O 101. EFFECTS ON SOIL QUALITY OF COMPOSTING TOGETHER OF SEWAGE SLUDGES WITH AGRICULTURAL WASTES

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ABSTRACT: In parallel with the increase in population, the increasing need for food with urbanization and industrialization requires to new and renewable production techniques as well. In environmental problems, as well as the disposal of solid wastes is significant , it is important that their use in food production too. In this respect, it has been allowed to use in the agricultural land of the sludges by Ministry of Environment for soil improvement if it is provided necessary conditions for sewage sludges.

The aim of this study investigates the effects on the agricultural land by mixing with bulking materials of sewage sludge. It has been investigated how affected the soil structure and plant growth by composting in different ratios with cornstalk which is used as a bulking agent of sewage sludge which provided from the sugar industry. The investigation; it was carried out in 5 different parcels (2m * 2m) and as 3 replications by mixing different amounts of agricultural waste and sewage sludge. It was studied parameter values such as pH, EC, COD, dry matter amount (KM), organic matter amount (OM), penetration resistance, infiltration rate at the investigation undergoing approximately one year. Further, spinach plant has been used in order to examine to plant development, in this study. Generally, it has been observed that there is an effective growth in parcels used sewage sludge and cornstalk when evaluated in terms of plant development. It was observed that sludge disposal or recycling is appropriate the composting together of the sewage sludge and bulking materials for this research.

Keywords: Sewage sludge, cornstalk, disposal, recycling, soil quality and plant growth

1. INTRODUCTION

The increasing population and developing technology constitute many problems. One of these problems that threaten our world is wastewater treatment sludge. Of course, there are many ways of disposal of sewage sludges. The sludges which consist of wastewater treatment plant can be used after passing through various stages. For example; the sludges can be given in the soil, burned, discharged into the sea, or used as terrestrial filling material (Uzun and Bilgili,2011). Nevertheless, many environmental scientists have recently adopted more environmentally friendly approaches.

The use of sewage sludge as compost material is widespread worldwide. The reason why the sludges are considered as compost material is the macro and micro nutrients contained. The use of the sludge due to the high water content can give rise to problems in agricultural areas. However, the use of the sludge due to the high water content can give rise to problems in agricultural areas. Therefore, if the sludge will use for compost, it should be used to bulking agents such as wood husks, corn stalks, maize cocoa, hazelnut husks, sawdust so as to improve the physical structure and properties of the sludge and increase the porosity (URL 1).

The composting process depends on many parameter values. These values can be varied according to the working type (Tchobanoglous, Burton and Stensel, 2003).

Table 1. Design Requirements for Aerobic Sludge Composting Process (Tchobanoglous, Burton and Stensel, 2003)

Item	Comment
Type of sludge	Both untreated sludge and digested biosolids can be composted successfully. Untreated sludge has a greater potential for odors, particularly for windrow systems. Untreated sludge has more energy available, will degrade more readily, and has higher oxygen demand
Amendments and bulking agents	Amendment and bulking agent characteristics (i.e., moisture content, particle size, and available carbon) affect the process and quality of product. Bulking agents should be readily available (Özdemir, Dede, and Dede,2014; Uçaroğlu, 2014; Uçaroğlu and Alkan, 2016).
Carbon-nitrogen ratio	The initial C/N ratio should be in the range of 20:1 to 35:1 by weight. At lower ratios ammonia is given off. Carbon should be checked to ensure it is readily biodegradable (Öztürk, 2014; URL2.)
Volatile solids	The volatile solids of the composting mix should be greater than 30 percent of the total solids content. Dewatered sludge will usually require an amendment or bulking agent to adjust the solids content
Moisture content	Moisture content of the composting mixture should be not greater than 60 percent for static pile and windrow composting and not greater than 65 percent for invessel composting (Gajalakshmi and Abbasi, 2008; Yıldız, Ölmez and Kiriş, 2009).
pH control	pH of the composting mixture should generally be in the range of 6 to 9. To achieve optimum aerobic decomposition, pH should remain in the 7 to 7.5 range(Vanlalmawii and Awasthi, 2016).
Temperature	For best results, temperature should be maintained between 50 and 55°C for the first few days and between 55 and 60°C for the remainder of the active composting period. If the temperature is allowed to increase beyond 65°C for a significant period of time, biological activity will be reduced(Öztürk, Çallı, Arıkan and Altınbaş, 2016).
Control of pathogens	If properly conducted, it is possible to kill all pathogens, weeds, and seeds during the composting process. To achieve this level of control, the temperature must be maintained between 60 and 70°C for 24 h. For temperatures and times of exposure required for the destruction of common pathogens.
Mixing and turning	To prevent drying, caking, and air channeling, material in the process of being composted should be mixed or turned on a regular schedule or as required. Frequency of mixing or turning will depend on the type of composting operation
Heavy metals and trace organics	Heavy metals and trace organics in the sludge and finished compost should be monitored to ensure that the concentrations do not exceed the applicable regulations for end use the product

