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EFFECTS OF BIOCHAR ON THE POLLUTED HEAVY METALS LEACHED CHERNOZEM SOIL

Abstract. In a 40-day laboratory experiment, a study was conducted of the effect of biochar on the properties of leached chernozem soil contaminated with heavy metals. Biochar exhibits a great potential to efficiently tackle soil contaminants considering the wide availability of feedstock, low-cost and favorable physical/chemical surface characteristics. The well-distributed pore network that includes micropores <2 nm, mesopores 2-50 nm and macropores >50 nm. It is established that the introduction of biochar led to an increase in NPK, a decrease in the content of heavy metals Zn and Pb in the soil. It is shown that the introduction of 2% biochar positively affects the growth of vegetation and seed germination in quantity increases 31 to 58 seeds.

Keywords: biochar, leached chernozem, humus, mobile phosphorus, total nitrogen, exchange potassium.

Introduction. The presence of excessive metal contents in soils may have serious consequences for surrounding ecosystems, groundwater, agricultural productivity and human health [1]. The emergence of new concepts and requirements in the sustainable development of the world economy could not but affect such an important sector as agriculture, which directly depends on nature and causes no small environmental damage [2]. The restoration of hazardous soils is thus essential. Conventional remediation techniques (e.g. excavation, landfilling, soil washing) are nowadays recognized as inappropriate because they generate considerable disturbance in the environment and they are economically unfeasible on a large scale. The restoration of hazardous soils is thus essential. Conventional remediation techniques (e.g. excavation, landfilling, soil washing) are nowadays recognized as inappropriate because they generate considerable disturbance in the environment and they are economically unfeasible on a large scale. An alternative technique consists in introducing in situ amendments into the contaminated soils in order to reduce the metal mobility while simultaneously creating conditions that promote plant growth. This technique has received a growing interest and is turning out to be a promising green and cost-effective alternative for soil remediation [3-6]. Thus, the natural growth of plants in technogenic landscapes, regardless of the climatic zone, the type of damage and the types of discoveries, is accompanied by slow growth and the plant cannot regenerate naturally [7].

Among the methods, biosorption technique is the most common and costeffective. This is because biosorbents are environmentally friendly and readily available in large quantities, and one of the most popular biosorbents is biochar. Biochar is a carbon-rich, fine-grained, and porous material. It has received increasing attention due to its ability to store large amount of carbon, increase crop yield, reduce soil emission of greenhouse gases, improve soil quality, decrease nutrient leaching, and reduce irrigation and fertilizer requirements [8-10].

As far as the former application is concerned, biochar has demonstrated to be able to improve soil properties [11, 12] as well as to reduce contaminant leaching [13, 14]. As adsorbent, it represents a more economically and environmentally sustainable alternative to commercial media because its use allows to avoid industrial activities for adsorbent production as well as to reuse a waste that alternatively would need to be disposed of. As adsorbent, biochar can be applied to water and wastewater treatment, for a wide range of pollutants such as lead arsenic, copper, cadmium, chromium, mercury, zinc and nickel [15-17]. Biochar, which can be applied to contaminated soils to reduce metals mobilization. Indeed, heavy metals become bound to carbonates and organic matter after biochar incorporation, which enhances the adsorption process due to metals building bonds with oxygen, carbon and nitrogen containing functional groups [18-20].

Quality and properties of biochar depend on many factors [21]; it is essential to identify characteristics of this adsorbent to predict its effectiveness towards the target contaminant. Many biochars have a high adsorption capacity for metal contaminants because of the high heterogeneous specific surface [22] and the well-distributed pore network that includes micropores (<2 nm), mesopores (2-50 nm) and macropores (> 50 nm) [23].

Material and methods. *Soil sampling and characterization.* The objects of study was leached black soil contaminated with heavy metals from emissions from the zinc plant of the Ridder city, East Kazakhstan region. Soil samples were collected from 0 to 30 cm depth [24]. When dry samples were homogenised and sieved (<2 mm). In soil samples, total nitrogen, mobile phosphorus (P_2O_5) and exchange potassium (K_2O) [25], the pH of the aqueous extract [26], the humus content according to generally accepted methods [27], Zn and Pb by atomic absorption spectroscopy were determined [28].

Production and characterization of biochar. Biochar was produced from rice husk which is an abundantly available agri-food residue in Kazakhstan. Then it was placed in a reactor to prevent O_2 input. The reactor furnace was heated at a rate of 50 cm^3/min up to 650ºC. The temperature was held for about one hour and subsequently cooled slowly to room temperature.

Results and discussion. The results of polluted soil sample analyses: pH-7.85; humus content 5.31%; total nitrogen 0,120%; mobile phosphorus (P_2O_5) 35 mg/kg; exchange (K_2O) 433.8 mg/kg; zinc 8804.84 mg/kg; lead 429.2 mg/kg. Our data shows that heavy metals Pb and Zn exceed the MPC.

