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RESEARCH OF ORGANIC CARBON LOSS IN SEWAGE SLUDGE COMPOST BY USING COMPOSTING COVERS

Ausra Zigmontiene[1], Egle Zuokaite[2]

[1, 2]*Vilnius Gediminas technical university, Sauletekio ave. II, LT-10223 Vilnius, Lithuania.*
E-mails: [1]ausra.zigmontiene@vgtu.lt; [2]egle.zuokaite@vgtu.lt

Abstract. Soil and climate change relation is highly important. Soil is part of climate change problem, but it could be a part of this problem solution. For better understanding and estimation of climate gasses emission and for slowing down these processes is necessary to do more investigation in this field. Sustainable soil usage could help to save or even increase carbon amount in the soil and this process will sustain balance of climate gas emissions. Soil carbon is essential element which determines soil fertility. Recently it is discussed the importance of organic materials for soil quality and the applicability of sewage sludge to enrich soil with organics. Sewage sludge as organic carbon source can improve soil quality. The best way to stabilise and immobilise carbon is mineralisation which happens in the composting process.

The aim of our research is to evaluate the loss of organic carbon during the sewage sludge composting process by applying natural composting covers. The main objective of composting covers is to solve problems related with air pollution, smells, and preservation of carbon in the compost. During the research were used multi-layer composting covers which consisted of grained tree bark, textile layer, and peat layer with grass. Research results revealed that natural layers of composting cover repress gas emission, formed during composting process, and minimizes the loss of organic carbon in the compost.

Keywords: sewage sludge, organic carbon, composting, composting covers.

1. Introduction

Major attention is currently devoted to the relationship between soil and climate change globally. Soil productivity is for the most part predetermined by organic materials in soil. A no lesser important is the fact that these materials are the world's second largest source of carbon after oceans. EU soils alone have accumulated more than 70 billion tons of organic carbon. This is an enormous amount having in mind that annual carbon emissions amount to around 2 billion tons in the EU (Dimas 2008).

Soil is part of the problem caused by climate change but at the same time it has to help dealing with that problem.

In order to better understand and calculate the possibility of reducing greenhouse gas emissions from soil and slowing down the process causing these emissions, the investigation of these processes is necessary.

The balance of emissions from fossil fuel can be maintained through the application of successful soil use and the preservation or even increase of carbon content in soil. It is assumed that the potential capacity of land ecosystems to accumulate carbon is equal to the reduction of atmospheric carbon dioxide emissions by 50 millionths parts; currently, the amount of carbon dioxide in the region totals 380 millions parts (Lal 2008).

Natural sources of carbon have to be both protected and enlarged. When preserving or increasing the amount of organic materials in soil the appropriate application of soil management practices is of utmost importance (Lal 2008).

Natural marshes perform the function of carbon repositories. They are also the potential source of methane and nitrogen oxide. Marshes perform an important role in the process of water filtration. In order to protect marshes and provide assistance for the remediation of drained marshes, it is necessary to reduce a large amount of greenhouse gases emitted by the marshy soil (Liski 2008; Freibauer 2008).

The European Union and the entire world have to adapt to climate change and to the fact that soil performs the key role when ensuring that nutrition and processes should not be adversely affected by climatic conditions.

Carbon in the soil content is the essential component predetermining the productivity of soil, which performs the key role in the processes of eco-systems, for instance in the process of water retention (Zuokaitė and Ščupakas 2007).

The activities of micromycetes and other microorganisms result in the formation of various gaseous materials in soil such as carbon dioxide, various nitrogen oxides, nitrogen, ammonia, hydrogen sulphide, methane, hydrogen ethane, butane, propane, methylene, propylene, butylene and a number of other gaseous hydrocarbons (Bridžiuvienė *et al.* 1997). Soil carbon loss is incurred together with gaseous organic compound emissions. Similar processes occur naturally in nature as well as when composting sewage sludge and other biodegradable wastes (Podgaiskytė and Vaitiekūnas 2009).

