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Research Article

The Effect of Aerobic and Anaerobic Composting of Municipal Solid Waste (MSW) Generated on Agriculture

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ABSTRACT

The expansive sums of Municipal Solid Waste (MSW) produced in modern society, as well as its transfer, represent a serious environmental, social and financial issue. Among the techniques of disposal characterized by a low environmental affect, composting of the organic fraction of municipal solid waste is an environmentally, economically and agricultural interesting solution. The main objective of this research was to study the physical and chemical properties of compost made of MSW. In this article, comparisons between aerobic and anaerobic composting processes have been discussed. As well as, results showed that utilization of aerobic and anaerobic composting of municipal solid waste caused significant differences in a few of chemical and physical properties. The results of this research appear that application of aerobic composting method in carbon sequestration, chemical, physical and biological properties are effective. In addition, it ought to be famous that the impact of the parameters tested in this paper on sustainable agriculture in aerobic compost compared to anaerobic compost was significantly different. Finally, it can be concluded that organic matter has pronounced effects on the physical, chemical and biological properties of soil and the use of organic fertilizers will definitely improve soil quality and productivity. It's safe use aerobic and anaerobic composting of municipal solid waste in agriculture can be ensured with source separation as well as the development and implementation of comprehensive industry standards.

Keywords: Municipal solid waste; Chemical property; Organic agriculture; Microbial enzymes

INTRODUCTION

Nowadays, sustainable development is one of the topics that have attracted the attention of numerous improvement specialists. Sustainable agriculture is one of the important aspects of sustainable development in organic agriculture [1]. Maintaining the optimal amount of organic matter in the soil is one of the most basic principles in sustainable and organic agriculture [2]. The most important sources of soil organic matters and nutrients are mostly livestock excrements, herbal remnants, and municipal waste compost that due to the importance of organic farming, their usage has been widely considered [3,4].

Mismanagement of crops, including intensive cultivation and complete removal of plant debris from the soil, led to a gradual reduction of soil organic matter [5]. As a result, the expansion of organic matter to the soil is one of the important factors that should be considered [6-8]. A solution to increase the amount of organic matter in soils of the country is the use of organic fertilizers such as compost [9].

They reported Municipal Solid Waste (MSW) is generally made-up of kitchen and yard waste, and its composting has been adopted by numerous municipalities [10,11]. Transfer of huge sums of Municipal Solid Waste (MSW) produced in modern society is a serious environmental, social and economic problem for municipalities. Among the disposal techniques characterized by low environmental impact, composting the organic part of municipal solid waste is an environmentally and economically interesting solution.

Composting MSW is considered as a way to reduce organic waste from landfills and create relatively low cost products that are suitable for agricultural purposes [12,13]. This issue is related to financial and environmental factors such as the capacity of municipal waste disposal. Appropriation of environmental protection laws,

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diminish to utilize of commercial fertilizers, expanding the reusing capacity of household waste and improving the quality of compost products is effective [14-17].

This result is consistent with the finding of and reported composting is a could be prepare of controlled degradation of organic matter by microorganisms [18,19]. Traditionally, composting has been utilized for agricultural wastes to decrease volume and water substance, destroy pathogens and produce a scent free, nutrient and humus rich product for use as a natural enrichment of soils. Composting has been widely recognized as an eco-friendly management approach to the treatment of the mechanically separated organic fraction of municipal solid waste. Commonly MSW is arranged of by incineration or landfill, however composting has become a well-established management approach to stabilize the organic matter contained in the MSW. The composting process can provide stable and valuable substrates through biological oxidation of the organic part from diverse parts of the waste. Compost is important as a modifier since it can improve the level of organic matter in marginal lands and maintain long-term soil fertility and productivity.

