INVESTIGATION OF OPTIMUM CONDITIONS OF CO-COMPOSTING PROCESS BY USING OF SEWAGE SLUDGE AND MUNICIPALLY WASTE

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ABSTRACT

Co-compost can be obtained by combination of sludge and solid waste which are using in the agriculture land and solve municipalies waste and water treatment plant problems. The goal of the study was to investigate a methodology for settling optimum conditions such as aeration rate, temperature, moisture content, C/N ratio and size of particle in composting process. Two pilots were prepared and in every pilot different combination of municipally waste, sludge and wood pulp were used. Particle size of blend and aeration rate was he differences between two pilots.

The results showed that the pH of compost pile was about 10 in begining of process and decreased to 7.25 gradually after 7 days. The proper size of particle was between 10-40 mm. The suitable C/N ratio was between 25 to 35 and it was about 33 in this experiment. Higher temperatures caused increasing microbial activity in begining of process. To homogenize the temperature, it is vital to make an agitating the compost pile every 4-6 days. Increasing in co-compost temperature was happened when the MC was between 50 to 60%. Aeration with three times of requirement air has given the best result. Finally, we found that the MC has a greater affect on the microbial activity than the temperature. These results support the use of co-compostng process with make-up particle size and moisture capabilities in preference to forced aerated enclosed reactors.

Keywords: Co-compost, Sludge, Municipally waste, Compost teperature

INTRODUCTION

More production and consequently more consumption is one of the specifications of novel world. Composting is a natural process by which microorganisms decompose organic matter into simpler nutrients. As the quickest way to produce high quality compost, aerobic composting is a widely accepted way of stabilizing organic wastes and converting them to a usable, and value added compost product.

Modern wastewater treatment plants use a combination of biological, physical and chemical processes to treat the water. A by-product of this treatment is biosolids, the dewatered sludge generated during primary, secondary, or advanced treatment of municipal wastewater.

Sludge refining is more sensitive and taking cost than others sections in the wastewater treatment plants. For example, 30% of total expenditure for manufacturing of wastewater treatments plants is allocated to sludge stabilization unit (Karimi, 1994). Many researches have been done to selection of suitable pattern of sludge stabilization in some developing countries and it should be considered by Iranian researchers too.

Co-compost should be provided and used in the suitable and sanitary situation, because the municipal waste has incongruous component and all of its components don’t have ability to decompose and generate compost. Also if some of the components of the garbage would have been mixed in soil, the quality of soil would have been decreased and it was infected with pathogenes. These pathogenes could have been created several diseases in animal and men too. Also the sludge contains high content of heavy metals that they can decrease the quality of sludge (Altenbas & yagmur, 2004). One of the effective ways to neutralize unfavorable effects of wastes and sludge is conversion of these materials to compost and reusing them as organic fertilizer to agriculture.

Therefore, the goal of our research is to understand the relationships between temperature, moisture content (MC) and microbial activity during biosolids composting, and quantify the effect of temperature and MC on microbial activity of a specific blend used in composting. Quantifying these relationships will lead to a sound foundation and new insight toward better control of commercial biosolids composting.

MATERIALS AND METHODS

In this work, the sludge which produced from Yasreb wastewater treatment plants in Ghaemshahr city was used. Also the compost was provided from Anjelsi compost manufacture in Babol city. The particle size of compost was 0-40 mm. The experiments were done two stages in the different seasons. In the winter season, first stage was done by using of municipally waste particles less than 10 mm and initial moisture about 78% without agitaion and also different aeration rate.

In this research the pelexiglass reactor with 20cm in diameter and 100cm in length has been used. In order to aeration on the reactor a vacuum engine with maximum aeration power 66 *l/min* was used and it was installed in bottom part of reactor. Likewise to circulation of air through co-compost was used from wooden intermediate 5*5 cm in dimensions. To maintain and control temperature in compost process, body reactor was covered by glass wool.

Initial compost mixture was made from dehydrated sludge of waste water treatment plant after secondary sedimentation, municipally waste and bulking agent. To attain optimum ratio, several samples was tested. The wood particles (5*5 in dimensions) were applied as bulking agent due to high MC and small dimensions of inlet materials.

