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Research Article

DISPOSAL OF STORAGE SLUDGE CAUSED BY ENVIRONMENTAL POLLUTION WITH BIOCHAR APPLICATIONS AND ENSURING ITS USE IN LANDSCAPE WORKS

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ABSTRACT. The study was carried out to determine the usability of waste sludge, which has been accumulating in the province of Tokat for years and causing environmental pollution, instead of high-cost plant development environments. To eliminate the harmful effects of waste storage sludge, biochars obtained from hazelnut shells or walnut pruning wastes were used. Except for the control group consisting of 100% waste storage sludge without biochar as a growing medium, media prepared by mixing 2% and 5% hazelnut or walnut biochar to the waste sludge were used. Calendula (Calendula officinalis) plant, which is used in landscape designs, was grown in prepared pots. Plants grown from seed were planted in pots, which were the subject of the experiment, when they had 2-3 leaves. While almost half of the plants in the control pots died, the mortality rate was 0 in pots with 2% walnut biochar addition, and only 11% in pots with other biochar. While biochar applications did not cause a significant change in root length and plant height, other biochar applications, except 2% walnut biochar (C2), caused some significant changes in root and herb weight, flower number and flower diameter. 5% walnut biochar (C5) caused a significant increase in root and herb weight, while both 2% (F2) and 5% (F5) hazelnut biochar caused a significant increase in flower number.

Key Words: *calendula officinalis, waste sludge, biochar, environmental pollution*

INTRODUCTION

As a result of rapid and unplanned urbanization with the effect of increasing population, the amount of domestic and industrial wastewater treatment sludge is increasing day by day. In 2018, 319 thousand tons of waste water treatment sludge (on the basis of dry matter) was obtained in our country [1]. In addition, waste sludge causes environmental pollution at a level that poses a great threat to human health. Therefore, the increase in the amount of waste sludge has become a big problem. It is of great importance to eliminate the damages of waste sludge and to reuse it [2, 3].

The use of sewage sludge for agricultural purposes will allow the reuse of this material economically and without harming the environment. The use of sewage sludge, which is rich in macro and micronutrients and contains 50-70% organic matter, in plant cultivation will enable economic production as it also acts as a fertilizer source [4]. Sewage sludge contains all the elements necessary for plants [5]. At the same time, the nutritional value of sewage sludge is close to the nutritional values of organic compost and barnyard manure [6, 7]. It is used in agricultural areas, forest areas, landscape designs, etc. in many countries. the use of sewage sludge has become widespread [8]. The use of sewage sludge in the production of ornamental plants is increasing in our country [9, 10, 11, 12]. The use of waste sludge in the cultivation of ornamental plants will enable the elimination of

the high cost allocated for the growing medium and the need for fertilization, as well as the harmless and economic reuse of the treatment sludge, which causes environmental pollution [13]. In addition to all these positive features, the use of sewage sludge, which contains many pollutants and pathogens, as a growing medium without taking any precautions brings serious health and environmental problems [3]. Zinc, copper, nickel etc. While heavy metals are absolutely necessary for plant growth, cadmium, mercury, lead etc. heavy metals are toxic. Excessive accumulation of heavy metals, including heavy metals required for plant growth, within the plant is extremely risky for the plant [14]. Heavy metals or toxic substances cause problems such as shortening in height, slowing down in development and even plant death, these effects vary according to the heavy metal tolerance of the plant [15]. Heavy metals also pass into the human or animal body through nutrition or respiration and have negative effects. For example, when lead accumulates in the body, it causes deterioration in the brain and nervous system and kidney damage [16]. Cadmium and its compounds, which generally accumulate in the kidney and liver in the body, can cause lung and prostate cancer, high blood pressure disease. In addition, cadmium can cause problems such as anemia, osteoporosis, and tooth loss [17]. Transforming the waste sludge into a form that will not harm the environment and health by taking precautions against the stated damages will enable the successful use of the waste sludge in ornamental plant cultivation [18].Using biochar can allow the use of sludge as a plant growing medium. Biological charcoal produced by burning at temperatures above 250^0C, in an airless environment or in an environment with little air, is called biochar [19]. Biochar increases plant yield and function while reducing atmospheric carbon [20]. It is thought that the use of biochar will be effective in preventing the damage caused by heavy metal pollution, which can be a great threat to living things. Studies show that biochar has high carbon stability, is a soil conditioner, has a high water holding capacity and contributes to the nutrient cycle [21, 22, 23]. The negatively charged biochar provides the retention of nutrients and water [24]. Biochar suppresses soil-borne pathogens, absorbs phytotoxic organic molecules and thus contributes to plant growth [25, 26].