Mineralisation which takes places during composting is the best way of stabilising and immobilising carbon (Bernal *et al.* 1998).

Currently the importance of the organic materials improving soil properties as well as sewage sludge preserving the levels of organic materials in soil has become more and more apparent. Sewage sludge, as a source of organic carbon, can contribute to the improvement of soil quality.

The atmospheric emissions of gaseous pollutants can be reduced through the formation of the optimum conditions for composting (C:N, aeration, pH and humidity) and the use of natural additives (sawdust, wood chips, zeolite, peat, *etc.*). Composting and compost use reduce greenhouse gas emissions directly through the isolation of carbon dioxide and indirectly by improving the properties and composition of soil (Brown *et al.* 2008; Composting Council 2008; Hellebrand 1998; Jackel *et al.* 2005).

Degradation of organic materials under natural aerobic conditions results in the formation of CO_2. However, when organic materials are degraded in the anaerobic environment carbon is released in the form of gaseous compounds (methane and other volatile organic compounds) (Ashbolt and Line 1982; Zigmontienė and Zuokaitė 2010).

Under ideal aerobic conditions organic materials are degraded up to CO_2 and H_2O; however, when composting takes place under aerobic environment 50 % of organic carbon is lost from compost in the form of CO_2. When composting takes place under anaerobic conditions, carbon loss accounts for up to 95 % which results from methane (CH_4) emission.

Biological, biochemical and physical processes take place during the composting of biodegradable waste in the course of which, with the participation of microorganisms and zoo-coenoses as well as enzymes evolved by them, the complex processes of organic waste mineralisation, biogenic element release and humus formation occur. Degradation is performed by bacteria, micromycetes (mold fungi), different kinds of protozoa, invertebrates and minor animals that feed on organic matter or degrade it (Spellman 1996; Baltrėnas *et al.* 2004; Baltrėnas *et. al* 2005). A product formed during composting by its appearance and properties is similar to dark humous soil. It improves the soil structure and enhances its ability to absorb air and water, reduces erosion and allows discontinuing the use of additional synthetic nutrients (Zuokaitė and Ščupakas 2007; Kvasauskas *et al.* 2009).

When waste is stabilised by using the method of biological treatment the short-cycle carbon dioxide remains in the obtained material for a limited period of time: it is assumed that around 8 % of organic material present in compost will remain in soil as humus in the period of 100 years (Commission of… 2008).

The impact on climate change of carbon dioxide sequestration (sequestration means CO_2 control in the form of inorganic carbonates) is limited and chiefly temporary (Commission of…2008).

The aim of research: to evaluate the amounts of organic carbon lost during sewage sludge composting, the regularities of these losses through the application of natural composting covers.

2. Research methods

The surplus sewage sludge dewatered with centrifuges, tree bark, sawdust, peat, and a grass layer (a lawn roll) were used for the investigations of organic carbon.

Investigations were carried out under natural outdoor conditions. Composted materials were piled in 1000x500x300 mm piles. Compost piles with sewage sludge and additives:

- 25±0.1 kg of sewage sludge and 5±0.1 kg of sawdust (control);
- 25±0.1 kg of sewage sludge and 5±0.1 kg of sawdust covered with a 6 kg layer of bark and grass;
- 25±0.1 kg of sewage sludge and 5±0.1 kg of sawdust covered with a 5 kg layer of peat and grass;
- 25±0.1 kg of sewage sludge and 5±0.1 kg of sawdust covered with a 3 kg layer of sawdust and grass.

Methodology for determining organic carbon. Organic carbon was determined with an *SSM-5000A* solid organic carbon sample analyser of *Shimadzu TOV-V* series (Fig 1).

Fig 1. Carbon analyser TOC-VCSN/ TNM-1

The *SSM-5000A* is used for the analysis of soil, suspensions and liquids. The results can be influenced by the form and matrix of solid samples as well as water amount. The efficiency coefficient of carbon burning oxidation reaction (TC (organic carbon) analysis) and the carbon acidification reaction (IC (inorganic carbon) analysis) can vary depending to the type of sample.