After sampling, the samples were kept at cool conditions until the experiment was performed. The experiments were done to measuring some quality properties such as dry solids, organic materials, C/N ratio and pH. The percentage of total solid (TS) in sludge was evaluated between 1 to %2. Before loading, the sludge should be concentrated and dehydrated to achieve %30 concentrated solid. In first stage, the sludges were placed in plastic container for several hours. Then the sludge was separated into two seperable phases: water and dense solids phases, as the solids density in sludge was reached to 2-3%. In next stage, these materials were scattered over a plastic on the ground until the materials were concentrated to 25-%35. To produce reliable compost at minimum time, the composting process have been monitored by sampling at suitable time to measure and adjust of index factors of process such as temprature, MC and pH.

Monitoring of process was accomplished via sampling and determination of content of index factors. Sampling was performed every 2 days manually**.** To determine the temperature and MC, the samples were provided from the middle and above of the pile. One sample was provided from this mixture to determine the pH.

Determination of organic mater and carbon

The mixture ratio should be chosen as it enables to modify characteristics of process such as stability, porosity, MC, C/N ratio and enability to produce of energy. Therefore, the optimum C/N ratio to prduce of compost is 25:1 to 35:1.

In combustion method, 2 gr of samples were weighed and dried in an air oven at 105°C for 24h, until the sample was dried (ASAE, 2004). Then the dried sample is weighed to determine dry weight (A). The dried sample is burned in furnace at 550°C. After cooling in desicator, it is weighed to measurement the ash weight (B). The contents of organic mater and carbon are measured as follows:

% organic mater: (A-B)/A × 100
% carbon: (% organic mater) / 1.8

Determination of nitrogen

The content of nitrogen was determined by kjeldahl method using automatic kjeltec analyzer (unit 2300). To determination of Nitrogen content, 0.5 gr samples were strewed into special experiment tube then 10 ml of 0.1N H_2SO_4, a digestion pellet containing $CuSO_4$ or K_2SO_4 and some drops of octane normal as anti-scum was added. Digestion system has been turned on already and after placing the pipes inside the system, the temperature of furnace raised up to 400ºC till complection of samples. After the digesting and cooling, some distilled water was added into each pipe and placed in titration section of automatic kjeldahl analyzer. The titration of samples was done for a few minutes and the total percentage of nitrogen was recorded on monitor.

Determination of moisture content, temperature and pH

After loading of the compost pile, to attain the optimum operation of process, the process was monitored by measuring of index factors such as pH, temperature and perentage of moisture. The moisture of sample removed from compost pile was measured using an oven drying method (ASAE, 2004), in which **2** g of sample (A) were dried in a convection oven at **105^{o}C** for **24 h** and then wheighing dried samples (B). The MC of sample was measured by using the following formula.

$$MC\% = \frac{A-B}{A} \times 100$$

To determination of pH, ten gr of samples was weighed and strewed into Erlenmeyer flask then 100 ml of distilled water was added to it. The prepared sample was placed in Auto shaker for 30 min. The pH of samples was measured by using of pH meter.

Measurement of temperature is one of the most obvious characteristics of progress of fermentation process. Three thermocouple sensors were used at the bottom, middle, and the top surface of the compost pile to measuring of bulk temperature. The values reported are the average of the material temperatures measured during process in the three layers. Changes in the material temperature during drying were recorded using a data logger.

RESULTS AND DISCUSION

Effect of the impressive factors in co-compost process was investigated in two stages.

Co-compost

The C/N ratio in municipally waste and sludge is equal to 40/1 and 9/1 respectively. In this experiment, the combination of waste to sludge was 3 to 1 which the C/N ratio was 33/1. The changes of index factors such as pH, temperature, MC and aeration quantity during the experiment is manifested in Fig. 1, 2 & 3. The variation in the pH to keeping time was illustrated in Fig. 1. The pH of compost pile was 9.63 in begining of process and decreased to 7.15 gradually. This value is about neutral.

