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HUMUS: pozabljen odgovor za klimatske spremembe in trajnostno kmetijstvo

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Izvleček
Do nedavnega so bili organski odpadki obravnavani kot nekaj česar se želimo znebiti po najnižji možni ceni. Počasi prihaja do spremembe paradigme, kjer se spoznava vrednost in potencial organskih snovi. Organski odpadki se lahko kompostirajo in z nekaj znanja lahko pridobimo humus. Ker lahko prst shrani dvakrat toliko ogljika, kot ga je v zraku, tla predstavljajo zelo pomemben rezervoar ogljika. S stabilizacijo ogljika iz organskih odpadkov in vrnitvijo tega nazaj v prst lahko dosežemo velik prispevek pri zmanjševanju CO_2 bremena. Arheologi so na nekaterih območjih našli izjemno rodno in stabilno humusno prst in če postopek kompostiranja pravilno usmerjamo lahko nastane stabilen in bogat kompost, ki lahko služi kot izjemno organsko gnojilo. Ta vrsta bogatitve tal ima nešteto prednosti prej običajnimi mineralnimi gnojili. Raziskave so že pokazale prve smernice, kako voditi proces kompostiranja, da pride do nastanka izredno rodovitne zemlje, podobne terra preta iz Amazonije. V Zelenem rudniku smo do sedaj kompostirali po uveljavljenih postopkih, vendar želimo sodobna spoznanja iz raziskav terra prete vključiti v proces kompostiranja. Ugotovili so, je prisotnost mineralne moke in oglja bistvenega pomena pri razvoju izjemno rodovitne prsti. Mineralna moka nudi mikronutriente in skupaj z drugimi sestavinami prsti tvori rodovitne kompozite. Olje pa nudi izjemno veliko površino na tvorbo novih habitatov za mikroorganizme in tako omogoči razmnoževanje koristnih mikrobov, ki so ključni za tvorbo rodovitne prsti. Prihodnost kompostiranja vidimo kot izjemno priložnost, da ustvarimo trajno rodovitno prst, ki bo obogatila in obnovila zdaj že izčrpane pridelovalne površine, hkrati pa fiksirala ogljik iz zraka in tako prispevala k varovanju podnebja.

Ključne besede: humus, terra preta, ogljik

HUMUS: the forgoten answer to climate protection and sustainable farming

Abstract
Until recently organic waste was viewed as something we must get rid of at the lowest possible cost. Now slowly the paradigm is shifting and the value and potential of organic matter is being recognised. Organic waste can be composted and with some knowledge a humus rich soil can be produced. Since soil can store twice as much carbon as is present in the air, the soil is a very important reservoir of carbon. By fixing carbon from organic waste in a stable form and introducing it back to the land, we can bring a huge contribution in reducing CO_2 burden. Archaeologists have found very fertile and stable humus soils in certain areas of Amazonia and if we lead the composting process in the direction to form stable and rich soil, we can offer a possibility of organic fertilisers that have shown an enormous advantage over mineral fertilizers. Researchers have found ways to influence composting processes to enhance production of extremely fertile soil in composition similar to terra preta found in Amazonia. The Green mine we have so far followed standard procedures of composting, but we plan to implement results of terra preta research terra in the process of composting. Research has shown that the presence of mineral flour and charcoal essential in the formation of extremely fertile and sustainable soil. Mineral flour offers micronutrients along with other ingredients forms fertile soil composites. Charcoal provides an extremely large surface for the formation of new habitats for microorganisms and thus allows propagation of beneficial microbes that are essential for the formation of fertile soil. We see the future of composting as a unique opportunity to create sustainable fertile soil that will enrich and renew by now exhausted fields and at the same time fix carbon from the air and contribute to climate protection.