The main condition for the application of compost on agricultural lands is its degree of stability (the point at which oxygen consumption is reduced so that anaerobic conditions or odors are not made) or the compost production process (conditions where compost is not made). Any unfavorable impacts on plant that imply stable organic matter content [20,21]. The use of non-stabilized compost within the soil can cause several effects of plant toxicity and negatively affect the environment [22]. Characterizing solid and simple explanatory methods for checking for monitoring and describing composting processes is crucial for appropriate compost quality control [23-25]. The frequency of chemical and biological changes that occur during the composting process and the number of strategies utilized to screen these parameters have driven to the specific trouble of concurring on a particular strategy for surveying the maturity of composts prepared from different organic wastes [26,27]. Among the various parameters that can be mentioned to monitor the evolution of compost are the analysis and characterization of the water-soluble part, which may be a useful tool to improve our understanding of the whole process and to assess the level of evolution of organic matter. This is because most biochemical transformations of organic compounds take place in this area. Enzymes released by microorganisms during composting also play a key role in the conversion of various biological and biochemical components. Microbial enzymes are responsible for the breakdown of several organic compounds that are characterized by complex structures and eventually lead to the dissolution of simple water-soluble compounds [28-30].

Composting MSW reduces the volume of the waste, kills pathogens which will be display, decreases germination of weeds in agricultural fields, and devastates smelly compounds [31].With rising interest in organic agriculture, the production of organic-grade MSW compost for agriculture is additionally gaining popularity because of its positive effect on biological, physical, and chemical soil properties [32]. The quality of MSW compost is dependent on many sources of variation including the composting facility design, feedstock source and extents utilized, composting procedure, and length of maturation. In expansion to the contrasts between MSW composts, when it is connected to distinctive sorts of field soils, there are assist inconstancy in plants reaction [33].

The present work monitored the chemical, biological and physical properties changes that occurred in a municipal solid waste composting process over a 65-day period. The aim of this study was to get it the connections between the different parameters that characterize the evolution of the different composting method in soil.

MATERIALS AND METHODS

For this experimental, Kerman province, Yazdanshahr city was selected that is located (29° 22 58 N, 56° 3600 E, 230 m above the sea level). The long-term mean precipitation of area is 145 mm per annum, which mainly occurs in winter. The average annual temperature for this region 9°C and varies from -20 to 38°C. This work was initiated in summer of 2019 and it was finished in winter of 2020.

Experimental method

In this experiment, for realizing that how many sample plots are needed for an accurate determination of cover, were used to minimal area method. The first, 6 plots were measured and then average and variance were calculated. According to the following formula, minimum plot number was calculated:

$$N = \frac{t^2\left(\frac{S\bar{x}}{\bar{x}}\right)^2}{p^2}$$

Where "N" is minimum plot number, "t" is t-test with proportion at level of 5%, "p" is the error is usually equal to about 0.05 mean, "$\bar{x}$" sample mean and "$S\bar{x}$" is sample stdevation. The field experiment consisted of 6 plots (1 m^2).

Composting method

Anaerobic compost: Organic residues are put in substitute layers. After filling, the pit is covered with a layer of deny of 15-20 cm. The materials are permitted to stay within the pit without turning and watering for three months. During this period, the material settles owing to reduction in biomass volume. The material undergoes anaerobic decomposition at an awfully moderate rate. It takes almost six to eight months to get the wrapped up item.

Aerobic compost: Composting is commonly described as aerobic degradation of organic wastes where air is released in the oxygen-consuming microbial metabolism, resulting in expanded temperature. A composting system is dynamic; with exceptionally seriously control the environmental moisture reduces the air space in the compost matrix cannot function in the present of air process. Increase a certain temperature ranges, and most acids and afterward rises above neutral since the acids are that is added to improve the process, basically, biologically or chemically. Most biological material can be composted depending on the composition of substrates biological activity. This causes the system to change its own environmental conditions. Most notable is the increasing temperature. Similarly critical is the utilization of oxygen and production of carbon dioxide. In active compost, the oxygen within the pore space is expended inside minutes, so a persistent supply of fresh air is crucial for the process to remain aerobic.

Composting sampling

The first, samples were taken, crushed to pass through a 2 mm sieve and, finally, selected physical and chemical properties were measured. Organic Carbon (OC) concentration was determined by a titration method after oxidation with $K_2Cr_2O_7$ [34]. Soil pH and EC were measured in saturated paste extract, respectively (Table 1) [35].

Table 1: Compost properties for organic compounds.