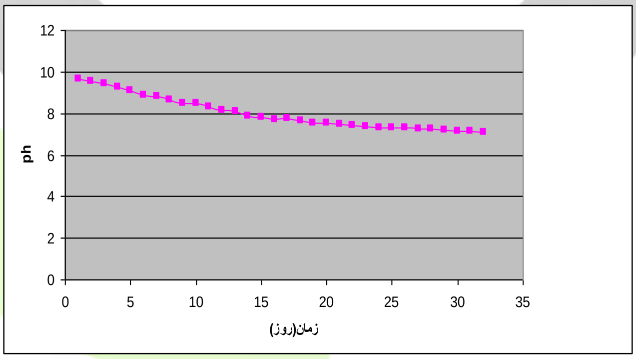

Fig (1): The change of pH versus keeping time at waste to sludge ratio 3:1 and C/N ratio 33.1

In many studies, temperature has been shown to be a critical determinant of composting efficiency (Miller, 1992; Namkoong and Hwang, 1997; Joshua et al., 1998). The variation of temperature to keeping time represents in Fig 2. It shows that by decreasing in pH, the microbial activity was started simultaneously. We found that pH was apparently important factors impacting microbial activity in composting mixes due to increasing in temperature.

Because of cold weather (8ºC) increasing in temperature was started from 6th day and it was reached to 50ºC after 25 days. Many researchers reported that the temperature range for optimal composting is between 52 and 60°C (MacGregor et al., 1981; Bach et al., 1984). After this stage, the tendency of temperature is declined even the aeration was stopped. In most cases, higher temperatures induced an earlier initiation of increased microbial activity.

Lack of increasing in compost temprerature represents that the sludge doesn't have perfect stability in compost pile. This lack is correlated with covering of reactor and cold environment. Also the amount of materials and size of reactor have been effect on the raising of temperature. Larger amount of materials and size of reactor produces high temperature.

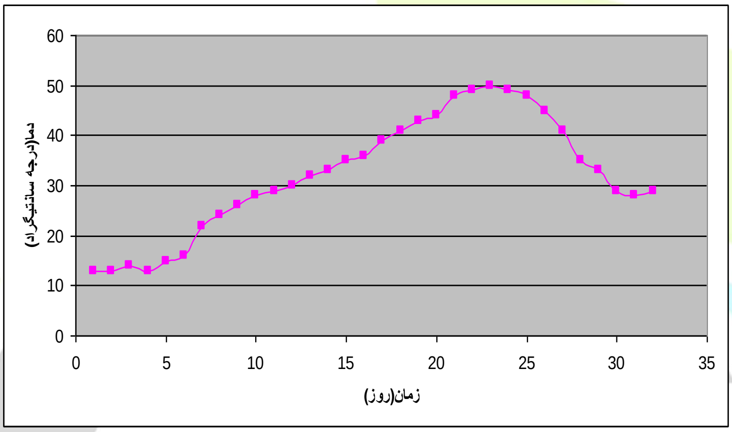

Fig (2): The change of temperature versus keeping time at waste to sludge ratio 3:1 and C/N ratio 33.1

Moisture content of the composting blend is an important environmental variable as it provides a medium for the transport of dissolved nutrients required for the physiological activities of microorganisms (Stentiford, 1996; McCartney and Tingley, 1998).

The diagram 3 is shows the variation in percentage of moisture. It was indicated that the moisture has been decreased from the beginning (78%) to end of process (48%). Due to production of emulsion, the reduction of MC was slightly high during the first week and then the speed of MC reduction was decreased.