Key words: humus, terra preta, carbon

1 Introduction

Artificial fertilizers and intensive cultivation have long term negative impact on the soil and its biology. Therefore, measures to revitalize the soil are becoming more and more important. An extremely fertile black earth, discovered by archaeologists in the Amazon Basin, offers an alternative to artificial fertilizers and intensive tillage. The so-called terra preta was developed by an advanced civilization, located in the Amazon region. One of the key elements is the enclosed charcoal.

The development of modern tillage and fertilization methods allows today the production of more agricultural products than ever before with fewer staff on less surface. The negative effects of it on the soil will not be noticed until decades later and are in most cases compensated by even more intensive tillage and over-fertilization. All activities that are performed in the soil affect one or more parameters. Loosening, mixing and tacking tillage completely changes the natural structure and creates new conditions for the edaphon (a term describing all organisms living in the soil). Biochemical processes are subsequently favoured or inhibited, depending on the type of intervention. By the tillage the soil is at least temporarily open and is increasingly exposed to mechanical and chemical influences such as erosion or immission (Kuntze et al. 1994).

One alternative to intensive cultivation and artificial fertilization is a preservative tillage and the introduction of organic nutrients from compost. A possibility the native Amazonians knew well. Archaeologist namely found extremely fertile sustainable humus the so-called terra preta. The natives found a method of composting that gave rise to fertile sustainable humus, that has been stable for thousands of years. When organic matter is reintroduced into the soil it stabilizes the humus content in the soil, which activates soil life, thereby promoting all nutrient transformations. It also stabilizes the soil structure, increases, porosity, water infiltration and storage capacity of the soil, protects against drying and erosion, and represents the largest reservoir of nitrogen in the soil (Amberg, 1979).

2 Current composting method in Zeleni rudnik

Composting at Zeleni rudnik Pomurja consists of three main parts:

- the preparation of composting materials
- the active composting process
- the processing of mature compost and storage

2.1 The preparation of composting materials

The preparation of composting materials is physically separated from the actual composting process, to prevent the contamination of mature compost with fresh biological material. The biological material delivered for composting is if necessary temporarily stored protected from the weather, whereas the required structural material, due to its inertness can be stored on an open platform. Ready and grind structural material and biological material is mixed and prepared in a mixture of compost in a dedicated mixer (Mashmaster) that adequately homogenizes the material. If necessary the mixture can be moisturised and stored temporarily in a separate box (7,5 m x 5m) protected from weather conditions.

2.2 The active composting process

The compost mixture of is moved to the active portion of composting on an open plateau, which has a regulated ventilation kinete (used for active ventilation and drainage of the compost heap). The mixture is moved to a separate mechanical composting station which is ventilated and equipped with the supervisory control technique (supervisory container, COMPOtainer and biofilter container)

The administrative / supervisory container is intended to control the composting process and manage the input / output data and protocols. The COMPOtainer is controlling the ventilation with pressure/vacuum system and connecting to the kinetic and ventilation biofillter module. The latter is used to clean the air sucked from the vacuum system of active composting.

Active composting is carried out on the high plateau which governs ventilation trenches, serving to promote and conduct regular biological processes. Each compost heap is 40m long and is formed with a wheel loader. When the heap is formed it is periodically mixed with a dedicated compost mixer. The dates of mixing are determined by the control techniques and experience.

Formed heaps are placed three lines depending on the maturation of the compost. In the initial phase in the area is vacuum ventilated and periodically shifted to the next line with pressure ventilation. Last line of is without active ventilation and is dedicated for final maturation and stabilization of the compost.

2.3 The processing of mature compost and storage

Mature compost is separated into two factions. Fine fraction is stored as a final product, coarse fraction is mixed together with a structural material and partially returned to the composting system (vaccination).

The mature compost can be stored either in the open plateau or protected from weather conditions..