Type of compost	Phosphorous (%)	pH	EC (ds m^{-1})	OC (%)
Aerobic compost	8.8	7.7	1.9	0.5
Anaerobic compost	2.8	7.89	2.3	0.3

Computation of carbon sequestration in compost

Carbon Sequestration (CS) was computed according to following equation [36]:

A: (a-100)*0.5

B: (A/100)

C: B/100

Where "A" is organic carbon (%), "a" is amount of compost ash (gr), "B" is organic carbon (g.m-2) and "C" is organic carbon (ton. he-1).

Statistical analysis

This pattern had a split-plot based on completely block randomized. All statistical analysis was performed in the SPSS system.

RESULTS AND DISCUSSION

Physical properties

There are various factors in the composting process, the most important of which have been investigated in this study. In the present study the monitoring of physical properties such as bulk density and water holding capacity was carried out and the results are summarized in different Figures.

Bulk density

The bulk density was ranged between 1.24 to 1.54 g.cm3 in anaerobic and aerobic samples during 10 to 65 days, respectively. The maximum and minimum bulk density was 1.50 and 1.24 g.cm3 in aerobic sample after 10 and 65 days, respectively. The minimum and maximum bulk density was 1.54 and 1.34 g.cm^3 in anaerobic sample after 10 and 65 days, respectively (Figure 1).

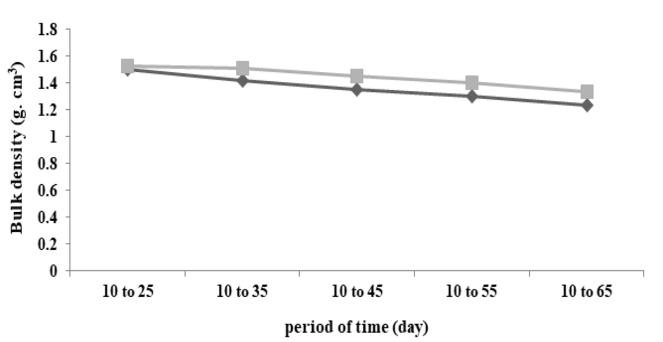

Figure 1: Comparison bulk density between anaerobic and aerobic compost in period of time. **Note:** (—◆—) aerobic; (—■—) anaerobic.

Soil bulk density can shift substantially among diverse soil types and is influenced by management practices. Consolidation of huge sums of organic matter into the soil will lower the bulk density, whereas processes that compact the soil will increase bulk density. In addition, soil bulk density has been diminished utilizing organic fertilizers because of its lower volumetric mass than soil. Moreover, organic waste matters improve soil structure and aggregation [37]. The results expressed the usage of cow manure excrement caused a diminishing in soil bulk density [38].

They conducted in northern China, reported that the use of organic and chemical fertilizers seem influence soil physical properties by changing the organic carbon content of the soil, as well the chemical composition of soil solution [39]. In another study the making of a physical, physicochemical, and biological characterization of the compost obtained from the crop residues of the horticultural plants grown in the greenhouses and to assess the physical and chemical responses of the soil to be tested after applying this organic amendment [40]. The compost has shown a high percentage of inorganic material, because the source of this compost includes not only crop residues but also soil; for this reason, it had a high coarseness index, Electrical Conductivity (EC), and pH [41]. In addition application of the organic amendment to a soil with reduced Bulk Density (BD) has increased the percentage of particles with large diameters, as well as increased the nutritional status and Organic Matter (OM). The use of municipal waste compost, sewage sludge and cow manure each, stated that addition of organic wastes to the soil increased the amount of organic material in plots compared to the control therefore the soil will lower the bulk density [42].

Water holding capacity

The variations in water holding capacity were ranged between 30.30% to 40.57 % in anaerobic and aerobic sample during 10 to 65 days, respectively. The minimum and maximum water holding capacity was 30.30% and 38.61% in anaerobic sample after 10 and 65 days, respectively (Figure 2).

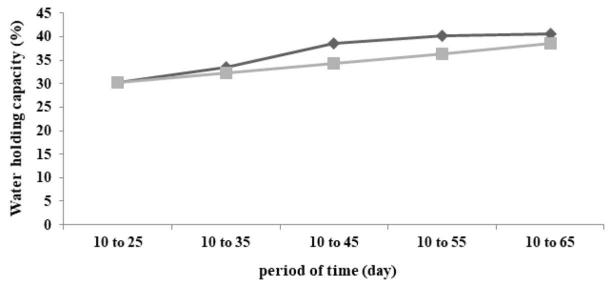

Figure 2: Comparison water holding capacity between anaerobic and aerobic compost in period of time. **Note:** (—◆—) aerobic; (—■—) anaerobic.

