Investigation of Compost Quality of Meadow Grass

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Abstract

In this paper, we have investigated the compost quality originated from natural process of decomposition of meadow grass. We have analysed three samples with different source and content of organic matter and they are named by: compost, garden and greenhouse in order to compare them. The compost sample implied the natural process of decomposition of meadow grass without the controlled conditions, i.e. under natural atmospheric conditions for a period of eight months. The sample of greenhouse means the soil that is enriched with fertilizer originating from goat (goat fertilizer), while the garden sample means the soil without any fertilization. To those samples are determined the percentage of moisture and organic matter, active and potential acidity and conductivity. In all three samples are determined certain essential macro-elements: the nitrogen, phosphorus and potassium. The experimental results showed that the natural process of decomposition of organic material (meadow grass) created a high quality ecological fertilizer with extremely rich content of sodium and potassium, while scarce phosphorus content.

***Keywords**:* nitrogen, phosphorus, potassium, compost, grass.

1. Introduction

1.1 Composting definition

Composting is a process in which organic substances are reduced from large volumes of rapidly decomposable materials to small volumes of materials which continue to decompose slowly. In this process, the ratio of carbon to other elements is brought into balance, thus avoiding temporary immobilization of nutrients [1]. Compost quality varies depending on the source and how it is produced.

1.2 Moisture of soil

Under the soil moisture implies the total amount of water that the soil contains at a certain point of time. It is very variable size and depends on the income and expense of water in land, as well as on the physical properties of land and relief. Water quantity in soils plays an important role in controlling energy balance and evapotranspiration rates on the earth surface [2, 3]. This data is closely related to the ability to move water into the soil. What is the amount of water or the humidity of the soil higher, the energy that keeps the water in the soil is lower, and its ability to move is higher.

1.3 Soil acidity

Soil pH and organic matter are key soil parameters. Soil pH and organic matter strongly affect soil functions and plant nutrient availability. Specifically, pH influences solubility and availability of plant nutrients, performance of pesticides (which include herbicides), and organic matter decomposition. [4]

Determination of the pH of agricultural soils is most commonly performed by measuring the mixture of water and soil in a ratio of 2: 1, thus obtaining values related to active acidity (H^+ ions in the soil solution), while by pH measurement in potassium chloride (KCl), the adsorbed H^+ ion is substituted with K^+, thus obtaining potential acidity. In addition to the generally gives lower values, the pH measurements in KCl indicate the adsorption ability of some soil, so that in clay soil the difference between these two measurements is significantly more pronounced than in sand. Today, soil pH is measured to give a general estimate of its usable value.

1.4 Soil organic matter

Organic matter of the soil includes non-specific and specific organic matter. Specific and non-specific organic matter affects the physical, chemical and biological properties of the soil. Non-specific organic matter represents non-humified plant and animal residues and has a total about 15%, while specific organic matter makes humus in the amount of about 85%. Non-specific organic matter plays an important role in soil fertility as it is the source of plant nutrition. In a soil with favourable physical and biological properties it is easy to decompose. [5]

2. Nitrogen, phosphorus and potassium as macronutrients

From amounts of required in plants, essential mineral elements are classified as macronutrients (N, K, Ca, Mg, P, and S) and micronutrients (Cl, Fe, Mn, B, Zn, Cu, Mo, and Ni). Six elements (C, H, O, N, P, and S) are constituents of organic compounds, such as protein, sugar and nucleic acid. Three macronutrients (K, Ca, and Mg) are present as cations (K^+, Ca^{2+}, and Mg^{2+}) and have controlling functions (pH, osmotic pressure, and enzymatic activity etc.,) in plant cells. [6]

In the process of nutrition, it can very little affect on the content of C, H and O in plant tissues which in spite of being of essential importance for the formation of organic matter of plants, primarily originate from water and CO_2. Typical concentrations sufficient for plant growth are: for Nitrogen 1.5 %, Potassium 1.0 % and phosphorus 0.2%. [7].

Micronutrients (Fe, B, Mn, Cu, Zn, Mo, Cl, and Ni) are found in the lowest concentrations in plant tissues. However, those in plant tissues must be present at certain concentrations, not only to achieve high plant productivity, but also to survive. The division into macro- and micro-nutrients is reduced only to the amount that the plants adopt, and not to the importance these elements have in the metabolism of plants, so it can be said that they are all equally important.

In the plant nutrition process, all these essential elements adopt the root in ionic form, which is the basic form of adoption. Thus, all plant species adopt soil nutrients exclusively in the inorganic form, in the process which, because of their physiological complexity, is called mineral nutrition.

