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Ecology

Improving Soil Quality Contaminated by Household Waste through Phytoremediation

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Abstract. Uncontrolled landfills contaminated with household waste can be found near settlements or in river valleys. These sites accumulate various types of waste, including construction, household, pesticides, etc. Such uncontrolled landfill can be found in the Aragvi River valley, near the village of Natakhtari. The research aims to identify the contaminants present in the soil and plant species for phytoremediation methods. The landfill soil samples contained heavy metals such as lead, zinc, manganese, and copper. The data collected from the baseline point (the bank of the Aragvi River) show that these metals are uncommon in the study area. The soil from the landfill's inner territory contained 2.7 times more lead than the soil sample from the baseline point and exceeded the reference permissible concentration (RPC) by 2.5 times. The manganese content in the landfill soil exceeded the baseline level by 2.5 times. The water channel that runs through the landfill was as heavily contaminated as the landfill itself. Microbiological analysis was carried out at two different points along the water channel. Bacterial levels in the water before the landfill were normal, but after passing through the landfill contained high concentration of *Escherichia coli*, coliform bacteria, and streptococci. Four annual plants carrots, beets, lettuce, and wheat were selected for phytoremediation. In the first stage of the experiment, they were planted directly on the landfill. In the second and third stages, they were sown in soils with high concentrations of lead and copper. It was discovered that all of these plants absorbed various metals to some extent. However, in the presence of high heavy metal concentrations, carrots and beets demonstrated the highest phytoremediation ability. The collected data were analyzed using mathematical and statistical methods, which confirmed the experimental findings. Carrots, beets, wheat, and lettuce were found to be effective in removing heavy metals from the soil.

Keywords: heavy metals, phytoremediation, waste

Introduction

As part of this research, we chose a natural landfill in the Aragvi River valley where various types of waste are deposited. They pollute the soil, air, and water that pass through the landfill. Soil and water samples were collected from the landfill. Heavy metals (lead, copper, manganese, and zinc) were found in the soil, and water contained *Escherichia coli*, fecal streptococci, and total coliform bacteria [1-3]. For soil remediation, we chose phytoreme-

diation, which involves cleaning the soil and water with plants.

Materials and Methods

We used atomic absorption spectrometry (AAS) to determine the amount of heavy metals in soil samples from the landfill and plants used in phytoremediation in the laboratory [4].

The first stage involved determining the concentrations of heavy metals (Pb, Cd, Mn, Cu, and Zn) in the soil of the waste disposal area. We also collected samples from the surrounding area and a baseline point on the banks of the Aragvi River. We compared the analysis results to the reference permissible concentrations (RPC) and indicative permissible concentrations (IPC) of each component.

Results

The lead content in soil analysis samples from the domestic waste disposal site (internal area) was found to be 2.7 times higher than those taken from the baseline point and 2.5 times higher than the reference permissible concentration (RPC). The lead content of a soil sample collected from the surrounding area was found to be 1.9 times higher than the reference permissible concentration and twice as high as the baseline point. The manganese content in the soil at the waste disposal site, both in the center and in the surrounding area, varies within the reference permissible concentrations and is approximately 2.5 times higher than the baseline point value. It should be noted that the cadmium, copper, and zinc levels are within normal limits [5, 6].

We analyzed the data from soil samples using mathematical (statistical) methods. The median of the data everywhere was consistent with the results of samples taken from the surrounding area. Lead: 61.6 mg/kg; manganese: 1330 mg/kg; copper: 41.9 mg/kg; zinc: 183.3 mg/kg. It was clearly demonstrated that heavy metal indicators decreased from the inner area to the baseline point.

Based on the soil sample data, manganese had the greatest range of dispersion (1520.2 - 520 = 1000.2 mg/kg), while copper showed the smallest range (66.4 - 31.2 = 35.2 mg/kg). Copper values are close to each other at all three points, whereas manganese is distributed from the inner to the outer areas. The standard deviation for all metals is comparable to the absolute deviations for the landfill's inner area (manganese – 443 mg/kg; copper – 14 mg/kg; zinc – 46 mg/kg; lead – 21 mg/kg).

Based on the mathematical analysis of the samples collected from the household waste disposal site, it can be concluded that all heavy metals are primarily concentrated in the inner area waste disposal site's, where the source of contamination is located. They extended from the inner area to the background point. None of their indicators exceed the dispersion range's permissible limit. This method can be applied to other household waste disposal sites, allowing us to accurately identify the source of contamination.

Cleaning the soil contaminated with toxic elements has always been a relevant and significant challenge for all countries around the world. To address this issue, a variety of modern methods are employed, including a highly promising phytoremediation method. For field application of this method, we selected annual plants such as beets, carrots, wheat, and lettuce, which were sown at the waste disposal site (after cleaning) and chemically analyzed after 2.5 months to determine their ability to absorb heavy metals from the soil. The plants were chosen based on the following criteria: they are annuals that grow quickly, they can germinate in all climatic conditions of Georgia and their root systems do not reach a depth of 60 cm, at which heavy metals accumulate. It turned out that every plant absorbs some amount of one or more heavy metals. Carrots were particularly effective at absorbing lead and manganese (28.9% and 25%, respectively). Zinc was absorbed by wheat and beets (41%), while copper was absorbed by all

plants in roughly equal amounts ranging from 19% to 27% [7].