3 Appying the knowledge of terra preta to practice

3.1 Rock Flour

Analysis of terra preta has shown this soil to be very rich in minerals. It is believed that the natives added rock flour of finely ground rocks to the composting piles to increase the fertility of humus. Research has shown that diabase or basalt rock dust stimulates microorganisms and provides micronutrients for the crops. The huge surface that is gained by the rock flour is an excellent habitat for diverse bacteria that are necessary for fertility of the soil. It has also been shown that some micronutrients from rock flour function as biocatalysts for enzymatic reactions. Enzymes are critical in the breakdown of raw organic matter during the composting process. In turn, organic acids formed as a byproduct of microbial activity help to solubilize and mineralize elements in the parent rock dust material, thus making these mineral elements more bioavailable. When organic matter, clay, and rock dusts are mixed together in the compost windrow, the complex biotransformation and repolymerization processes that occur during composting provide an opportunity for organo-mineral chelated complexes to form (Li JG, Dong YH., 2013).

3.2 Biocoal

Another interesting feature of the terra preta is a high content of charcoal, even up to 35% of organic matter (Glaser et al., 2001). Biochar (charcoal produces with the process of pyrolysis) acts as a stable carbon compound being degraded only slowly with a mean residence time in the millennial time scale. Biochar has a high specific surface area (400 – 800 m2 g-1), it provides a habitat for soil microorganisms which can degrade more labile organic matter. In addition, higher microbial activity accelerates soil stabilization. Furthermore, higher mineralization of labile organic matter and biochar itself provided important nutrients for plant growth. Research has shown that biochar application to soil influences various soil physico-chemical properties. Due to the high specific surface area of biochar and because of direct nutrient additions nutrient retention and nutrient availability are enhanced after biochar application (Glaser et al., 2002; Pietikäinen et al., 2000). Higher nutrient retention ability, in turn, improves fertilizer use efficiency and reduces leaching (Steiner et al., 2008; Roberts et al., 2010). Most benefits for soil fertility were obtained in highly weathered tropical soils but also higher crop yields of about 30% were obtained upon biochar addition in temperate soils (Verheijen, 2009). Furthermore, enhanced water-holding capacity can also cause a higher nutrient retention because of a reduced percolation of water and the herein dissolved nutrients (Glaser et al., 2002).

Table 1: Soil properties after harvesting a crop of soybeans in Indonesia

	pH	Exchangeable cations (mg/100g soil)		Maximum water holding capacity %
No charcoal	4.7	Potassium = 50	Magnesium = 4.1	40
With charcoal	5.1	Potassium = 70	Magnesium =10.4	47

Source:

Table 2: Soil properties after harvesting a crop of soybeans in Indonesia

	Yield t/ha	Relative ratio
No charcoal	0.65	100
With charcoal	0.85	131

Source: Waksman, Selman. 1952. Soil Microbiology. John Wiley & Sons, New York

Table 3: Soil properties after harvesting a crop of soybeans in Indonesia

	Yield t/ha	Relative ratio	Number of root nodules	Relative ratio
No charcoal	1.56	100	777	100
With charcoal	2.18	138	1,212	156

Source: Waksman, Selman. 1952. Soil Microbiology. John Wiley & Sons, New York

Table 4: Effect of charcoal on crop biomass

Treatment	Charcoal t/ha	Relative biomass %	Crop/Plant
No Charcoal	0	100	Pea
Charcoal	0.5	160	Pea
No Charcoal	0	100	Moong
Charcoal	0.5	122	Moong

Source: Waksman, Selman. 1952. Soil Microbiology. John Wiley & Sons, New York

3.3. Edaphon

Edaphon is a collective term describing the community of organisms living in the soil. In Figure 1 the relative ratios of different organisms are depicted. It is evident that microorganisms comprise the largest portion of the edaphon, since bacteria, algae and fungi represent around 80% of all organisms present in the edaphon. Research indicates that these organisms are the ones determining the quality of humus and consequently also crop yields.