In order to obtain a good compost product, the parameter values in Table 1 must be provided. The table it can be infered from this that the standardization of a composting process is not a simple task, especially if optimum results are obtained. For this reason, most of the developed commercial composting processes have been highly mechanized and executed in specially designed plants ((Eriçyel, 2008).

2. MATERIAL AND METHOD

2.1. Materials

The present study area is get involved in Konya province in Turkey. The study area consists of at "14m * 8m" size and 15 parcels. The parcels were randomly placed and designed to have a clearance of 0.5 m between each parcel. Sewage sludge (SS), which is one of the basic materials in the study, was supplied from Cumra Sugar Factory in Konya. It was used as bulking agent the corn straw (CS) residues, harvesting by local farmers in the Büyükaşlama neighbourhood. The corn straw (CS) residues were brought to the dimensions of 5-10 cm.

2.2. Composting process

Samples was prepared 5 different mixtures which including 100 kg of sewage sludge (SS) and 50 kg of corn straw (CS) residue. It was planned to have 3 replicates for each mixture. Each parcel forming 1 set was constituted area of 15 sets. In general, the study plan area to be performed is given in Table 2. Figure 1 shows the first preparation time of the current trial site.

Table 2. The study plan area

1 (0-0)	2 (SS- CS)	3 (0-CS)	4 (SS-CS2)	5 (SS-0)
6 (SS-CS)	7 (SS-CS2)	8 (SS-0)	9 (0-0)	10 (0-CS)
11 (0-CS)	12 (0-0)	13 (SS-CS2)	14 (SS-0)	15 (SS-CS)

- Sewage sludge (SS) + Corn straw (CS) [1^x1] [(SS- CS) - (parcels containing 100 kg from sewage sludges and 50 kg corn straw residues)] / (3 replications)
- Sewage sludge (SS) + Corn straw (CS2) [1^x2] [(SS- CS2) (parcels containing 100 kg sewage sludges and 100 kg corn straw residues)] / (3 replications)
- Sewage sludge (SS) + Corn straw (CS) [1^x0] [(AÇ-0) (parcels containing 100 kg sewage sludges)] / (3 replications)
- Sewage sludge (SS) + Corn straw (CS) [0^x1] [(0-CS) (parcels containing 50 kg from corn straw residues)] / (3 replications)
- Sewage sludge (SS) + Corn straw (CS) [0^x0] [(0-0) (control parcels)] / (3 replications)

The compost application was accomplished by applying directly on area. The study was gone on about 1 year. experiments were started 3 months later after the compost material was placed on the area. Aeration of the sludge-corn stalk-soil mixture was supplied with manual spadework. This procedure was repeated least 3 times. The initial parameter values of the study area and the materials used are given in Table 3 and Table 4.

Table 3. Initial pH and EC values of the study area and materials used

Samples	pH	EC(µS/cm)
Corn straw residues	8,13	265
Soil sample	8,31	124
Sewage sludge	8,72	169

Table 4. Initial elemental values for study area and used materials

Measured Ion values	**The Initial Samples**		
	The raw of soil (mg/kg)	**The raw of corn straw (mg/kg)**	**The raw of sewage sludge (mg/kg)**
B	25,74	32,74	39,3
Ca	132853	10974	174391
Cd	0,073	0	0,074
Co	0	0	0
Cr	18,44	0	26,49
Cu	11,13	4,2	16,77
Fe	9541	601,16	14849
K	10916	18554	15140
Mg	4002	2809	6258
Mn	268	82,92	344
Mo	7,28	0,38	3,7
Na	6937,21	17645	11407

Ni	32,73	3,054	43,41
P	634,61	181,2	975
Pb	77,21	24,44	77,15
S	351,82	1072	516,38
Zn	92,37	57,46	103,43

In order to evaluate the effect of compost material on the field, plant cultivation was also performed on the field. According to also the results of plant cultivation, compost mixtures were evaluated. Experiments were carried out for 3 months.
In order to determine the studying yield applied to the field, several parameters were measured. It was analyzed the parameters such pH value, EC (conductivity), moisture content, organic matter content, dry matter content, C / N ratio, COD, infiltration rate, penetration resistance and some ions.