Preparation of sample vessels. The sample vessel was heated in the furnace at a temperature of around 900

°C for 20 minutes. Quartz glass filter paper was heated in the furnace at a temperature of around 600 °C for 20 minutes. The roasted sample vessels and quartz glass filter paper are kept in a clean container or box.

Sample crushing. The components of solid samples, unlike of liquids, do not mix thoroughly. Therefore, it is very important to homogenise solid samples in order to obtain the clearest possible elements of the sample.

- All materials that are not necessary for the research were removed from the sample.
- Several samples were taken from different places. Different samples were carefully crushed in a crusher and prepared for research.
- Crushed samples were sieved through a sieve with appropriate meshes.
- Non-sieved particles were crushed once more.
- The process of crushing and sieving was repeated 3 to 4 times to obtain the final sample which was sieved through a 200-mesh sieve.

Sample vessel loading. The accuracy of the investigation result is directly dependent on the accuracy of weighing. To achieve the most accurate weighing result a micro-balance was used. A sample for weighing was placed in the roasted sample vessel and the weight of the vessel was deducted.

3. Analysis of the experimental results

The surplus sewage sludge dewatered in centrifuges from Vilnius municipal waste treatment facilities was used for the experiment. Additional materials used included wood bark, sawdust, peat and a grass layer (a lawn roll). Upon mixing up sawdust and sewage sludge, the porosity of compost increases, compression decreases and oxygen circulation within the compost pile improves.

One of the aims of the experiment is to determine which natural materials are best suitable for increasing the amount of retained carbon in compost.

Bacteria which are thriving in the oxygen-saturated medium self-decompose and compost sewage sludge. During the process of oxidation organic materials are degraded into carbon dioxide (CO_2), water (H_2O), nitrates, sulphates and biomass. Normally, the C/N of sewage sludge is low, 5–16, whereas the C/N of wood reaches even 600. Where the C/N is below 20/1 carbon is rapidly consumed by microorganisms and nitrogen remains free, and ammonia and nitrogen oxides are released into the atmosphere.

Characteristics of the sewage sludge used for the investigations: pH 6.5–6.8 weakly acid-neutral; humidity (water percentage in material) 80.2 %. Peat pH was 6.2.

Humidity of the additional materials used for investigations: 1.05 % of sawdust; 1.44 % of bark; 47.9 % of peat.

The experiment was carried out during the warm season of the year under outdoor conditions, and the average (daily) ambient air temperature varied from 4 to 18 °C, during the experiment the average ambient air temperature was 9 °C.

Fig 2. Compost piles

The determined content of organic carbon of the initial material in a dry material is presented in Figure 3.

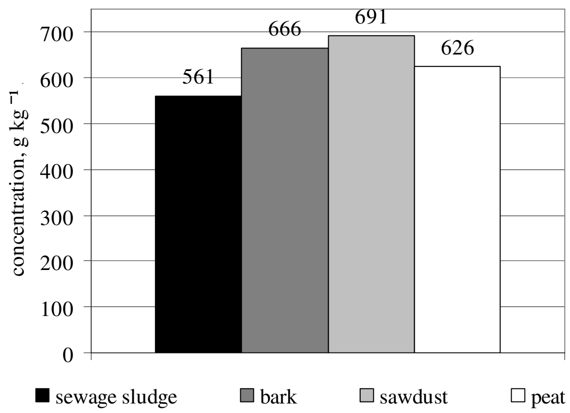

Fig 3. Carbon quantity in raw materials

The identified content of organic carbon of the sewage sludge used for the investigation is 561 g kg^{-1}. The determined content of organic carbon in the peat used for the experiment is 626 g kg^{-1}. The content of organic carbon identified in wood bark is 666 g kg^{-1}, in peat – 626 g kg^{-1}.

The content of organic carbon in "fresh" sewage sludge was 56.1 %. No inorganic carbon was found in the investigated samples. After 6 weeks, the content of organic carbon in composed sewage sludge mixed up with sawdust decreased to 52.9 %.

