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Characteristics of fabricated soil for landscape rehabilitation: The four crop test for biological activity

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Abstract

Fabricated soil (FS) is a mixture of substrates containing balanced amounts of carbon, nitrogen, phosphorus, potassium and mineral elements that support plant growth. In our experiments, we use FS for the rehabilitation of land from mining soil pollutants. Characteristics of fabricated soil were determined including measurements of N, P, K; other nutritive elements including Mg, Ca, S, and Fe; and micro-elements and toxic elements including Mn, Zn, Al, Ni, and Pb. Also, microbial activity of the soil was tested to determine fungal and bacterial presence. After investigating these soil characteristics, we used a four-crop test to investigate fabricated soils and related substrates for biological activity. Soil health includes a balance of mineral and organic elements and healthy microbial activity. These characteristics play the key role in the soil's ability to support the growth of higher plants which complete the regenerative process of soil cycling. Healthy soils provide materials for food, energy, and shelter. Healthy soils are crucial to all biological, geological, and water cycles.

Key words: Fabricated soil, four-crop test

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Introduction

The present study is a continuation of research at the Center of Restoration of Biological Cycles which is located in Jennings Environmental Education Center, Slippery Rock, PA. At the Center, mining site restoration is the focus for integrative studies of regeneration of water and soil cycles as well as shelter construction. As part of the study of soil restoration in mine damaged areas, native soil profiles were studied for Western Pennsylvania Gresham Soil (Kefeli et *al.,* 2006). Soils were then fabricated and observed for qualities necessary to restore mine damaged areas. Native and fabricated soils were analyzed for mineral and organic content and microbial activity. The four crop test was done to determine the ability of the various soils to support plant growth.

The ability for soils to support life depends on the availability of nutritive macro- and micro-elements and also on protection from toxic elements. The presence of fungi and bacteria is an indicator of soil health. These organisms play important roles in the sustainability of soils and the soil's relationship with the plants it supports. Previous work by Kefeli *et al.* (2006) analyzed soil for microbial activity and elemental concentrations. These studies compared fabricated, forest, and mining soil samples. In addition, these studies revealed changes over the course of five years in levels of nutritive elements in fabricated soils.

