. In the second year the amount of biomass harvested was 2 to 2.9 times higher than in the first year of cultivation. Moreover plants not harvested in the second year of culture bore fruit. Also, the root network strongly stabilized the slag and boiler ash particles against land spreading. Rapid and effective rehabilitation of the landscape destroyed was achieved with the use of herbaceous crops of the species *Lolium perenne.* Monitoring bioaccumulation of heavy metals *i.e*. Cd, Cr, Cu, Ni, Pb, Ni, Zn, etc. in aerial plant tissue was needed to decide the sector where the biomass harvested from inert waste dump covered with vegetation.

Keywords: extract of brown seaweed, inert waste, landscape rehabilitation

1. Introduction

Urban development in the last decade led to the massive increase in the quantity of waste accumulated at the neighborhood of cities. Storing them on one hand caused the removal from the agricultural circuit of large areas of land primarily by the physical location itself as well as by high dispersal potential of such waste and secondly by unwanted altering of the landscape [1]. From the burning of combustible materials in power plants, coal combustion residues result. These solid wastes include fly ash, heavy ash, boiler slag and gas. In a proportion of 25-40% of the coal combustion residue, boiler slag and heavy ash result [2]. Fly ash and slag dumps are devoid of vegetation, desert look like, have the potential of spreading dusts and granular material into the atmosphere and/or on the ground. Also, by washing the deposits with water from rainfalls the polluting components are dispersed on the neighboring surfaces and deep layers of the soil. The literature shows intense concerns of various teams of researchers on how to conserve ash and boiler slag deposits currently unusable [3-5]. The layer of ash and boiler slag is devoid of organic matter needed for plant growth [6]. Ash and slag dumps organic matter is represented only by the unburned coal. In the absence of organic substrate with a suitable source of N, the addition of organic matter with low ratio C:N, which is very important

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for plant growth, is required. The addition of organic substances initiates the nutrient cycle. Under such conditions, the landscape deteriorated by the inert deposits which lack bio assimilable nutrients, is restored [7].

Many researchers show that organic substances contained in the biological sludge can be used to promote an ecosystem with plant growth conditions. From the municipal treatment plants result annually high amounts of wastes consisting of biological sludge that are stored on waste dumps. They contain large amounts of nutrients needed in the topsoil to form adequate reserves of bio assimilable compounds for the plants. The positive effect of the organic sludge mentioned above is supported by a number of researchers as Mulhern et all, 1989; Juwakar and Jambhulkar 2008 [8, 9], etc. The relative sterility of the inert deposits must be destroyed by seeding specific plants. In addition, it requires inoculation of bacterial stimuli that are associated with soil microbial activity. Present research worldwide includes the incorporation of a certain amount of organic matter in the upper layers of the slag and ash dump to support the forming of a culture on their surface. It helps to initiate a vegetation resistant to climatic and biogeochemical conditions as well as the adaptation of plant species that can further contribute to nitrogen fixation in the soil. In this regard the microbial activity is important for a number of reactions and functions of the soil such as decomposition of organic matter, the formation of humus, the inhibiting cycle (in particular N, P, S) of the formation of aggregates in the soil, of soil stabilizing. As fertilizer agents dried biosolids, different composts, chicken manure, green compost and others can be used. These materials are mixed with the inert material of the surface layer of 5-10 cm to form an artificial, fertile layer of soil [10]. Biological restoration performed on the biologically inactive dump was done by seeding plants. It is widely appreciated that the best method for ecological conservation and rehabilitation for currently unusable ash and slag deposits is to cover the deposit with a mulch of annual or perennial plants, spontaneous and resistant flora and shrubs specific to disadvantaged areas [10, 11].

Phytoremediation studies are conducted in many countries by many researches in pot or in-situ with grassland plants and specific shrubs [12, 13]. In this study are presented the obtained results regarding: 1. recycling nutrients embedded in biodegradable and non dangerous organic waste, sewage sludge anaerobically stabilized; 2. the restoration of landscapes destroyed by depositing ash and slag dumps near cities, 3. obtaining seeds and biomass with possibilities for reuse.

2. Materials and methods

The experimental study was done in the experimental block: pot 1 named vn s1, pot 2 named vn s2, pot 3 named vn s3 - three experimental variants of inert boiler slag of thermal plants, topsoil fertilized with sewage sludge in quantity of 5.0, 10.0, respectively 25 $t{\cdot}ha^{-1}$ and bacterial stimulus Biocomplex 900, provided Ekogea Slovenia. Biocomplex 900 is based on a marine brown algae extract. Control variant - pot named vn 1, was fertilized with 5 $t{\cdot}ha^{-1}$ sewage sludge without marine brown algae extract addition. Each variant is done in three replicates. During sowing, topsoil was watered with a mixture of extract of brown seaweed and water (ratio 1:50). The experiment was carried out in pots with 6.5 kg of soil. In the pots, 20 g per pot of seeds from the *Lolium perenne* plant species were planted. The species of *Lolium sp.* tolerates pedoclimatic conditions specific to the western part of Romania. Plants were seeded in the spring. Pots were placed in the open and watered periodically. In the first year of culture, plant samples were harvested between July and October, every two weeks. In the second year of culture, plant samples were harvested in May-July, every 2 weeks. In the second year of culture, during August–September, plants were not harvested to allow their fructification. Seed biomass harvesting was performed at the end of September. Metal analysis was done for the aerial parts and seeds of the plants obtained in the 2nd year of culture. The metal analysis of aerial part of plant was presented by Mâşu and Rus [14].