2.1 Nitrogen

Nitrogen is an essential element for all organisms, which composes proteins, nucleic acids and other important organic compounds.

We can freely call it the leading among the essential elements because of its irreplaceable role in plant life. The effects and velocities of nitrogen action in plant nutrition, as well as the overall influence on their development, are not manifested so quickly and so clearly like in other elements. It is an element that is most often deficient in plant production, primarily because it is a plant species of high biological potential that require significant amounts of nitrogen in the diet. Soil as a nutritious medium cannot usually provide sufficient quantities of affordable N, especially if it is intensive plant production.

Nitrogen is one of the most reactive biogenic elements, as it occurs in nature in various valent conditions. [5].

Nitrogen exists in the soil system in many forms and changes (transforms) very easily form one form to another. The route that N follows in and out of the soil system is collectively called the "nitrogen cycle". The nitrogen cycle is biologically influenced. Biological processes, in turn, are influenced by prevailing climatic conditions along with the physical and chemical properties of a particular soil. [8]

The reactions of mineralization-immobilization in the soil describe the relationship that is established in the process of degradation of organic matter (organic nitrogen) and the accessibility of its inorganic forms (NH_4^+, NO_3^-). Nitrogen fertilizers today are the main source of N for plants.

2.2 Phosphorus

Phosphorus (P) is one of the essential nutrients for plants, and is indispensable for plant growth and development [9]. Phosphorus is known for all energy processes in plants and therefore the processes of growth and development. Phosphorus represents an energy source, by which is generated by the total amount of energy needed for all metabolic processes.
P deficiency severely limits crop yield, and regular fertilizer applications are required to obtain high yields and to prevent soil degradation.
The plant only gains phosphorus from the soil. The accompanying removal of the nutrient must be replaced in agricultural systems by fertilizers. The substitute can in principle take the form of organic or mineral fertilizers. [10]

Phosphorus is adopted in much smaller quantities compared to nitrogen and soil solution also contains much smaller amounts of phosphorus relative to nitrogen. Insufficient presence of phosphorus in an aqueous medium, from where the plants it adopted, indicating that soil phosphorus is insufficient for nutrition of cultivated plants.

In addition to small amounts, phosphate ions in the soil are subject to a number of physical and chemical processes from which are formed fractions of phosphorus that are accessible for various plants. Mostly complex fixation reactions of phosphorus lead to conversion of phosphorus fertilizers into insoluble forms.

Today, the main source of phosphorus are considered phosphoric fertilizers for plants, but also phosphorus arrived to soil or by organic fertilizers or from organic residues. The presence of phosphorus in rocks and minerals, mainly is insufficient, so for the plant nutrition in addition to mineral very important role have reserves of phosphorus in organic form.

Low solubility of phosphorus mineral (inorganic P) and slow release of available phosphorus from organic sources indicates the complexity of chemistry of phosphate ions in the soil. Plants adopted phosphorus from the soil solution exclusively in the form of ions or orthophosphate $H_2PO_4^-$ HPO_4^{2-}. The domination of any of these two ions in the soil solution depends only on the pH of soil.

2.3 Potassium

According to the amounts in plant tissues, potassium is immediately after nitrogen. Potassium is not a constitutional element, i.e. it is not included in the structure of organic compounds (proteins, carbohydrates, fats, etc.), but is in relation to other cations present in most cell protoplasm. Its presence in the tissues is responsible for the operation of more than 60 enzymatic systems, and many other processes in plants are related to its concentration in tissues (total growth and development of plants, water regime, metabolism and transport of carbohydrates, resistance to low temperature, osmotic pressure, and synthesis of chlorophyll). Because of the great need of this element for plants, it is adopted to a greater amount than other cations (Ca^{+2}, Mg^{+2}).

The principal source of potassium to the plants represents potassium obtained by dissolution of its minerals. Fixed potassium, which is located in intralamellar space of clay, is not accessible to plants because it is in a position in which it can not be replaced by some other ion. Clay content in soil significantly affects on the mobility of K in the soil.

Soils with high amounts of clay and/or organic matter typically have higher cation exchange capacity (CEC), that is, are able to bind more cations such as calcium or potassium than more silty or sandy soils.

3. Experimental Section

3.1 Soil sampling

All the samples were taken by a shovel from a depth of (25 cm) i.e. up to a depth of a specific plant species. For analysis were taken three different samples. All samples were taken in middle April 2017.

Sample 1 - called compost, in which is nothing previously grown. Compost is created naturally by decomposition of plant mass without controlled conditions for a period of eight months.

Sample 2 - the soil of greenhouses which is enriched with fertilizer originating from goats. On that soil was grown tomato in a previous year.