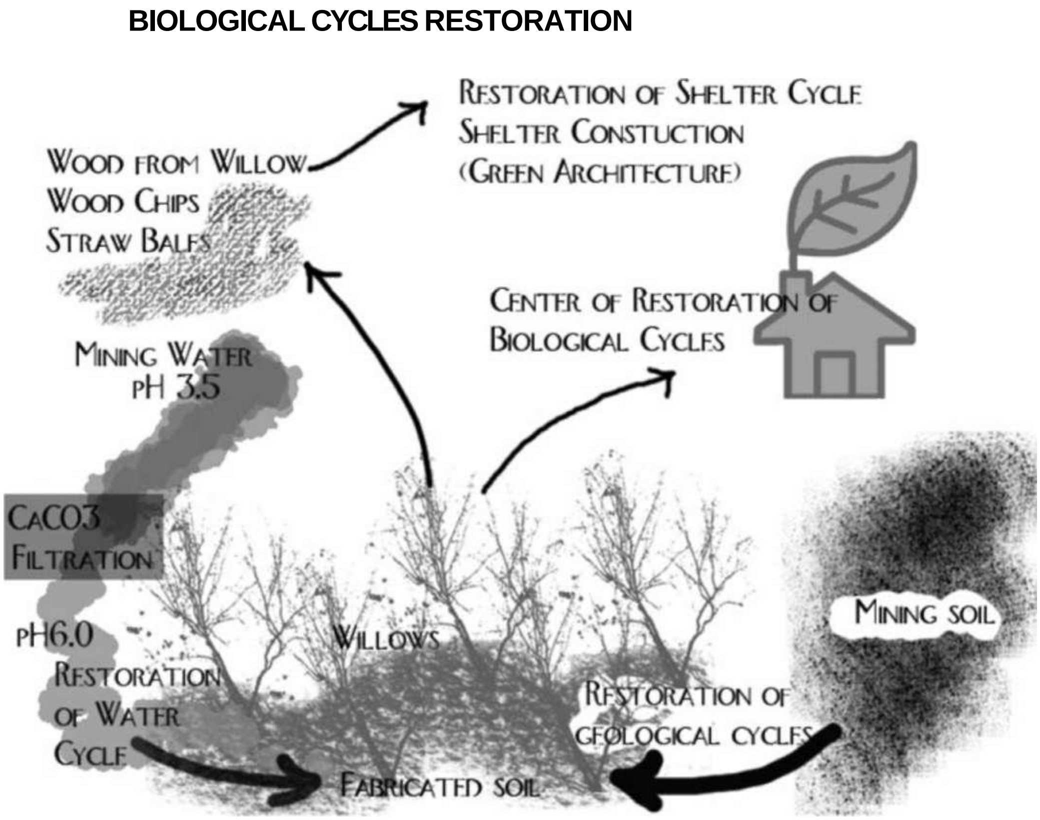

Figure 1. The Center of Restoration of Biological Cycles restores soil, water, and shelter cycles.

Materials and methods

Four crop test

First we determined the most appropriate vessel choice for our experiment with a preliminary experiment using Koch dishes, Petri dishes, and flasks. The Koch dishes had nearly 100 % germination rate. We did the four crop test in both Koch dishes and Petri dishes. A circle of filter paper was placed in the bottom of each dish. On top of the paper a Styrofoam cross was placed to divide the four varieties of seeds. Soil was placed in the dishes. Each container received 20 ml of sink water which measured a pH of 6.55. One variety of seed was placed in each quadrant of the dishes. We used turnip, lettuce, rye, and clover to determine the ability of the soils to support plant growth. The soils were forest soil, restored soil from the DeSale restoration site, fabricated soil from the Jennings restoration site, and mining soil. After one week, the five longest shoots of each seed variety were measured and averaged. A percentage was determined based on the growth of the seedlings on the forest soil.

Observations

The seedlings in the Koch dishes had nearly 100 % germination. The Petri dishes dried out, decreasing germination and growth. However, the mining soil in the Petri dish remained wet and grew mold. The seedlings grew successfully in the Koch dishes. Compared to the forest soils as controls, the seedling growth in the other soils varied from 76 % to 114 %. The exception to this is the mining soil which had a pH of 4.3, significantly lower than the other samples which averaged 6.7. The growth rates in the mining soil ranged from 13 % to 40 % compared with the control averages.

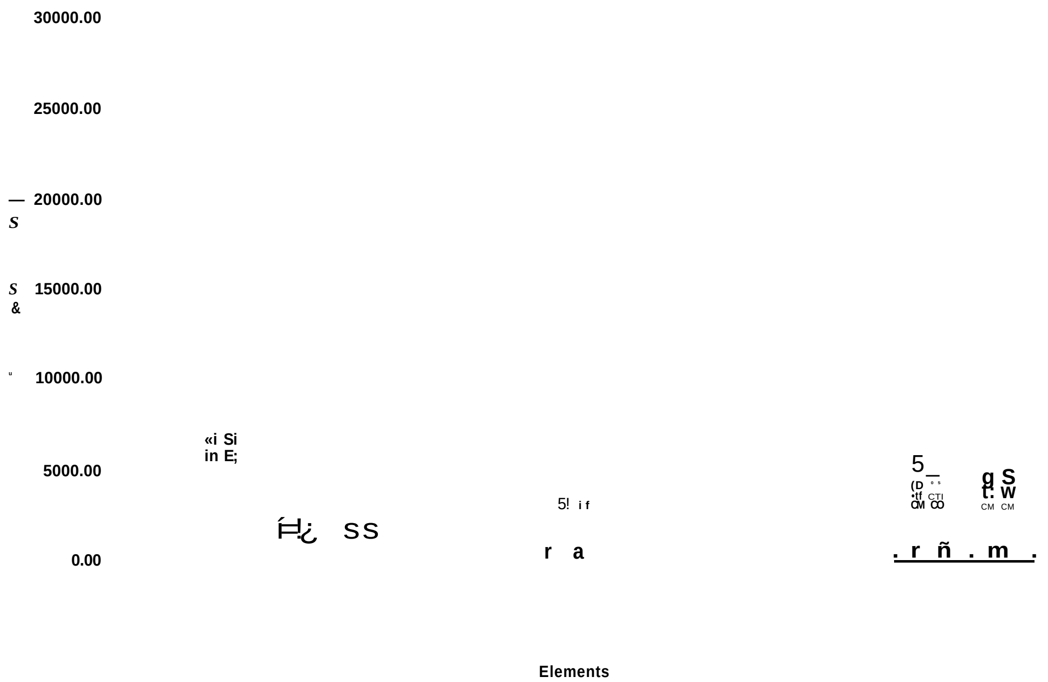

Figure 2. Forest Soil 2cc7, Chestnut Project.