To obtain biochar, rice husk was used (Bakanas, Almaty region), which is a renewable waste of plant origin. In order to extract the powdered remains of rice, the husk was washed with water and dried in a drying cabinet at a temperature of 120°C. Next, the husk was carbonized in a laboratory reactor [28] at a temperature of 650°C for one hour in an inert atmosphere of Ar flow. Quality and properties of biochar depend on many factors [15] it is essential to identify characteristics of this adsorbent to predict its effectiveness towards the target contaminant. We studied biochar with a particle size of not more than 1 cm, obtained from rice husk. The resulting biochar had the following properties: humidity - 1.7%, carbon - 39.98%, oxygen - 34.53%, silicon - 25.49%. In the experiment used the original soil and soil, which made biochar. Biochar properties vary considerably with feedstock material and pyrolysis temperature, with high temperature producing biochars with higher surface area, porosity, mineral contents, but less functional groups. To determine the effectiveness of the biochar obtained by us, 0.5%, 1%, and 2% of biochar were added to the soil; also a control sample of soil without biochar was prepared. There were 3 replicates for each group. Samples were kept under static conditions at room temperature (21±10°C). After a 40-day incubation period in the soil of biochar, the chemical and physical properties of the soil changed: humus 5.31% decreased to 4.20%. With the introduction of 2% biochar after a 40-day incubation period in soil pH 7.85 to 6.56, the content of exchangeable potassium (K_2O) increases significantly - 433.8 mg/kg to 589.8 mg/kg, mobile phosphorus (P_2O_5) - 35 mg/kg to 48.40 mg/kg, nitrogen 0.120% to 0.130% increased by comparison in the control variants of the experiment. These changes are due to the adsorption capacity of biochar, as well as a decrease in the alkalinity of the studied soil, which has led to an increase in the availability of substances for plants. This indicates a long-term positive effect of the use of biochar. And the content of zinc heavy metals is from 8804.84 mg/kg to 6000,5 mg/kg and lead from 429.2 mg/kg to 129.3 mg/kg.

Additionally, biomass and growth were determined, the time of death of «Aray» plant wheat plants on leached chernozem soil contaminated with heavy metals. Seeds were planted vessels, each of which contained 300 g of soil with different content of biochar - 0.5%, 1%, 2%. Soil without biochar was used as a control. Wheat seeds before sowing were calibrated, and defective ones were removed. Sowing was carried out in a moist soil at the rate of 80 seeds per vessel. None mineral or organic fertilizer was applied.

In controlled conditions: the temperature is 23-25 °C, the light period is 14\10 h (day\night) and the soil humidity is 50% of the total moisture capacity of the soil. 14 days after sowing, wheat shoots are observed.

After 25 days on the studied vessels, the grown wheat differed in the amount of each other. As can be seen in Figure 1, out of 80 wheat seeds in the control soil, 31 wheat seeds grew, and 58% of wheat seeds grew in 2% of biochar. This suggests that biochar affects vegetation growth (figure 1).

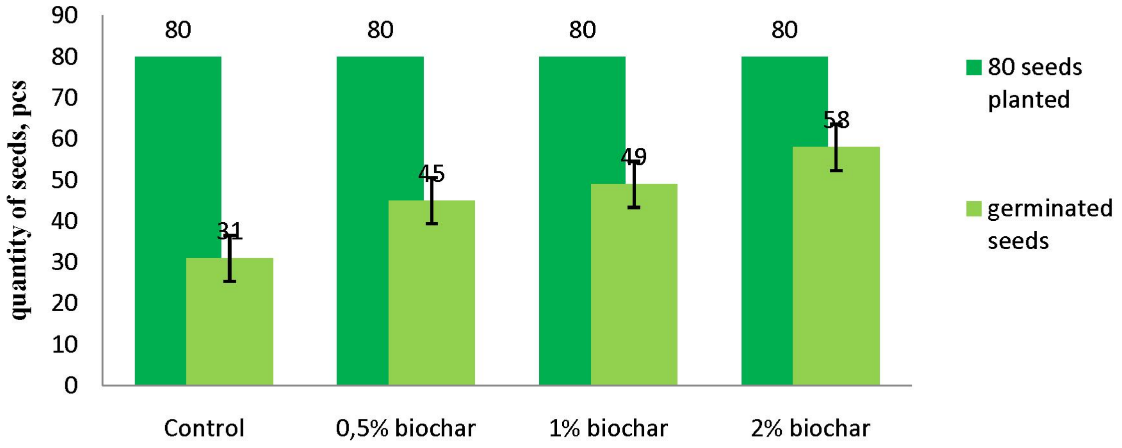

Figure 1 – The effect of biochar for wheat seedlings

The average length of the roots of wheat on the 25th day of the experiment was 1.5 cm for the control variant. The introduction of biochar into the soil led to a significant ($p<0.05$) increase in the length of wheat roots by an average of 2.6 times as compared with the control variant (figure 2).