Sample 3 – soil from garden without any fertilization. On that soil were grown potatoes, onions and peas in a previous year.

3.2 Methods

3.2.1 Procedure for determination of moisture percentage

10 g of sample was dried in the oven at 110 °C for 24 hours. From the data mass obtained before and after drying it is possible to estimate the percentage of moisture.

Soil moisture is a very important parameter that directs us to proper irrigation. After drying of the soil sample, the percent moisture in the soil is determined by using equation (1):

$$\text{mass weight of \% moisture in soil} = \frac{a-b}{b} \cdot 100 \qquad (1)$$

a – sample mass in gram before drying

b – sample mass in gram after drying

100 – value for calculation in %.

4. Results and Discussion

4.1 Procedure for determination of percentage of organic matter

For the determination of organic matter was used the method of annealing at a temperature of 500-600°C. 3-5 g of cleaned soil sample from the rest of the root was transferred to the crucible which was previously weighed. A sample with the crucible was transferred to an annealing furnace and slowly heated to a temperature of 500-600 ° C for 3 hours where a combustion of organic matter occurred.

Table 1 gives the experimental values of percentage of moisture and organic matter for all three analyzed sample.

Table 1. Percentage of moisture and organic matter.

sample name	**% moisture**	**% Organic matter (OM)**
1-compost	6.64	3.66
2- greenhouse	5.15	2.92
3-garden	3.44	2.29

For better visibility, diagram 1 shows the results of percentage of moisture and organic matter.

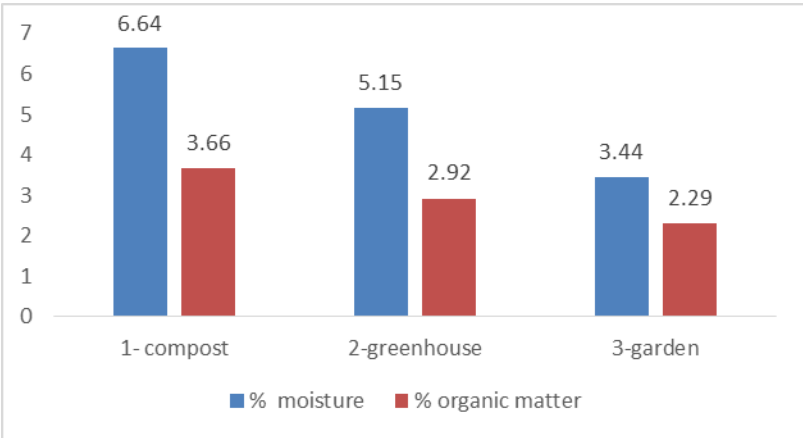

Diagram 1. Percentage of moisture and organic matter.

4.2 Procedure for determination of pH values and conductivity

In two glasses of 100 ml was weighed 10 g of sample. In the first glass was added 25 ml of distilled water, and in another 25 ml of 1 M KCl, and left for stirring 30 minutes by a glass rod. After 30 minutes was performed measuring the pH of the soil suspension. Determined pH value in distilled water is called active acidity while in 1MKCl is potential acidity.

pH is a necessary parameter during fertilization and fertilizer dosage and use for this purposes we use mostly the results of substitutional acidity.

In addition to the pH value was measured and electrical conductivity as a value that is closely linked to the soil reaction.

Depending on extraction medium which we used, pH may give an indication of:

-Active acid-base status of the soil, while we have proceeded with extraction in distilled water (to neutral base).

- substitutional acid-base status of the soil or physiologically active where we have done the extraction with 1 M KCl) and get a result of pH values from 5.78 to 7.22 (slightly acid - poorly alkaline).

In Table 2 are given the experimental values for pH and conductivity of all three samples.

Table 2. Active and reserve acidity and conductivity in soil samples

Sample	**pH in distilled water**	**pH in 1 M KCl**	**conductivity (μS/cm) in distilled water**
1-compost	6.90	6.80 (neutral)	1222
2-greenhouse	7.29	7.22 (poorly alkaline)	947
3-garden	6.14	5.78 (slightly acid)	112

For better understanding we show the active and reserve acidity for all 3 soil samples on diagram 2.