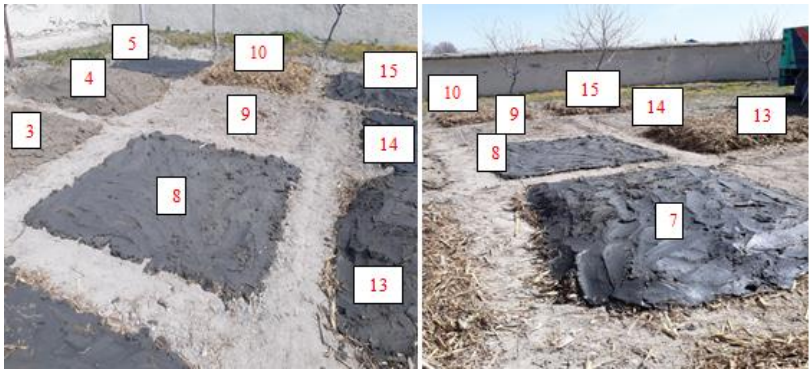


Figure 1. Preparation time of the workspace / images from in march month (3= 0-CS, 4= SS-CS2, 5= SS-0, 7= SS-CS2, 8=SS-0, 9=0-0, 10=0-CS, 13= SS-CS2, 14= SS-0, 15= SS-CS)

2.3. Analytical Methods

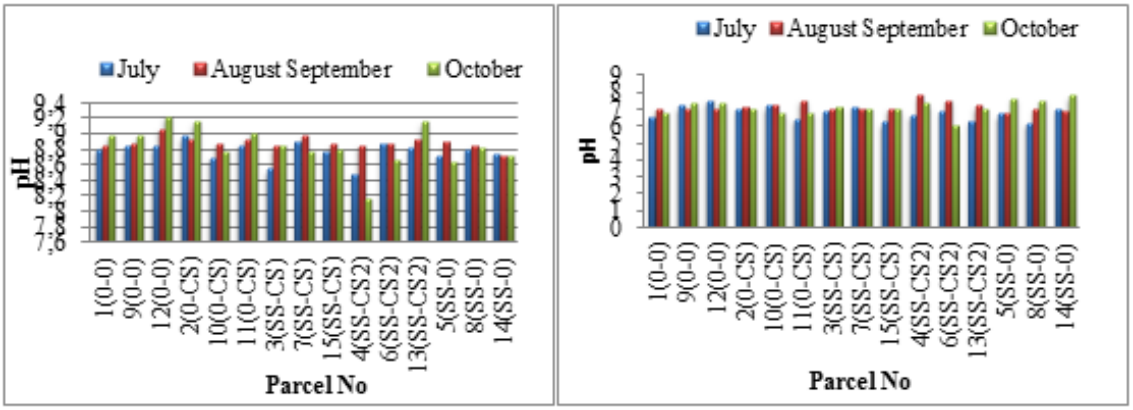
100 ml of distilled water was added to 1 g of soil sample. The samples were mixed 5-6 times with a magnetic stirrer at 10 minute intervals. The pH and EC values of the prepared samples were measured using a pH meter and conductivity meter (Zengin,2013; Rhoades, 1982; Mc Lean, 1982). Also, it was performed measurement for pH and moisture on the study area. The amount of dry matter and moisture content were calculated upon drying at 105 ± 5 ° C for 5 to 6 hours (Bayraklı, 1987; URL3; Uzuner, 2007; American Public Health Association [APHA], American Water Works Association [AWWA], and Water Pollution Control Federation [WPCF], 1998). The OM contents and the OC contents of all of the samples were determined as follows: OM (%) = 100 – ash (%) and OC (%) = OM (%)/1.8 (Barrington et al., 2002; (Haug, 1993)). COD measurements of samples were calculated according to standard methods (Standard Method-Method No 5220-COD).The NO_3 analyses were performed with nitrate kit test method. Spectrophotometer reading was performed for each of the same group samples. Ion analyzes were calculated by using ICP-OES reading and sample dissolving device in Faculty of Agriculture Laboratory in Selcuk University. Soil samples coming to the laboratory are analyzed with ICP-OES after dissolved in acid. It was analayzed ions such as B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, and Zn. So as to measure the infiltration rate of the soil was designed the device. The part of the device that will enter the soil is made of iron and the part made to measure water velocity is made of fiber pipe. The height of each of the 4 devices were 20 cm, the outer diameter were 60 mm and the inner diameter were 55 mm. The penetration resistance of compost samples was measured by using volumetric measurement method. For the porosity value, it was used the volumetric measurement method used for penetration measurements. In addition, it was benefited from (Zengin, 2013) for calculation.