3. Results and discussion

The plants have sprung up after 2 weeks of sowing. The vegetation coverage 30 days after seeding was of 95 % in all the experimental versions. In this period on the experimental variant fertilized with sewage sludge in the absence of the stimulus the plants dried at a rate of 30%. The culture showed signs of distress during the warm summer period and the second half of August. With the weather cooling the plants recovered and in the second year the vegetation layer recovered. In Figures 1 (a and b) are shown the quantities of biomass and aerial plant parts harvested periodically from the sites planted with the herbaceous species *Lolium sp.*

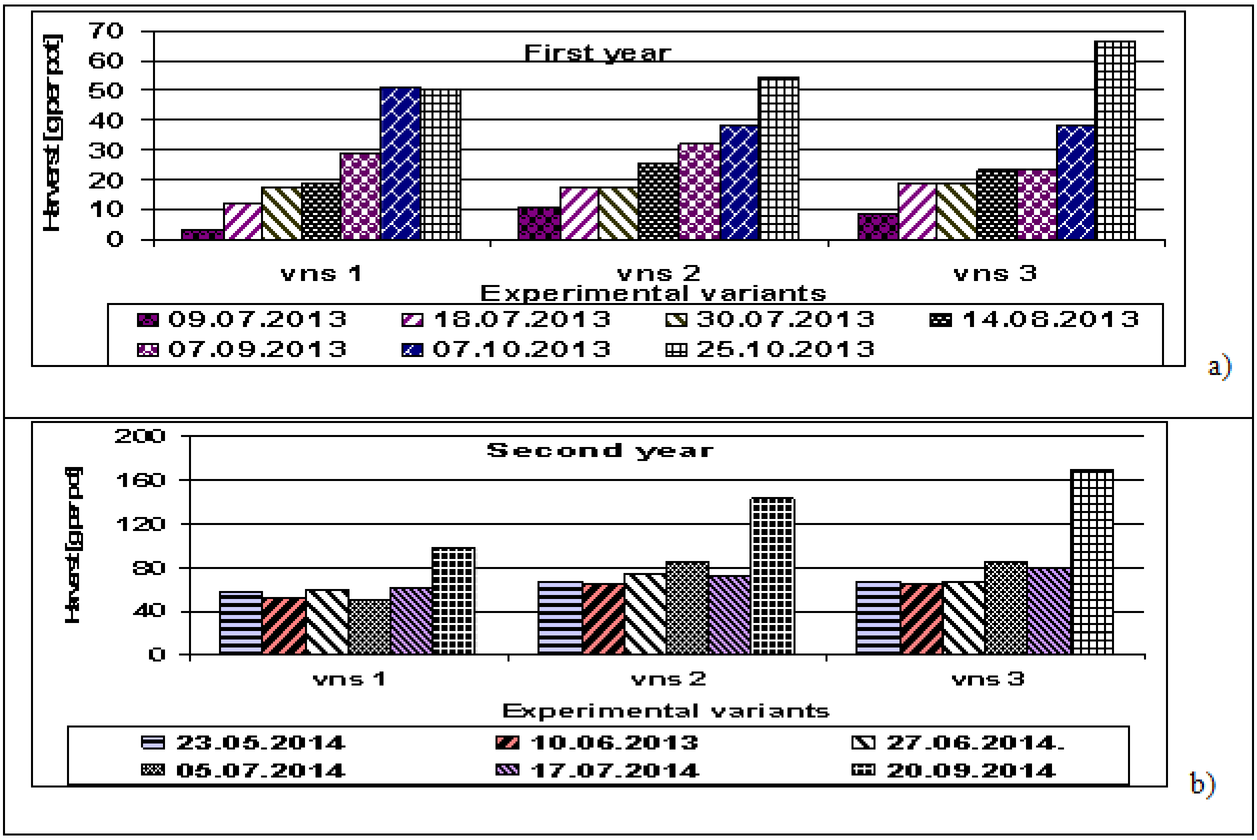

Figure 1. Quantities of biomass, aerial parts of plants harvested periodically from areas cultivated with the herbaceous species, a) first year of culture, b) second year of culture

We can see from the figure that the amount of biomass harvested has been increasing in time, which demonstrates plant adaptation to the conditions imposed by this experiment. Conversely the amount of fertilizing agent added does not alter the amount of biomass harvested in the second year of culture. The amount of biomass harvested periodically reaches a level of 69±17g per pot.