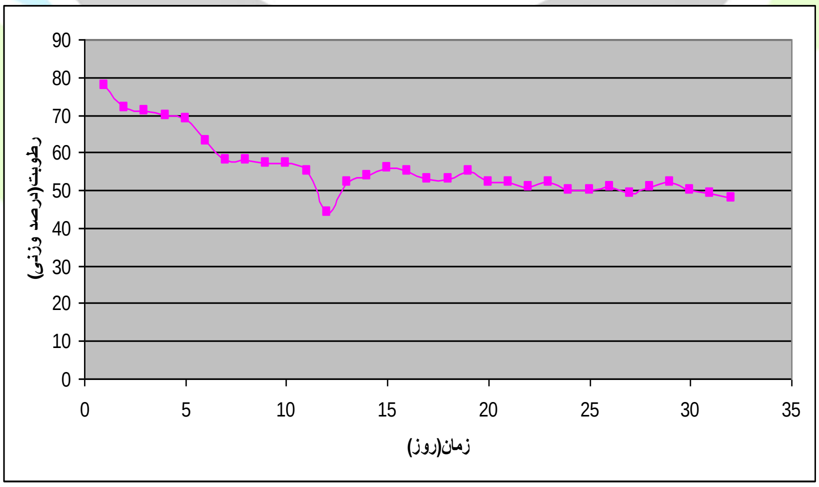

Fig (3): The change of moisture versus keeping time at waste to sludge ratio 3:1 and C/N ratio 33.1

Very low MC values would cause early dehydration during composting, which will arrest the biological process. On the other hand, high moisture may produce anaerobic conditions from water logging, which will prevent and halt the ongoing composting activities (Tiquia et al., 1998).

The result shows that increasing in blend compost temperature was occurred when the MC was between 50 to 60%. The results confirmed the obtaind data by some investigators (Tiquia et al., 1998; McKinley et al., 1986; Liang et al., 2003) that 50–60% MC is suitable for effective composting. Some parameters were changed to increase fermentation efficiency in the second experiment such as the size of waste particle to simplify aeration, nonareation in initial several days and then increasing aeration rate.

As shows in Fig (4), increasing in temperature rate was desirable. The compost temperature was decreased about 5°C after 7 days due to starting of aeration. It is interesting to say that, the compost temperature was kept at 55°C for 4 days.

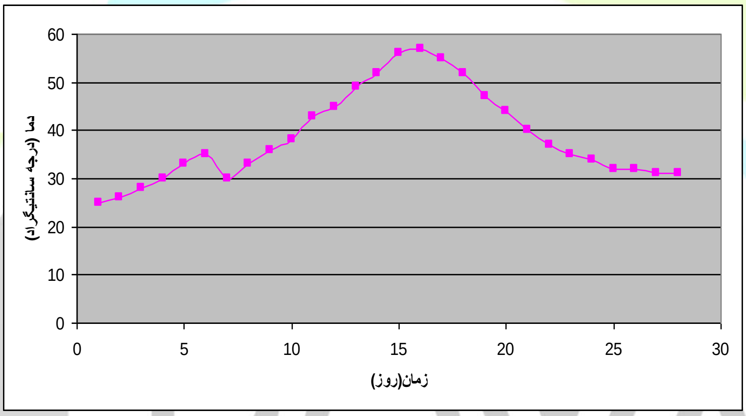

Fig (4): The change of temperature versus keeping time at second stage

As exhibited in Fig (5), the amount of moisture has been declined (less than %33) by increasing aeration rate and it have also been shown to reduce the keeping time for 4 days.

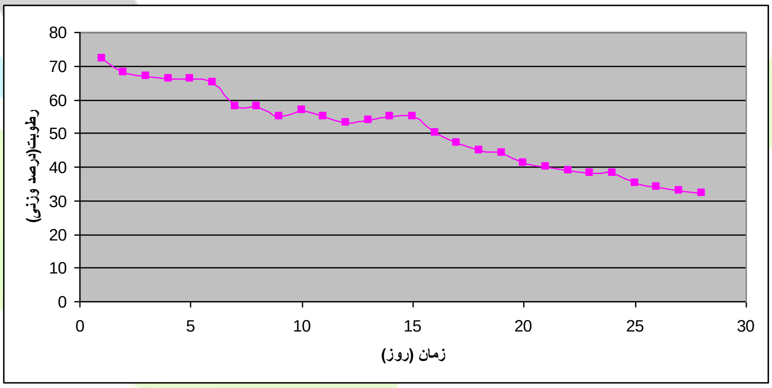

Fig (5): The change of moisture content versus keeping time at second stage

Decompose of organic matter into simpler nutrients is natural process of microorganisms. Pathogenes and some disease in compost have been related to all kinds of the microorganisms. Most of these pathogenic organisms prefer the temperature under 42ºC. Some researchers suggested that lower temperature might be more suitable for composting (Liang et al., 2003); McKinley et al., 1986).