2.4. Statistical Analysis

Anova and LSD programs were used to evaluate the statistical significance of the data obtained.

3. RESULTS and DISCUSSION

pH is one of the important parameter values in composting process. Figure 2 (a,b) shows the values obtained from each plot study for July, August-September and October months for pH measurements both at laboratory scale and on study field. pH values vary between 8 and 9.2 in laboratory measurements. It is seen that the pH values of the parcels increase compared to months. The highest increase is observed in parcels 2 (0-CS), 12 (0-0) and 13 (SS-CS2). The pH value is between 7-8 in the study field. In general, the desired pH in the composting process is in the range of 6-9 (Vanlalmawii and Awasthi, 2016). It can be said that the values obtained from both measurements are in the range value range. In addition, it can be said due to microbial activity that the increase and decrease in measurements.



(a) **(b)**

Figure 2. pH measurements both at laboratory scale and on study field

EC is an important parameter value for plant growth. It is also an indicator of salinity. In Figure 3, a decrease was observed in EC values in August-September, while an increase occurred in each plot study in October. In parcels with 1: 2 mixtures, an increase was observed compared to other parcels. It can be said that the study field and the parcel samples are in the range of 2-4 dS / m and enter the salt free class (URL2; Zengin, 2013).

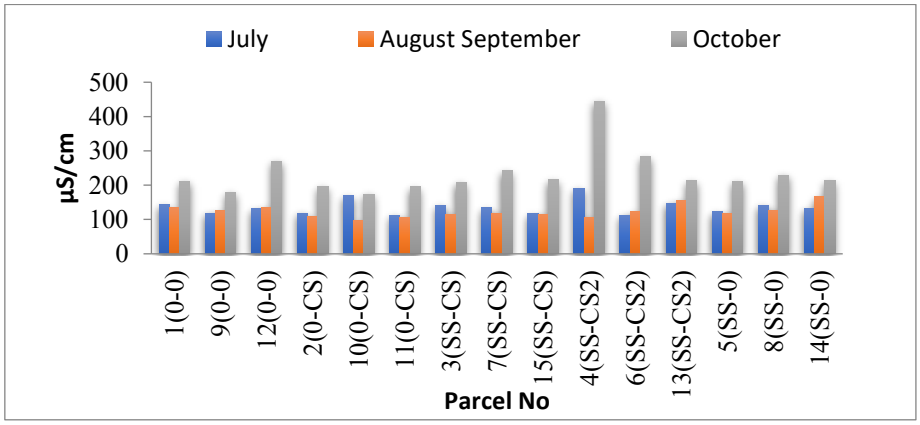
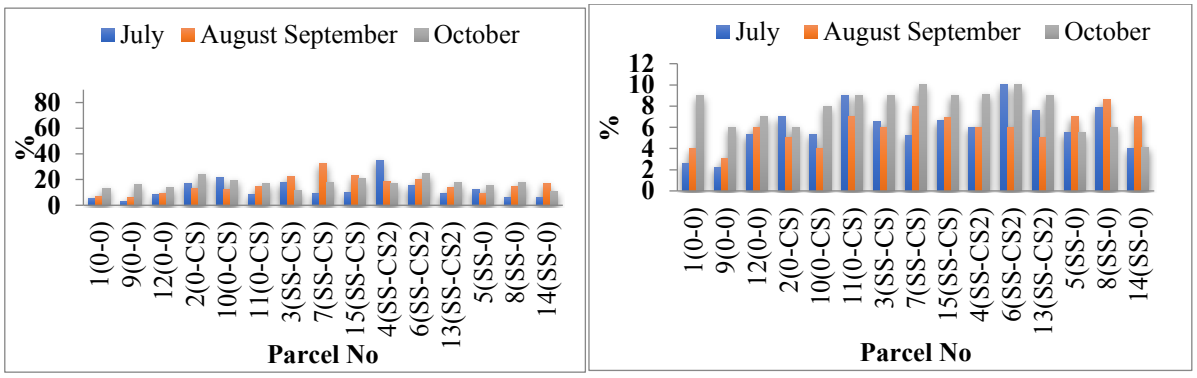


Figure 3. EC measurements

Moisture content (%); moisture content affects microbial activity. The presence of microbial activity is associated with the amount of moisture content. Therefore, moisture content is very important in the composting process. The moisture percentages of the parcels by months are given in Figure 4(a, b) both at laboratory scale and on study field respectively. It is seen that 1, 9, 12 (0-0) control parcels have less moisture holding capacity compared to sewage sludge and corn straw applied parcels.