The following model experiment was carried out with copper. Since it was absorbed equally by all plants, we added varying amounts of copper sulfate (90 and 180 g) to the test soil to determine the plant's ability to absorb it at higher levels.

The average data for all plants are as follows: carrot – 4229 mg/kg; wheat – 747.28 mg/kg; beet – 1112.6 mg/kg. The square deviations for carrot were 5963 mg/kg, for wheat 795 mg/kg, and for beet 1025 mg/kg.

We can conclude that carrot is the best plant for phytoremediation of the heavy metal copper, which is supported by the mathematical and statistical analysis of the obtained results.

A similar study was conducted with lead and the findings indicate that beet is the most suitable plant for phytoremediation of lead from soil, which is also supported by its mathematical properties.

Conclusion

The study revealed that household waste contaminates soil with heavy metals and water with bacteria. Carrots, beets, lettuce, and wheat demonstrated potential for phytoremediation of contaminated soil, and mathematical and statistical characteristics confirmed the validity of the experiments.

ეკოლოგია

საყოფაცხოვრებო ნარჩენების შედეგად დაბინძურებული ნიადაგის ხარისხის გაუმჯობესება ფიტორემედიაციის მეთოდით

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(წარმოდგენილია აკადემიის წევრის გ. კვესიტაძის მიერ)

საყოფაცხოვრებო ნარჩენებით დაბინძურებული არაკონტროლირებადი ნაგავსაყრელები ძირითადად მდინარეთა ხეობებში ან დასახლებული პუნქტების მახლობლად მდებარეობს, სადაც თავმოყრილია ყველა ტიპის ნარჩენი, სამშენებლო, საყოფაცხოვრებო, პესტიციდი და სხვა. ასეთი ტიპის არაკონტროლირებადი ნაგავსაყრელი მდინარე არაგვის ხეობაში, სოფელ ნატახტართან მდებარეობს. კვლევის მიზანს წარმოადგენს ნიადაგში დამაბინძურებელი ელემენტებისა და მცენარეების შესწავლა ფიტორემედიაციული მეთოდით. ნაგავსაყრელის ნიადაგის სინჯებში აღმოჩნდა მძიმე მეტალები: ტყვია, თუთია, მანგანუმი და სპილენძი. ეს მეტა-

ლები საკვლევი ტერიტორიისთვის დამახასიათებელი არ არის, რასაც მოწმობს ფონური წერტილიდან (მდ. არაგვის ნაპირი) აღებული მონაცემები. ნაგავსაყრელის შიდა ტერიტორიაზე აღებულ ნიადაგში ტყვიის შემცველობა 2,7-ჯერ მეტია, ვიდრე ფონური წერტილიდან აღებულ ნიმუშში. ხოლო 2,5-ჯერ სჭარბობს ზღვრულად დასაშვებ კონცენტრაციას. მანგანუმის შემცველობამ ნაგავსაყრელის ტერიტორიაზე 2,5-ჯერ გადააჭარბა ფონური წერტილის მაჩვენებელს. ნარჩენებით არის დაბინძურებული ნაგავსაყრელზე გამავალი წყლის არხი. წყლის არხში ჩატარდა მიკრობიოლოგიური ანალიზი, მასში აღმოჩნდა ეშერიხია კოლის, კოლიფორმული ბაქტერიების და სტრეპტოკოკების დიდი რაოდენობა. ფიტორემედიაციისთვის შეირჩა ოთხი ერთწლოვანი მცენარე: სტაფილო, ჭარხალი, სალათა და ხორბალი. ექსპერიმენტის პირველ ეტაპზე ისინი დაითესა უშუალოდ ნაგავსაყრელზე. მეორე და მესამე ეტაპზე – ტყვიით და სპილენძით გამდიდრებულ ნაიადაგებში. აღმოჩნდა, რომ ყველა ეს მცენარე გარკვეული რაოდენობით ითვისებს სხვადასხვა მეტალს, თუმცა მძიმე მეტალების გაზრდილი კონცენტრაციების შემთხვევაში, ყველაზე ძლიერი ფიტორემედიაციული უნარი გააჩნია სტაფილოს და ჭარხალს. მიღებული მონაცემები დამუშავდა მათემატიკურ-სტატისტიკური მახასიათებლებით. მიღებულმა შედეგებმა გაამყარა ექსპერიმენტის შედეგები. დადგინდა, რომ ნიადაგიდან მძიმე მეტალების ამოსაღებად შესაძლებელია გამოყენებული იყოს სტაფილო, ჭარხალი, ხორბალი და სალათა.

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