In composting process several items are effective on vital system of organisms such as temperature, emission of ammonia and duration of process (Ahn et al., 2007). Among of these parameters, high temperature is much more important to destroy some disease. High temperature in short time and low temperature in long time has been same effect on the composting (Ahn et al., 2007; Tchobanoglous et al., 1993). Therefore it could be concluded that the Most of pathogenic factors present in compost pile would be destroy due to suitable temperature which the final product is devoid of any disease. This result was consistent with previous study (Liang et al., 2003). It is clear that pH has a significant impact on composting performance (Jackson and Line, 1997). The pH of compost pile was about 10 in begining of process and decreased to 7.25 gradually after 7 days. It was fixed during the experiment.

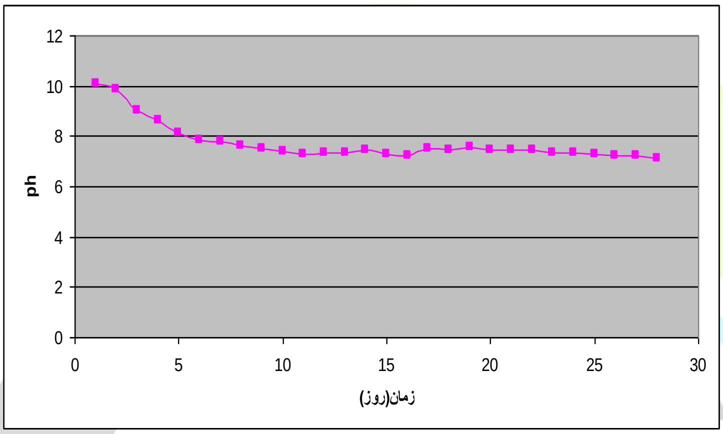

Fig (6): The change of pH versus keeping time at second stage

Measurement of the rest organic matters

Stabilization in environment sanitation sciences is always synonymous with the oxidation of organic wastes and converting them to a usable, nonhazardous and value added. One of the measurement methods of stabilization degree is based on measuring of remain organic matterials during the process (Huang et al., 2004). Reduction of organic matters is depending on combiniation of matterials and operation in composting process.

The organic matters can be stabilized in mature compost by measuring. Also by measuring the remained organic matters in compost from a collection (batch), the degree of their stabilization can be compared together rapidly. The organic matters were 30% in the first stage wherease it decreased to 25.4% in the second stage. It is therefore concluded that the second stage compost is more matured.

CONCLUSIONS

The goal of the study was to develop a methodology for determining optimum conditions such as temperature, MC, C/N ratio in composting process. The following results can be concluded. To increasing of contact surface to attack of microorganism, the particle sizes must be so small. The materials smaller than 10 mm resulted in clod pile, which is created an impervious surface to passing the air for reducing moisture. Therefore the microorganisms couldn’t feed from nutrients in garbage. Therefore, the proper size of particle is between 10-40 mm.

- The nitrogen is the main necessary nutrient for microorganisms. The suitable C/N ratio was about 25-35.

- By consideration of moisture importance for microorganisms, the suitable MC was between 50–60% for effective composting.

- The aeration can be decline the compost moisture. Aeration with three times of requirement air has given the best result.

- To homogenize and balancing the temperature, it is necessary to make an agitating the compost pile every 4-6 days.

Finally, there is closed relationship between MC and temperature but the MC has a greater influence on the microbial activity of biosolids blends than does the temperature. These results support the use of co-compostng process with make-up particle size and moisture capabilities in preference to forced aerated enclosed reactors. Further work is required to validate these results in full-scale operations and different combinations.

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