The aim of the study is to eliminate the harmful effects of the waste storage sludge accumulating in the province of Tokat, which causes environmental pollution, and to ensure the use of this material as a growing medium in the ornamental plant sector, which has become an important trade area after the Second World War [27]. Since waste sludge is used without taking any precautions, it will continue to harm the environment and may cause plant death. In order to eliminate the harmful effects of waste sludge, growing media consisting of different biochar types and doses have been prepared. Calendula officinalis plant, which is included in the herbaceous ornamental plants, was used to represent ornamental plants in the prepared growing media. Calendula officinalis is a plant species belonging to the Asteraceae family. In our country, it is known by the name of Calendula. It does not grow naturally in our country. It is generally annual. As a result of the study, it was tried to determine whether the waste sludge can be used as an ornamental plant growing medium, according to the results of the observations made on the grown plants.

MATERIALS AND METHODS

The study was carried out at Gaziosmanpaşa University Agricultural Application and Research Center. When Calendula plants grown from seed have 2-3 leaves, only 1? with sludge (control) or sludge with added biochar? transferred into liter pots. In the study,

hazelnut or walnut biochar was used in two different doses (2% and 5%). The experiment was established according to the randomized plots experimental design, with 3 replications in each replication, with 3 flower pots. One plant was planted in each pot. After the waste sludge obtained from the Tokat landfill area was dried, it was sieved with a 4mm sieve and 1750 g of treatment sludge was weighed for each of the 6 numbered plastic pots. In the study, control (100% waste sludge), 98% waste sludge+2% hazelnut biochar, 98% waste sludge+2% walnut biochar, 95% waste sludge+5% hazelnut biochar, 95% waste sludge+5% hazelnut biochar constituted the trial subjects. Plants need water fairly regularly watered. The nutrient content of the waste sludge, which was not fertilized to the flowers, was used. The heavy metal content and nutrient content of the waste sludge used in the experiment are given in Table 1.

Table 1. Heavy metal and nutrient content of the waste sludge used in the study (mg/kg)

Nutritional Elements	Total concentration (mg/kg)	Concentration suitable for the plant and adequacy status for the plant (mg/kg)*
N	%0.88 (Sufficient)	
P	5732	73,4 (More)
K	4792	275 (Sufficient)
Mg	18375	1874 (More)
S	4529	2120 (Much)
Ca	58308	7845 (More)
Fe	38676	150 (Much)
Zn	189	86 (Much)
Mn	790	54,7 (Much)
Cu	161	32,2 (Much)
B	53	18,3 (More)
pH	6,70 (Nötr)	
Tuz (%)	0,306 (Medium Salty)	
Kireç (%)	6,1 (medium chalky)	
organic matter (%)	6,45 (Yüksek)	
Heavy metals		
Heavy metal	Total concentration (mg/kg)	Receivable concentration by the plant and the risk status for the plant (mg/kg)
Ni	83,5	7,12 (Risky)
Al	18545	9,86 (No risk)
Cd	1,0	0,12 (No risk)
Co	9,85	0,62 (Medium Risk)
Cr	104	0,08 (No risk)
Pb	47,7	0,64 (Medium risk)

** Sparks ve ark., 2020. Methods of soil analysis, part 3: Evaluated according to chemical methods [28]*

***86/278/EEC — It has been evaluated according to the criteria specified for soil and sludge in the Sewage Sludge Directive.*

In the production of biochar, hazelnut shells brought from Trabzon province and pruning wastes of walnut trees in Tokat Gaziosmanpaşa University were used. After drying (air dry), hazelnut shells and walnut pruning wastes were ground in 0.5 mm size and turned into biochar by applying slow pyrolysis process at 500 oC in specially prepared chrome steel containers in a muffle furnace (Figure 1 and Picture 1).

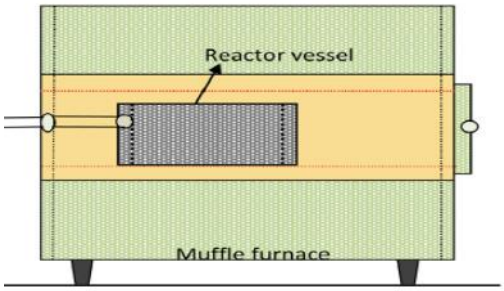

Fig. 1. *Illustration of the pyrolysis unit used in the production of biochar*

Pic 1. *The view of the specially manufactured container for the production of biochar inside the muffle furnace*

At the end of the growing season, the number of flowers per pot, flower diameter, plant height, herb weight, root length and fresh root weight were measured. The stem diameter was measured 1 or 2 cm above the soil surface, where the stem part was considered to be the thickest. In order to determine the wet root weight, the plants were removed from the soil without damaging their roots, and the remaining soil particles were cleaned, washed and dried after they were weighed.