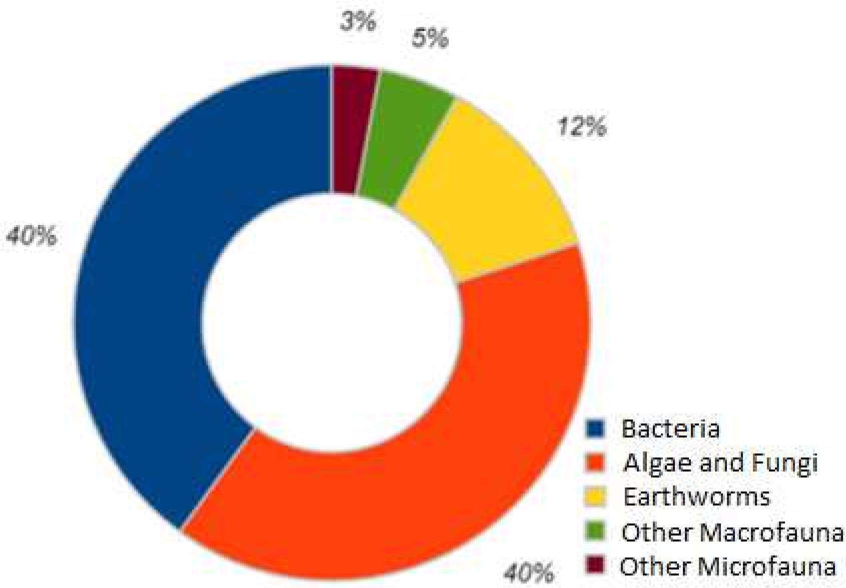

Figure 1. Structure of the edaphon: a visual representation of the percentage of different organisms comprising the edaphon

The terra preta soil is an interesting example where the abundance of microorganisms is very high and also diversity of organisms is much higher in comparison to other humus. An interesting study performed at the Sonnenerde research center investigated the abundance of microorganisms in different types of humus and also in terra preta. They have found that the number of microorganisms increases most evidently with the addition of biochar. This observation is an indication that the biochar is important structuring and protection element that promotes the growth of selected beneficial microorganisms. The porous structure of biochar, its large surface area and the ability of soluble organic substances to absorb gases and inorganic nutrients are the properties which makes it a suitable habitat for microorganisms. The pores of the biochar also form a protective habitat where microorganisms are protected from natural predators (Saito and Muramoto, 2002).

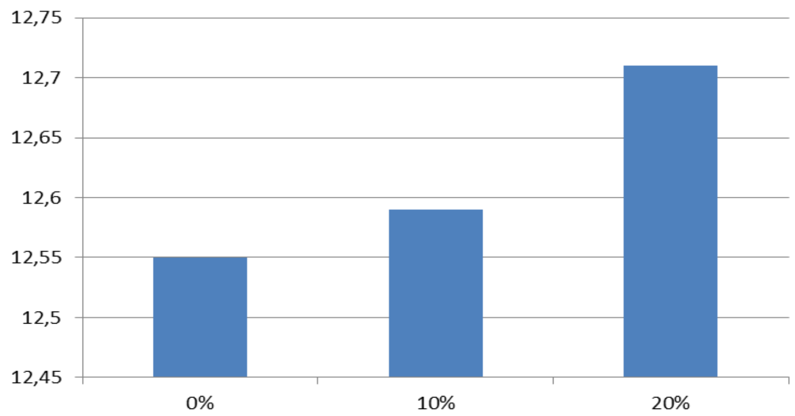

Figure 2. Relative number of Gama proteobacteria estimated with amplification of specific genes per g of compost with 0%, 10% or 20% Biochar (Hofbauer B., 2012)