(a) (b)

Figure 4. The moisture percentages of the parcel samples

The COD is an indicator of the chemical oxygen demand. This parameter value indicates the presence of organic matter. According to Strandart methods, the COD value calculated is given in Figure 5. The decrease in COD value indicates that chemical events occur in the environment. The Figure 5 shows that COD decreases over time. As a result, it is concluded that microbial activity in the parcels applied to the sewage sludge and corn s is more effective than the others.

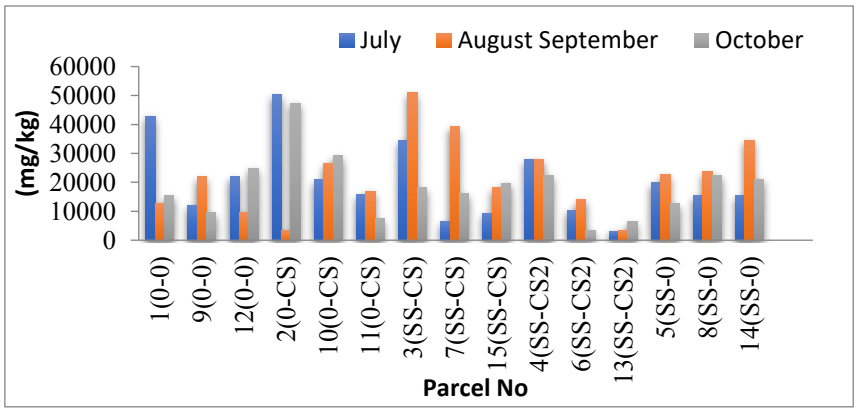


Figure 5. COD values of parcels

The C/N ratio is an important parameter value to be considered in the composting process. If this ratio is higher or lower than the recommended value, it means that no good compost material can be obtained. The C/N ratio should be between %25-50. The recommended range is %25-30 (Öztürk, 2014). Figure 6 shows the C/N ratios of the parcels. Accordingly, it is seen that there is an increase in the parcels where only corn straw is applied on a monthly basis. The decrease in other parcels is thought to be caused by microbial activity.

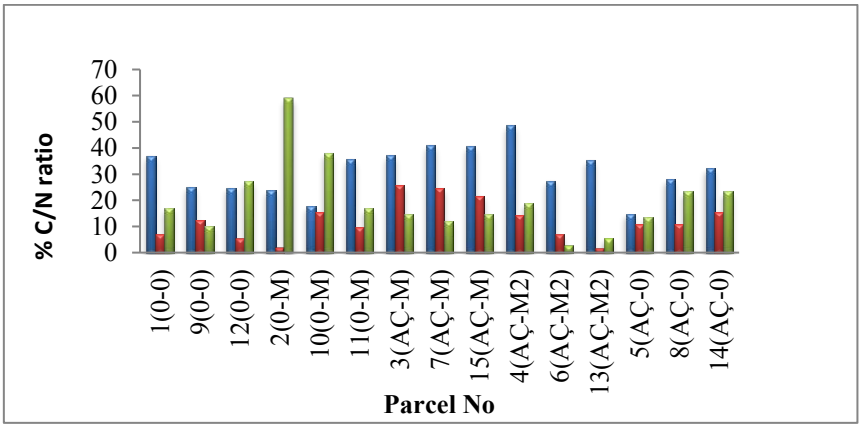


Figure 6. %C/N ratio of parcels

The amount of organic matter, the low value of this parameter in the soil disrupt the soil structure. If this parameter value is not sufficient for both soil and plant, it means that macro nutrients required for plant and soil are low. As an indicator of microbial activity, the amount of organic matter is expected to be primarily high and then low. Figure 7 shows the variation of the amount of organic matter over months. Accordingly, a decrease is observed in all parcels after the increase in the initial months. The highest value is observed in the parcels 0-CS (2, 10, 11) and a less increase is observed in the parcels 0-0 (1, 9, 12). On the other hand, it is seen that there is a higher increase in the parcels treated with sewage sludge and corn straw. This can be originated from bulking agent material and sewage sludge yielding organic matter to the soil.