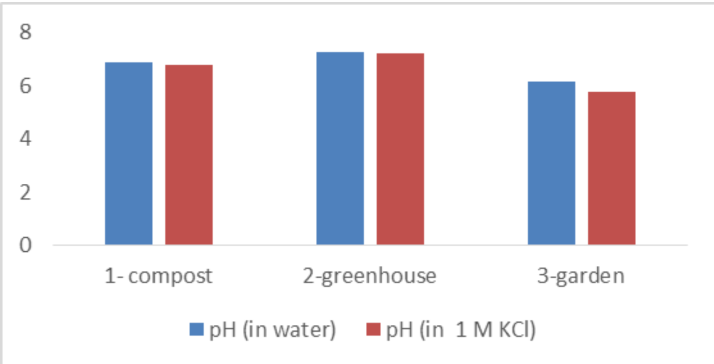

Diagram 2. Active and reserve (potential) acidity in soil samples.

Based on the results presented in Tables 1 and 2 we can see that the compost sample has the highest content of organic matter and that is characterized by a higher percentage of humidity as well as conductivity.

Interestingly enough, we find here very pronounced the difference in conductivity values for these three samples. Namely, the compost sample has the highest conductivity, than greenhouse and at the end garden. We can see that conductivity of compost sample is 1222 μS/cm and for garden is only 112 μS/cm. So, it is obvious that compost sample has ten times higher concentration of free ions than the garden sample. From this data we can assume that that the mobility of ions in compost sample will be ten times faster than in a garden sample.

We also find the pH values according to chemical composition of all three different samples. So, the compost sample has no significant changes in pH values determined in distilled water and 1M KCl. And the pH values are closed to 7 and it is very desirable pH for growing the plants.

We have found a little bit higher pH values in greenhouse sample and that is in line with the goat fertilizer that has been used for this soil sample. The pH value for this sample is about 7.2 and this value is also desirable for growing the plants.

The last one sample is garden, and we found here slightly acidic soil and that is also understandable since that this soil does not contain any fertilizer and this result can be explained by slightly acid rain. The value for this sample is about 6.

4.3 Determination of nitrogen, phosphorus and potassium

4.3.1 Determination of total nitrogen

For the determination of total nitrogen was used Kjeldahl method. Digestion of samples (1-2 g) is conducted with a specific catalyst (Cu-Se) (1.5% $CuSO_4$*5H_2O + 2% Se) in order to accelerate the decomposition, producer Panreac Quimica SAU, by adding 20 ml of 96% sulfuric acid for 140 min which decomposes the organic substance by oxidation to liberate the reduced nitrogen as ammonium sulphate. After the digestion the samples were cooled to room temperature, after which was added 50 ml of distilled water in the cuvettes. Chemical decomposition of the sample is complete when the initially very dark-coloured medium has become clear and colourless. In the Erlenmayer flask were added 50 ml of 2% boric acid (H_3BO_3) and 10 drops of indicator (a mixture of cresol and methyl red). The solution is then distilled with a small quantity of sodium hydroxide, which converts the ammonium salt to ammonia. The amount of ammonia present, and thus the amount of nitrogen present in the sample, is determined by back titration. Subsequently, the cuvettes and Erlenmayer flask were placed in Kjeldahl instrument, and then in the cuvettes with the samples were added 32% sodium hydroxide (about 50 ml) whereupon the colour changes to brown and after then was started the distillation process. Extracting the nitrogen in the Erlenmayer flask and leads to visible change the colour from red to light green. After the distillation, the sample from the Erlenmayer flask was titrated with 0.1 M HCl to give the colour change from light green to pink.

4.3.2 Determination of total phosphorus

Phosphorus content was determined by a modified standard spectrophotometric method BAS EN ISO 6878. Phosphorus in the substrate is in an organic, orthophosphate or polyphosphate, and so the method is based primarily on the transformation of the entire phosphorus content in orthophosphate. Polyphosphate and certain related organic phosphoric components are converted to orthophosphate by hydrolysis with sulfuric acid. Many organic compounds are converted to orthophosphate by mineralization with the $K_2S_2O_8$. Subsequently, is recorded calibration curve of known phosphate samples, with addition of reagents for the determination of phosphate (ammonium heptamolybdate tetrahydrate, antimony potassium tartrate hemihydrate and sulfuric acid) and L-ascorbic acid. In the same way are treated samples, and were determined the concentration of total phosphorus. Analysis was carried out on a Shimadzu spectrophotometer UV 1800 at wavelength 880 nm.

4.3.3 Determination of total potassium

The digestion of soil samples was done using 1: 1 HNO_3 and HCl. On 1 g of the soil sample was added a little amount of distilled water and then 1 ml of 65% HNO3 and 1 ml of 35% HCl. After a reaction time of 1 hour, samples were filtered. In this prepared samples, the content of potassium were determined by atomic absorption spectrometer Varian 200.

Diagram 3 shows the experimental results of the analysis of the macro elements: nitrogen, phosphorus and potassium.