Wood and wood sawdust, tree bark and peat are ascribed to materials with large carbon content (waste). In the meantime sewage sludge is ascribed to materials with large nitrogen content (waste). When sewage sludge is composed with wood waste the C to N ratio of microorganisms, the main nutrients, is optimised.

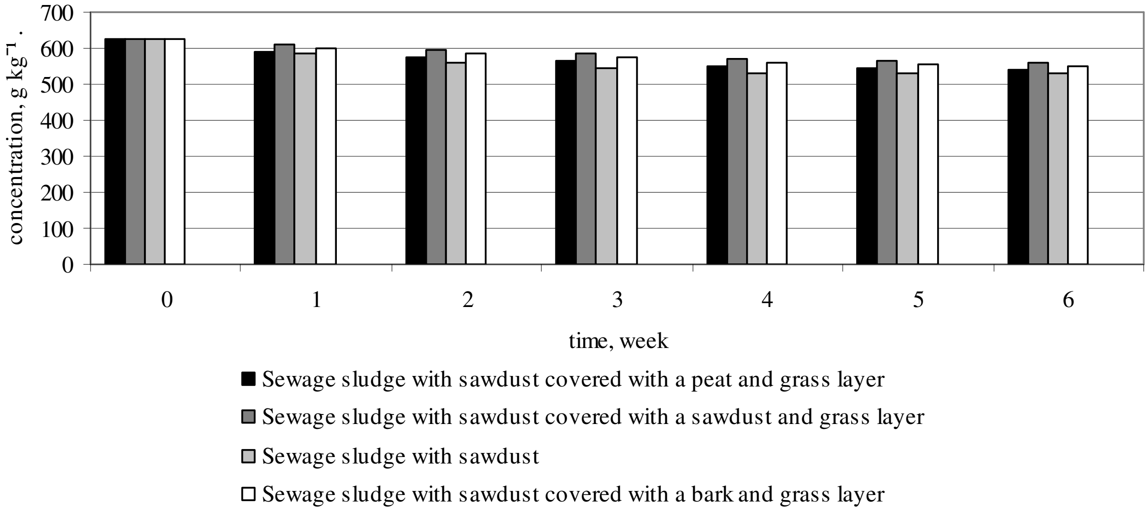

Fig 4. The content of organic carbon in composted sewage sludge and in the sludge covered with composting covers

Carbon loss during composting is calculated according to the formula (Tiquia *et al.* 2002):

$$\text{Carbon loss} = \frac{\text{initial mass of C} - \text{final mass of C}}{\text{initial mass of C}} \text{ x } 100 \quad (1)$$

Table 1. Organic carbon (C) loss

	Organic carbon (C) loss, %		
	after 2 weeks	after 4 weeks	after 6 weeks
Sewage sludge with sawdust	10,7	15,0	15,5
Sewage sludge with sawdust covered with a bark and grass layer	6,5	10,5	12,1
Sewage sludge with sawdust covered with a peat and grass layer	8,1	12,1	13,7
Sewage sludge with sawdust covered with a sawdust and grass layer	5,0	8,9	10,5

As determined during the experiment the biggest loss of carbon (Table 1) was incurred when composting uncovered sewage sludge with sawdust. As the findings of the investigation show, organic carbon loss reaches 13.7 % when sewage sludge is composted under a cover of peat and a grass layer. The biggest loss of carbon is incurred in the active phase during which microorganisms most rapidly degrade bio-degradable matter.

4. Conclusions

1. The use of composting covers composed of bark, sawdust, peat and grasses during the process of composting bio-degradable waste can help retain gaseous emissions containing carbon.
2. As determined during the experimental investigations, the biggest loss of carbon, 15.5 %, is incurred when composting uncovered sewage sludge.
3. As the findings of the investigation show, organic carbon loss reaches 10.5 % when sewage sludge is composted under a cover of sawdust and a grass layer.

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