A primary benefit of MSW compost is the high organic matter content and low bulk density [43]. A survey of MSW compost reported that on average, 20% of the total C in MSW compost was organic C, 8% carbonate C, and 71% residual C which may have included organic C components. Furthermore, the majority of the humic substances found in MSW compost were recognized as humic acid, with a humic acid to fulvic acid ratio of 3.55. Humic acid is generally considered to be more stable than fulvic acid and has been associated with increasing the buffering capacity of its organic matter content, which in turn improved the water holding capacity of the soil [44,45]. When MSW compost was connected to soil at application the major structural units of humic acid in MSW compost were incorporated into the humic acids in the soil. The change in soil structure persisted and was structurally changed 9 years after the initial application [46]. Repeated application of MSW compost consistently increased soil organic matter content and soil C:N ratio to levels greater than those of non-amended soil [47-50]. Municipal solid waste compost had a high water holding capacity because of its organic matter content, which in turn improved the water holding capacity of the soil [51,52]. Furthermore, application of MSW compost increased the aggregate stability of soil through the formation of cationic bridges thereby, improving the soil structure. Another study also found that the addition of mature MSW compost, in this case to a silt loam, increased aggregate stability and improved the water holding capacity of the soil [53].

Chemical properties

A few soil chemical properties such as Electrical Conductivity and soil organic carbon content were measured in this study.

Soil organic carbon

Figure 3 shows that percentage of total organic carbon distribution in different compost. The results show that distribution of total carbon under different composting method was significantly increased compared with control sample. It was compared in aerobic and anaerobic compost. Being this inclination more prove in aerobic compost and less in anaerobic compost. Based on the results, it showed up that the biggest rate of add up to of total carbon had been reserved in 10 to 65 day in both of them (Figure 3).

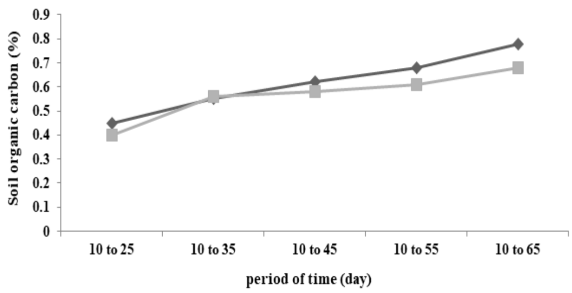

Figure 3: Comparison soil organic carbon between anaerobic and aerobic compost in period of time. **Note:** (—◆—) aerobic; (—■—) anaerobic.

In later decades it has been recognized that the amount of Carbon (C) put away in soils is critical on a worldwide scale so that management practices that either increase or decrease Soil Organic Carbon (SOC) content, can have a worldwide positive or negative impact [54,55]. The management practices of this research (composting method) accessible to organic carbon include increased use of bioenergy crops. Reported that application of organic fertilizer generally had lower soil temperatures higher soil moisture and increased organic matter in soil. The result of other researches show that using of organic fertilizer protects the soil from the direct impact of raindrops and reduce excessive fluctuation of freezing and thawing cycles of surface soil too, the application of them a buffer and sun protecting the soil from direct sunlight in this manner it may have slowed mineralization of organic carbon and, therefore, higher amount of organic carbon can be stored in the soils [56-58].

SOC concentration was greater in aerobic compost and generally decreased with anaerobic compost. Hence, they reported that application of different composting method can effect on hydrophobic properties can be more pronounced and result in lower rewetting of aggregates [59].

Consequently, hydrophobicity may be due to the presence of humic acids, which serve as strong binding agents of soil particles into aggregate [60]. This method can advantageously or antagonistically influence by affecting soil temperature and soil moisture [61]. It would sequester carbon, off-set atmospheric CO_2 levels, and improved soil and environmental quality [62].