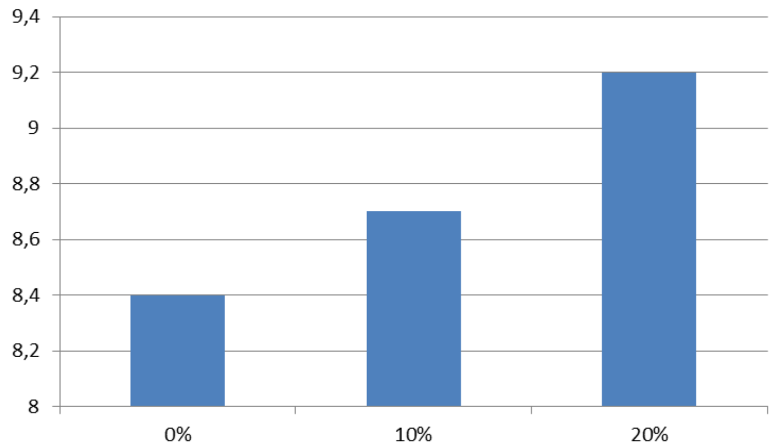

Figure 3. Relative number of Firmicutes in compost estimated with amplification of specific genes per g of compost with 0%, 10% or 20% Biochar (Hofbauer B., 2012)

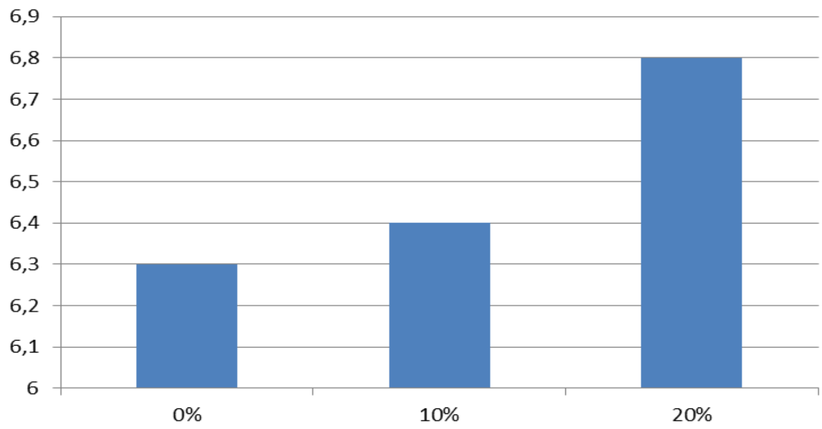

Figure 4. Relative number of nitrogen fixating bacteria in compost estimated with amplification of specific genes per g of compost with 0%, 10% or 20% Biochar (Hofbauer B., 2012)

With the addition of biochar the numbers of all investigated bacterial groups increased, the largest difference was observed in nitrogen fixating bacteria. This is especially interesting with regard to the fact that nitrogen is in most cases the limiting nutrient in growing plants and crops. Bacteria are the crucial players in conversion of elemental nitrogen. In the atmosphere there is 78% nitrogen, but it is the least reactive form on nitrogen and is not directly available to plants. To bioavailable forms of nitrogen for plants are nitrate and ammonium. Bacteria are the capable of converting the inert form of nitrogen from the atmosphere into bioavailable forms. Usually these bacteria live in symbiosis with legumes (Bradic et al, 2003), are associated with plant roots or free living in earth (Vadakattu & Paterson, 2006). The presence of these bacteria in the soil is a prerequisite for a fertile soil.

4 Future

We are planning to use the current knowledge from terra preta research to our composting processes and aim to produce highly fertile humus. This humus can then in turn be used in sustainable agriculture and farming. In this way damage to the environment due to intensive tillage could be dramatically reduced. Applying the knowledge of terra preta to contemporary soil management can reduce environmental pollution by decreasing the amount of fertilizer needed, because the bio-char helps retain nitrogen in the soil as well as higher levels of plant-available phosphorus, calcium, sulfur and organic matter. The black soil also does not get depleted, as do other soils, after repeated use (Lehmann, 2003).

So we believe that producing and applying humus to soil would not only improve soil and increase crop production, but also could provide a novel approach to establishing a significant, long-term sink for atmospheric carbon dioxide. It is estimated that we require only 10% of our productive, degraded lands to absorb the estimated 6.1 gigatons of carbon dioxide emissions to make a carbon negative world possible in our life time (O'Grady R. and Rush R, 2007).

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