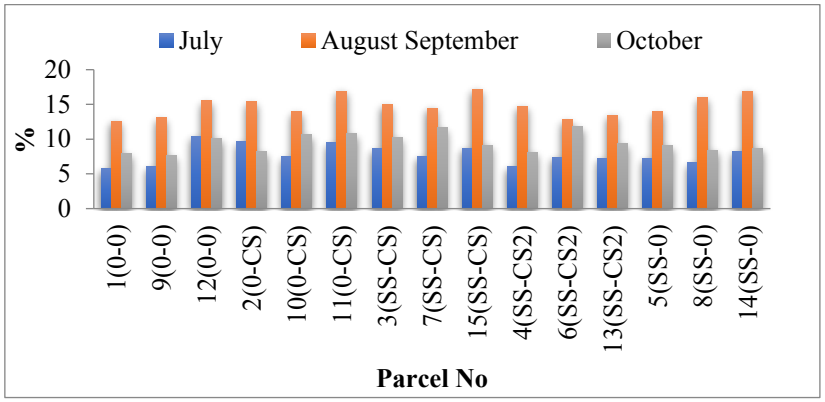


Figure 7. The organic matter quantity on the parcel samples

The penetration resistance, this parameter value varies depending on the moisture content of the soil. Soil compaction occurs in soils with low humidity (Negiş et. al., 2016). This soil compaction provides a negative effect on plant growth by preventing root growth in the plant (Turgut and Öztaş, 2008). The volumetric measurement results of the penetration resistance are given in Figure 8. According to this; high penetration resistance was not obtained at the end of the study. The reason for this is thought to be due to the increase in soil moisture content due to winter and autumn conditions. Although it cannot say clearly due to weather events, the use of maize alone is predicted to cause soil compaction. In addition, at least one year is required for this composting on the area.

Porosity is related to soil structure, texture, organic matter content and bulk weight. The porosity value, which represents the ratio of the void volume to the whole volume in the ground, is always expected to be less than 1 (100%) (Uzuner, 2007). The porosity value of the medium constitution of soils is in the range of 50% (Demiralay, 1993). In the study, the porosity rates of parcels SS-CS (3-7-15) and SS-CS2 (4-6-13) are higher. This high value is expressed as an indication of water and gas storage in the soil. In this study, it can be said that it has an effective result when compared to control parcels. Along with porosity value alone isn't sufficient, it does not give precise information about soil structure too.

The rate of infiltration is related to the rate uptake water of soil. Environmental conditions such as soil structure and texture affect the rate of water uptake, ie infiltration rate. For the infiltration rate, this study was carried out on the velocities of water intake velocities at depths of 5, 7.5, 10, 15 and 20 cm. When all parcels were irrigated for moisture balance during the same period, it was observed that water accumulation occurred on the upper surface of parcels 0-0 (2, 9, 12). In the parcels 0-CS (2, 10, 11), it is seen that less water intake rate occurs in more time than the others. It can be said that this situation causes less water permeability due to the compression of the soil structure of the parcels 0-0.

Ion analysis, macro and micro nutrients are important for both soil and plant. When some parcels are compared with control parcels, it is seen that there is a decrease. There are many reasons for these diminish. However, the most obvious reason is that it is not a farmland but a residential garden. It was later learned that the garden area was used as stove residue place and waste collection place in the area where the application was made in previous times. This suggests that these values also vary due to the study area.

4. CONCLISION

The widespread use of these practices in arid climates such as Konya Plain is very important both in terms of soil quality and other nutrients required for soil. In this study, the effects of corn stalk and sewage sludge on soil quality were investigated. As a result of the study, it can be said that the use of mixture of sludge and corn straw in different ratios gives effective results on soil quality. It is believed that the treatment sludge (SS) and corn straw (CS) samples are more effective than the control samples. Apart from physical and chemical analyzes, plant material was cultivated in the study parcels. It was used spinach as plant material. According to the results of plant cultivation, the most effective application can be said to be parcels applied the sludge and corn straw. Also, in terms of variation and LSD analysis, it can be said that give effective results.in SS-CS2, SS-CS and SS-0 parcels

With this research, it is concluded that the composting of sludge and bulking materials is suitable for sludge disposal. In order to be able to evaluate the results of the study and to reveal more detailed results about the yield, application studies should be carried out on a broader scale in agricultural land. In addition, this study was started in April. It is thought that this period can be kept in winter to obtain more efficient results for compost. Further research on the industrial sludge used in the study should be conducted and composting with different volume increasing materials should be carried out.

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