Electrical conductivity

The Electrical Conductivity (EC) values ranged from 3.1 to 5.2 $dS.m^{-1}$ for different compost types. The highest value of EC (5.2 $dS.m^{-1}$) was found for anaerobic compost and the lowest value of EC (3.1 $dS.m^{-1}$) was determined for the aerobic compost (Figure 4).

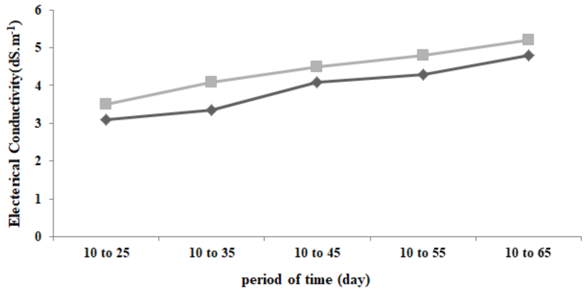

Figure 4: Comparison electrical conductivity between anaerobic and aerobic compost in period of time. **Note:** (—◆—) aerobic; (—■—) anaerobic.

Plants are contrarily influenced by abundance salts in soils and Na can be hindering to soil structure. Electrical Conductivity (EC) of the soil solution is related to the dissolved solutes content of soil and is often used as a measurement of soil salt content. A survey of selected United States MSW composts found that the Electrical Conductivity (EC) of the composts were much higher than that of agricultural soils and their use in agriculture could potentially inhibit seed germination. Agricultural soils EC levels range from 0 to 4 $dS.m^{-1}$ while MSW composts ranged from 3.69 to 7.49 $dS.m^{-1}$. The Municipal solid waste composts connected at rates extending from 40 to 120 Mg.ha-1 were seen to proportionally increase the EC of soils to which they were applied. Increased soil EC values were found to decline over time, perhaps because of nutrient removal by crops and leaching [63]. Plant growth was not inhibited in these experiments; be that as it may, the authors suspected a decrease of soil biological activity due to the increased EC levels, which were higher than the threshold value for optimal soil biological activity [64].

Biological properties

Aerobic and anaerobic composts require microbes to decomposition raw materials. Regarding this issue, it should be noted that most pathogens are not sensitive to high temperatures and anaerobic conditions. Under aerobic conditions, the compost mass may reach temperatures of 600°C to 700°C, which is high enough to kill pathogens in the raw material, while in the anaerobic compost process the temperature never reaches 700°C.

Therefore, the possibility of the pathogens to stay into the compost is essentially higher as compare to aerobic decomposition. In aerobic composting systems, the most important factor is interaction between weed species and different composting parameters like temperature, time, and moisture [65]. During aerobic composting, higher temperature (up to 700°C) increases the mortality rate of weed seeds. In this manner, the longer the term of high-temperature introduction in composting, the higher weed seed mortality. Comparative think about on compost reports that, at 35% moisture and 50°C to 700°C the weed seeds like barnyardgrass, pigweeds, and kochia were killed. Generally in aerobic composting process fungal pathogens do not survive due to high temperature [66].

Be that as it may, numerous of them a reproductive structures are ordinarily more warm resistant than their vegetative structures. Many pathogenic fungi like Fusarium oxysporum, Olpidium brassicae, Synchytrium endobioticum and Plasmodiophora brassicae, Phytophthora infestans can produce their reproductive structure that can survive from 400°C to 650°C for 10-30 minutes. Additionally bacterial plant pathogens are impossible to survive composting, where temperature normally rises above 500°C [67]. Therefore, high temperature is one of the essential factors for complete removal of pathogenic fungi in compost. In all of these studies, the important role of the thermophilic phase of aerobic compost processes compared to anaerobic compost, whereas at that temperature never rises to 650°C.

In anaerobic compost, pathogens are a major risk to compost because of the need of warm that can kill the pathogens. The as it were way to annihilate the pathogen during this process is the lack of access to oxygen, which provides unfavorable conditions for pathogens that can eventually be slowly removed from the compost. In addition, biological antagonisms against these pathogens in compost can reduce the possibility of pathogens in anaerobic compost and it fundamental to have completely anaerobic conditions in this regard.