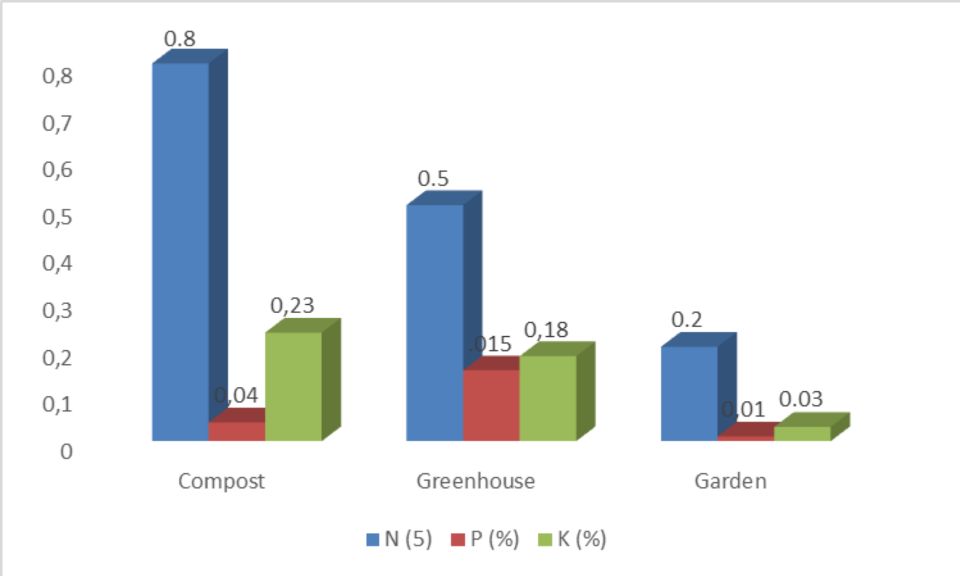

Diagram 3. The total amount of N, P and K.

The values obtained for N, P and K are different depending on the type of sample. The content of these elements was the largest for the compost sample compared to samples of garden and greenhouse. Results of total organic matter content, moisture content, the concentration of N, P and K, as well as the pH values obtained for the compost are an indicator of optimal conditions of soil when it comes to growing plants.

In Figure 1 are shown cucumber and zucchini which were planted in soil sample called compost.

Figure 1. Growing cucumbers and zucchini on a sample of compost.

Figure 2. Peas, corn and potatoes in a garden sample.

Figure 3. Growing tomatoes and cucumbers on a sample greenhouse.

Conclusion

Based on the results obtained we can see that the compost sample has the highest content of organic matter and that is characterized by a higher percentage of humidity as well as conductivity. The content of organic matter is an important prerequisite for growing many crops, and moisture content is an additional parameter that helps degradation of its high speed.

The optimum moisture content obtained for the compost are also an indicator of sufficient amount of water which effect on a faster degradation of compost as well as on the yield of macro and micro elements with an organic matter can build a chelated complex which the plant can adopted.
We find that the "compost" sample has the highest conductivity, than greenhouse and at the end garden. We can see that conductivity of compost sample is ten times higher than the garden sample and consequently we can predicted a ten times higher concentration of free ions than in the garden sample. From this data we can also assume that that the mobility of ions in compost sample will be ten times faster than in a garden sample.
We also find the pH values according to chemical composition of all three different samples.

The "compost" sample has no significant changes in pH values determined in distilled water and in 1M KCl. And the pH values are closed to 7 and it is very desirable pH for growing the plants. pH value of the compost of 6.9 is also an indicator that the fertilizer is preferably suited for both neutral and acidic soil. On the compost sample are planted zucchini and cucumber and we have already the successful results of a growing of selected plants.

We have found a little bit higher pH values in "greenhouse" sample and that is in line with the goat fertilizer that has been used for this soil sample. The pH value for this sample is about 7.2 and this value is also desirable for growing the plants. On the sample greenhouse are planted tomatoes, peppers, cucumber, where we also have a lot of good results of growing.

The last one sample is "garden", and we found here slightly acidic soil and that is also understandable since that this soil does not contain any fertilizer and this result can be explained by slightly acid rain. The value for this sample is about 6. On the sample garden are planted peas, corn and potatoes and we have already the yields in optimal amounts.

On the basis of the values obtained for N, P and K, as well as the content of organic matter it can be concluded that the compost obtained by decomposition of meadow grass can be successfully used as an alternative fertilizer in the cultivation of certain crops.

The experimental results showed that the natural process of decomposition of organic material (meadow grass) created a high quality ecological fertilizer with extremely rich content of sodium and potassium, while scarce phosphorus content.

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