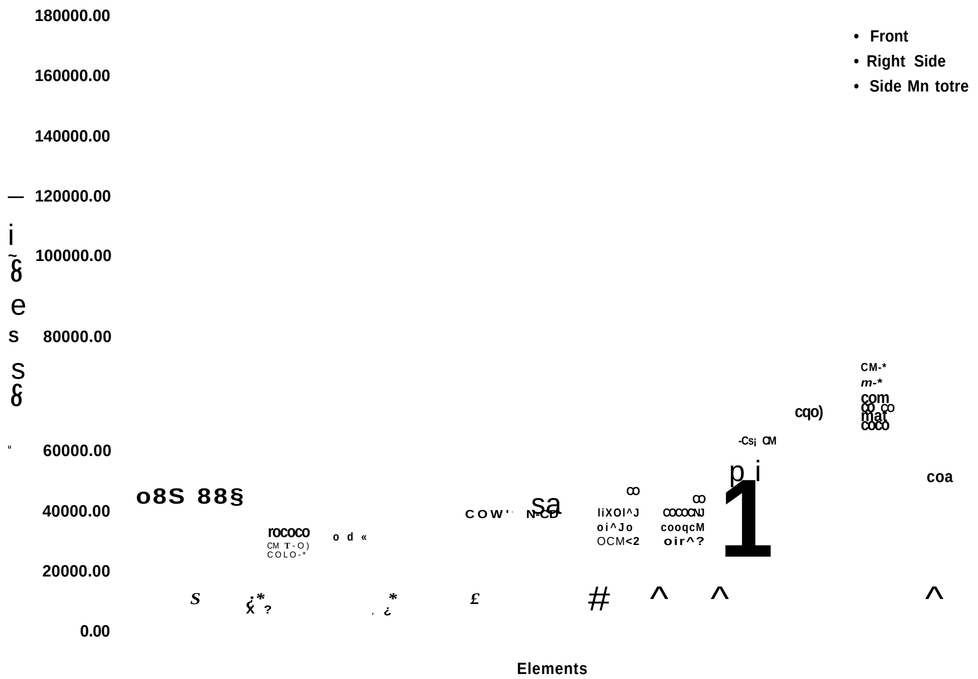

Figure 3. De Sale 2cc7

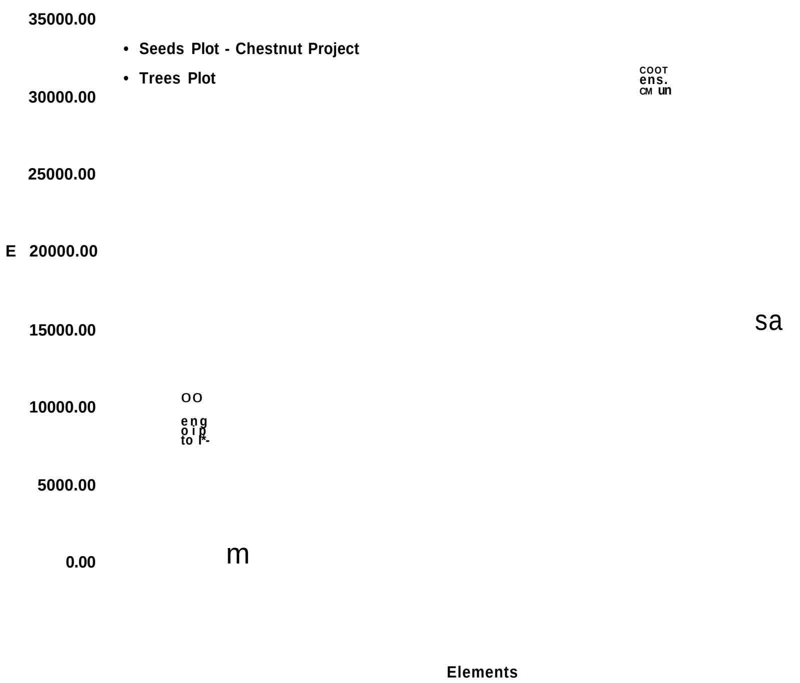

Figure 4. Fabricated Soil 2007.