Variability of metal levels in MSW compost somewhat hinders the ability to directly compare studies because of the sensitivity of soil microorganism to heavy metal stress. Studies on the effects of MSW compost on soil biology should include metal analysis results for this reason. Whereas MSW compost appears to enormously influence soil enzyme activities, no short term change in the structure of the bacterial community, measured using molecular techniques, have been observed.

The thermophilic stage of composting occurs as microorganisms multiply in the pile and is characterized by increased temperatures ranging from 45°C to 70°C. The thermophilic stage is also important in diminishing the populaces of pathogens in MSW compost, which cannot live at these high temperatures. Total faecal coliforms, and specifically Escherichia coli, faecal Streptococci, Staphylococci, Salmonella, and Shigella decreased greatly in numbers in MSW compost after the compost reached temperatures above 55°C. However, regrowth of fecal coliforms was observed in all windrows tested and may have posed a health risk when the piles were turned [68].

Carbon sequestration

Figure 5 shows that percentage of carbon sequestration in aerobic and anaerobic compost. The results show that carbon sequestration under aerobic composting method was significantly increased compared with anaerobic composting method.

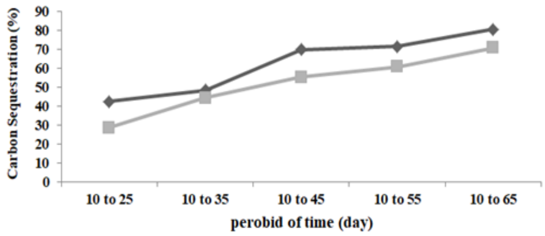

Figure 5: Comparison soil organic carbon between anaerobic and aerobic compost in period of time. **Note :** (—◆—) aerobic; (—■—) anaerobic.

The variation carbon sequestration was ranged to 28.57 to 80.55 in anaerobic and aerobic compost during 10 to 65 days, respectively. The minimum carbon sequestration was 42.34 after 25 days maximum was 80.55 after 65 days in aerobic sample. The minimum carbon sequestration was 28.57 after 25 days maximum was 70.68 after 65 days in anaerobic sample (Figure 5) [69].

As a practical result, the effect of the type and application rates of different compost on the content of SOC at the end of the experiment for both soils is presented in Figure 3. As shown, the application of aerobic and anaerobic compost into the soils led to a significant increase in the SOC content. The higher the rate of added organic matter was, the higher increase in SOC content was observed. This result is consistent with the findings of who found an increase in the final SOC content after application of organic matter. So also, observed that carbon sequestration was improved with the application of organic fertilizer such as distinctive compost.

They reported that application of aerobic composting generally had lower soil temperatures higher soil moisture and increased organic matter in soil. The result of other researches appear aerobic composting protects the soil surface from the direct impact of raindrops and reduce excessive fluctuation of freezing and thawing cycles of surface soil moreover, the application of this compost a buffer zone between the soil surface and sun protecting the soil from direct sunlight therefore it may have moderated mineralization of organic carbon and, therefore, higher amount of organic carbon can be put away within the soils.

SOC concentration was greater in aerobic composting and generally decreased by anaerobic composting method. The magnitude and trends of change in physical properties depend on composting method. Thus, reported that anaerobic composting method lead to soil compaction, low Organic Matter (OM) and weak structure of the soil. Application of aerobic composting method can effect on hydrophobic properties can be more pronounced and result in lower rewetting of aggregates. Consequently, hydrophobicity may be due to the presence of humic acids, which serve as strong binding agents of particles into aggregate. This method can beneficially or adversely affect by influencing soil temperature and soil moisture. It would sequester carbon, off-set atmospheric CO_2 levels, and improved soil and environmental quality.

CONCLUSION

Anaerobic composting was considered as a possible alternative to aerobic composting. The major support of anaerobic composting was the minimization of nitrogen loss. Even had this advantage, the imitation and disadvantages of the anaerobic mode cannot be neglected. There are several advantages of aerobic composting over anaerobic composting like: a) rapid decomposition of raw material, b) temperature of pile raises up to that level where pathogens and weeds cannot survive, c) the number and intensity of objectionable emissions are sharply reduced and, d) can be generated in a short period of time. Finally, it can be said that the use of aerobic compost versus anaerobic compost can have a significant impact on physical, chemical and biological properties and ultimately create sustainable agriculture.

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