After the obtained data were analyzed with one-way analysis of variance, the differences between the application averages were compared with the Duncan Multiple Comparison Test.

RESULTS AND DISCUSSION

In the study in which 9 plants were used for each application, four of the nine plants in the control group died. All of the plants in 9 pots with 2% walnut biochar added and in all other applications with biochar added 8 plants out of 9 grew healthily (Table 1). Both doses of biochar prepared from hazelnut shells caused a significant increase in the number of flowers. While an average of 12.2 flowers per plant was obtained from the plants in

the control pots, this value increased to 18.3% with 2% hazelnut biochar and 18.6% with 5% hazelnut biochar. It was determined that the applications containing walnut biochar did not cause a significant change in the number of flowers. When the effect of applications on flower diameter was examined, it was determined that other applications, except F5, did not have a significant effect on flower diameter. It was determined that the flowers of the plants in the F5 application were larger than the flowers of the plants in the control application. Plant height varied between 37.8 cm in the control application and 43.9 cm in the F5 application, but the differences between the applications were not statistically significant. Similarly, the treatments did not cause a significant change in root length compared to the control. Herb weight, which was 71.2 g in the control group, was measured as 84.3 g in the application of 5% walnut biochar. Other biochar applications did not cause a significant change in herba weight. The effect of only C5 application on root weight was found to be significant, and the root weight, which was 11.3 g in the control group, increased to 19.4 in 5% walnut biochar application (Table 2).

Table 2. *Effect of different biochar varieties and doses on the growth of Calendula plant grown in waste sludge*

Applications	Live Plant Rate (%)	Number of Flowers (number/plant)	Flower Diameter (cm)	Plant Height (cm)	Herba Weight (g)	Root Length (cm)	Root Weight (g)
Control	55	12.2 b	4.7 b	37.8 a	71.2 b	7.9 a	11.3 b
C2	100	15.8 ab	5.9 ab	42.3 a	74.1 b	8.5 a	16.7 ab
C5	89	13.5 b	5.8 ab	41.1 a	84.3 a	8.8 a	19.4 a
F2	89	18.3 a	5.8 ab	43.1 a	75.5 b	9.8 a	14.1 ab
F5	89	18.6 a	6.1 a	43.9 a	71.1 b	9.7 a	14.5 ab

The difference between the means with the same letter in the same column is not significant ($p<0.05$)

Although fertilization was not done, the plants showed healthy growth and development. It is thought that the reason why there is no need for fertilization is the high nutrient content of the waste sludge. Dede [29] suggested that the increase in growth and development seen in plants grown in growing media using waste sludge is due to the high nutrient content of waste sludge, especially N. Similar to the results of the study, Chaney [30] suggested that using waste sludge can meet the N and P needs of the plant. On the other hand, Logan and Chaney [31]; They reported that element deficiencies such as Cu and Zn found in long-cultivated soils [32] can be eliminated by using waste sludge.

Again, in accordance with this study, it was observed that the use of waste sludge and biochar significantly increased plant growth in the study using lettuce [33].

Pic.2. *The effect of using waste sludge and biochar on Calendula (Calendula officinalis) plant*

The fact that only 5 of the 9 plants in the control group survived and they were not as productive and healthy as the pots with biochar added, supports the view that the heavy metal concentration and phytotoxic effect in the waste sludge are high and these effects can be reduced or eliminated by using biochar. Akın and Kahraman [15] suggested that waste sludge used at high doses has a phytotoxic effect and adversely affects the plant. In this study, the fact that the plants grown in pots using biochar are healthy shows that biochar eliminates or reduces the harmful effects of waste sludge on the plant. In line with this result, Oleszcuk et al. [26] suggested that the harmful effects of sludge can be reduced or eliminated by using biochar. In a study using wheat plant, it was observed that biochar applications were effective in reducing the Cd concentration in the plant [34].

CONCLUSION

As a result of the study, it was concluded that the sewage sludge has the potential to be used in ornamental plants cultivation together with biochar applications. The data obtained show that the harmful effects of sludge can be reduced or eliminated by using biochar. It will be a big step for sustainability to remove the harmful effects of waste sludge, which causes environmental pollution and accumulates day by day, by adding biochar. In addition, the use of waste sludge instead of peat, which is used as a growing medium, which is harmful to the environment and has a high cost, will both be a beneficial solution for the environment and make an economic contribution to the country. In addition, the use of sewage sludge as an ornamental plant growth medium will enable the material that poses a threat to the environment to be transformed into a useful material by removing its harmful effects. According to the results obtained in the study, it should be noted that different types and doses of biochars may have different effects on different plants.

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