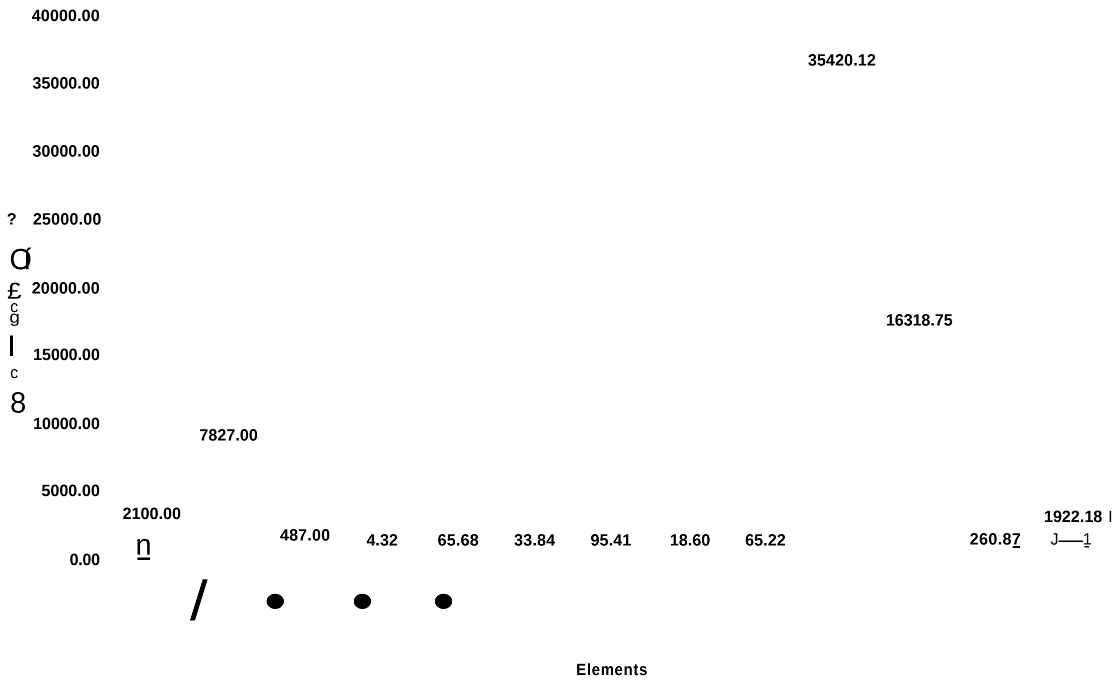

Figure S. Mining Soil 2007

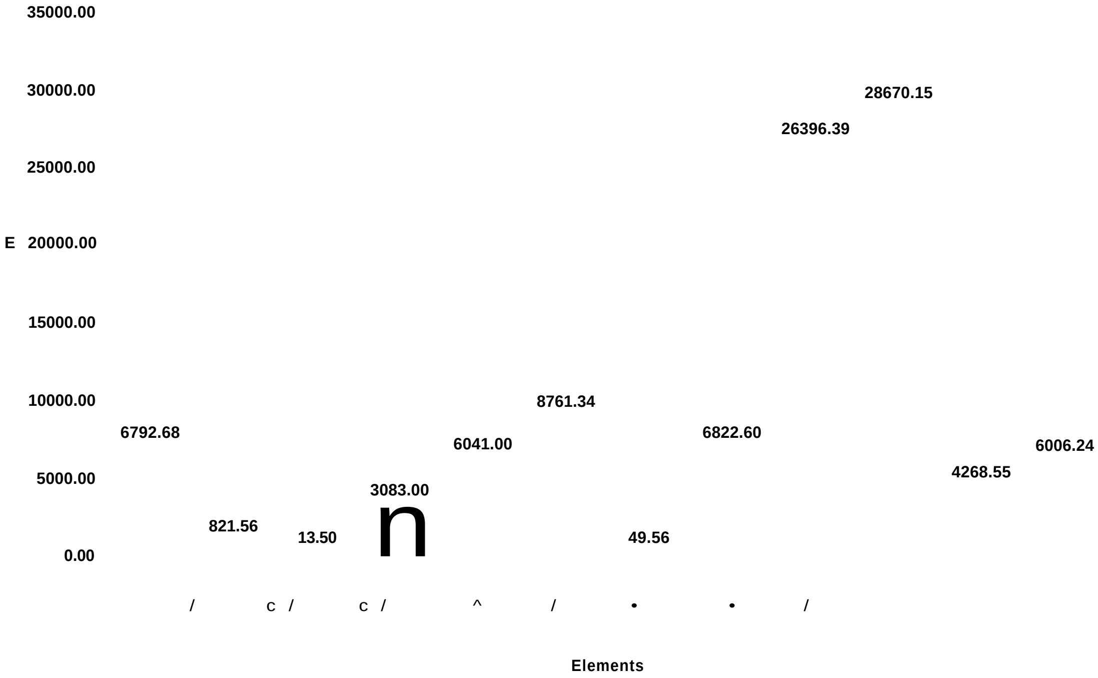

Figure 6. Montana Soil standart (Conti).

Figure 7. Petri dish, Koch dish, and flask with turnip, lettuce, dill, and clover seeds.

Table 1. Comparative growth of turnip, lettuce, rye, and clover in various soils in Koch dishes. Numbers represent average length of shoots in centimeters. Percentages are measured from the average of the forest soils as 100 %.

FOUR-CROP TEST IN KOCH DISHES					
SAMPLES	**pH**	**CROPS**			
		Turnip	Lettuce	Rye	Clover
1. Forest Soil	pH 6.5	5.2	4.1	8.1	4.7
Chestnut Project One					
2. Forest Soil	pH 6.4	4.6	3.5	7.9	4
Chestnut Project Two					
Avg. Forest Soil		4.9 = 100 %	3.8 = 100 %	8.0 = 100 %	4.4 = 100 %
3. De Sale Front (%)	pH 6.6	5	3.1	8.9	4.3
		102	98	111	97
4. De Sale Right (%)	pH 6.7	4.6	3.3	7.6	5
		94	87	95	114
5. FS Seed Plot	pH 6.8	4.2	3	8.2	3.6
Chestnut Project (%)					
		86	79	102	82
6. FS Trees plot (%)	pH 6.8	4.9	2.9	7.3	4.5
		100	76	91	102
7. De Sale Mn (%)	pH 6.7	4.8	3	7.4	4.8
		98	79	93	109
8. Mining Soil (%)	pH 4.3	1.9	0.5	2.7	1.8
		39	13	34	40

Results

The mining soil contains less nitrogen in comparison with the fabricated soil. The Phosphorus level was four times less in the mining soil than in the fabricated soil (FS). Potassium level was similar. Mining soil contains much less Ca and Mg than FS.

The dynamics of change of these elements shows that FS, in five years, lost part of its Phosphorus pool and Ca pool. The level of K remained almost the same. At the same time, mining soil also lost part of its Ca, K, Mn, and P.

The microbial analytics show that mining soil contains fewer microbes than FS. The mining soil contains only four types of microbes while the FS has ten species. The microbial count for FS is 76-82 x10^6 Count Fungi Units (CFU)/gram. Mining soil has only 3,600 CFU/gram, significantly fewer than in the FS. Mining soil has mostly unidentified actinomycetes. No actinomycetes were found in FS. FS is also richer in microorganisms than forest soil.

The experiment for biological activity, the four crop test, shows that mining soil is toxic for crops. It has lower pH than other types of soil. Thus FS not only creates a new landscape rehabilitation system, but also improves the pattern of mineral elements, microelements, and microbial community. In addition, fabricated soil creates a better medium for plant propagation.

The elemental analysis shows that during the five years presence of FS on mining soil, the level of nutritive elements changed. The amount of P decreased five times. Mg decreased three times. Copper decreased two times. Co and Zn decreased by twenty times. This may be connected with the activity of trees growing on FS. In five years, FS greatly decreased in nutritive elements, requiring additional nutrients.

Conclusions

The simple four-crop test is one step in the process of discovering ways to restore soils. It clearly demonstrates the inferiority of mining soil for growth of plants. The pH is obviously the most inhibiting factor for plant growth. In addition, the lack of organic material and the lack of microbial activity decrease the soil's health and ability to support life on all levels. The fabricated soils act as a temporary measure to grow plant materials. However, the decrease in nutritive elements reveals the need for continuous soil rehabilitation and a sustainable system for regenerating nutritive elements and organic materials. Perhaps the most significant results of these studies is the generation of questions. For example, what causes the decrease in many elements, and how can these elements be sustained without non-local inputs?

References

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