Table 1 shows the seed, annual and total green biomass quantities harvested from the experimental variants soils cultivated with the *Lolium perenne* species. The highest amount of seeds was obtained in the vn s1 variant fertilized with the least amount of 5 $t{\cdot}ha^{-1}$ sewage sludge. Note that in the first year of culture the absence of a extract of brown seaweed stimulus, on the experimental variant fertilized with a small amount of fertilizing agent resulted in a first year harvest 50% poorer than from the one gathered from the variant where the stimulus was used. In the second year in the absence of a stimulus, the experimental variant fertilized with sewage sludge caused a 46% lower yield vs. the variant where the stimulus was used. Increasing the amount of fertilizing agent did not increase the amount of harvest in the first year but had positive effects of crop growth in the second year.

The highest amount of seeds was obtained from the variants fertilized with small amounts of fertilizing agent, the stimulating agents did not influence though the amounts of seeds produced.

Table 2 shows metal quantities that have accumulated in the green biomass harvested in the second year of culture, in the aerial parts of plants.

Table 1. The seed and annual and total green biomass quantities harvested from soils cultivated with the *Lolium perenne* species

No	Harvest [g per pot]	Fertilizer agent sewage sludge[t·ha^{-1}]			
		without stimulus (extract of brown seaweed)	with stimulus (extract of brown seaweed)		
		5	5	10	25
1	Seed Second year	3.08±0.3	3.04±0.5	1.34±0.2	2.16±0.5
2	First year green biomass harvest	88.0±10.3	181.5±25.4	193.5±25.1	186.1±23.4
3	Second year green biomass harvest	213.5±35.2	378±35.8	506.0±37.2	538.0±34.8
4	Total green biomass harvest	291.5±32.1	559.5±41.1	699.5±52.0	724.1±52.2

Table 2. Metal quantities accumulated in the green biomass harvested in the second year of culture, in the aerial part

Variants	Metal [g·kg^{-1} D.M.]						
	*Cd	Cr	Cu	Fe	Ni	Pb	Zn
vn s1	-	1.48	1.55	27.0	2.6	6.0	17.9
vn s2	-	1.46	2.30	30.0	5.2	12.9	18.0
vn s3	-	1.56	2.50	31.5	4.0	26.4	25.2

*below the limit of detection

It can be observed from the table that regarding the aerial parts of the plants that reached the 2nd year of culture, Cd was below the limit of detection. The plants have accumulated small amounts of toxic metals (Cu, Cr, Ni, and Zn) but also large amounts of lead. Due to the high bioaccumulation of lead, the harvests resulted in the second year of culture will be managed as hazardous waste. Seeds harvested from the herbaceous plants' second year of culture can however be used for the next sowing. Furthermore all crops resulting from sites fertilized with sewage sludge and treated with fly ash will be closely monitored. The crops can be used in animal feeding only if the bioaccumulation of metals will not endanger their health. Crops resulted from the phytoremediation processes of sites treated with fly ash in suitable mixtures with the waste from plants harvested from normal unpolluted lands can be recycled as compost.

4. Conclusions

The vegetation strategy for landscape rehabilitation relates generally to the overcoming of barriers due to the physical, chemical and biological characteristics of the land proposed for vegetation: high content of heavy metals, low nutrient contents, inappropriate texture, minimized capacity to retain water, etc. The selection of plant species is an important factor because they have to withstand as much as possible of the state of deterioration of the landscape. The addition of an organic growth stimulus in combination with a fertilizing agent was effective in the first phenophases of the culture of *Lolium perenne,* determining in the first year of culture a fast and efficient vegetation in extreme hydro climatic conditions of high heat specific to the warm season in western Romania. Using a fertilizer like sewage sludge in the absence of plant growth stimulus caused the delayed installation of a vegetation cover. But the vegetation layer will expand to the sown areas in the second year of culture. To install the culture of herbaceous plants on the inert slag topsoil, quantities of 5t·ha^{-1} of sewage sludge in the presence/absence of plant growth stimulus for the *Lolium perenne* species were sufficient. In addition, in terms of the inert slag top soil's fertilization with quantities of 5 t·ha^{-1} sewage sludge in the presence / absence of plant growth stimulus, extract of brown seaweed maximum amount of seeds of 3 g per pot were obtained. The bioaccumulation of lead in the grass crops makes it necessary to monitor them closely. Seeds harvested from inert fly ash sites treated with organic fertilizer can be used though for future seeding. Vegetation strategy restores destroyed landscape, preserve inert dump and produced plant seeds and green biomass that can be recycled.

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