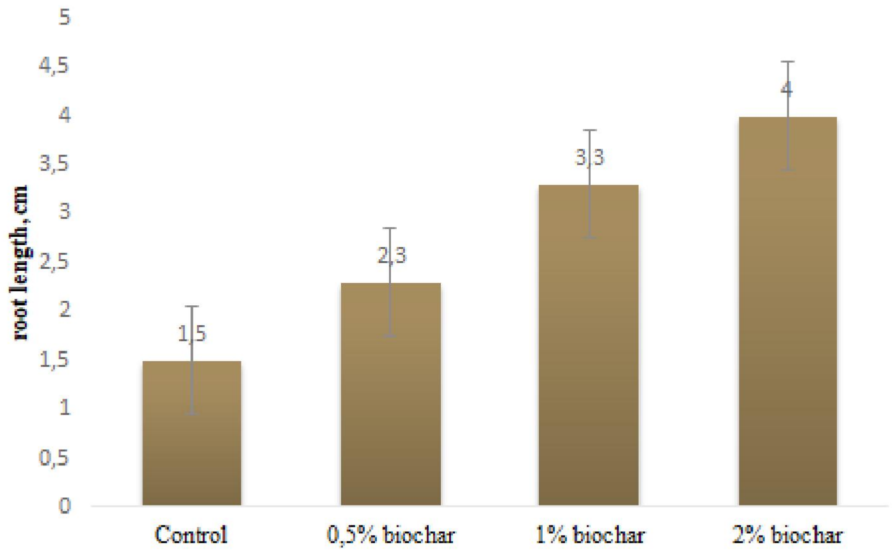

Figure 2 – The average length of the roots of wheat

Conclusion. The results of the study showed that the introduction of biochar led to an increase in the mobile phosphorus (P_2O_5) - 35 mg/kg to 48.40%, in soil pH 7.85 to 6.56, the content of exchangeable potassium (K_2O) increases significantly - 433.8 mg/kg to 589.8 mg/kg, nitrogen 0.120% to 0.130% increased by comparison in the control variants of the experiment. The content of heavy metals in the soil

after the introduction of biochar of zinc reduces from 8804.84 mg/kg to 6000.5 mg/kg, and lead - from 429.2 mg/kg to 129.3 mg/kg. Adding 2% biochar to the soil shows that it improves wheat growth. In the study of the germination of wheat seeds with 2% biochar increased the number from 31 to 58 seeds. The introduction of biochar into the soil led to a significant ($p<0.05$) increase in the length of wheat roots by an average of 2.6 times as compared with the control variant.

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АУЫР МЕТАЛДАРМЕН ЛАСТАНҒАН СІЛТІСІЗДЕНГЕН ҚАРА ТОПЫРАҚҚА БИОКӨМІРДІҢ ӘСЕРІ

Аннотация. 40 күндік лабораториялық экспериментте ауыр металдармен ластанған сілтісізденген қара топырақтың қасиетіне биокөмірдің әсері. Биокөмір шикізатының қол жетімділігін ескере отырып, шығыны төмен, беттік ауданының физика-химиялық қасиетінің қолайлы болуы себебінен топырақты ластаушы заттармен эффективті күресуде үлкен мүмкіндікке ие. Кеуекті торларының жақсы жетілгендігі, микрокеуек <2 нм, мезокеуекті 2-50 нм және макрокеуекті >50 нм. Биокөмірді топыраққа қосқанда NPK жоғарылап, ауыр металдар Zn және Pb төмендеуі анықталды. 2% биокөмірді топыраққа қосқанда өсімдіктердің өсуіне оңтайлы әсер етіп және тұқымның өңгіштік саны 31-ден 58 тұқымға дейін артты.

Түйін сөздер: биокөмір, сілтісізденген қара топырақ, гумус, жылжымалы фосфор, жалпы азот, алмаспалы калий.

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ВЛИЯНИЕ БИОУГЛЯ НА ЗАГРЯЗНЕННОЙ ТЯЖЕЛЫМИ МЕТАЛЛАМИ ЧЕРНОЗЕМ ВЫЩЕЛОЧЕННОЙ ПОЧВЫ

Аннотация. В 40-суточном лабораторном эксперименте провели исследование влияние биоугля на свойства чернозем выщелоченной почвы, загрязненного тяжелыми металлами. Биоуголь обладает огромным потенциалом для эффективной борьбы с загрязнителями почвы, учитывая широкую доступность сырья, низкую стоимость и поверхность благоприятные физико-химические характеристики. Хорошо распределенная сеть пор, которая включает микропоры <2 нм, мезопоры 2-50 нм и макропоры >50 нм. Установленно, что внесение биоугля привело увеличению NPK, снижение тяжелых металлов Zn и Pb в почве. Показано, что внесение 2% биоугля положительно влияет на рост растительности и всхожесть семян по количеству увеличивается 31 до 58 семян.

Ключевые слова: биоуголь, чернозем выщелоченный, гумус, подвижный фосфор, общий азот, обменный калий.

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