EVALUATION OF THE BIOSOLIDS COMPOST MATURITY IN SOUTH ISFAHAN WASTEWATER TREATMENT PLANT

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ABSTRACT

The composting process is a useful method of producing a stabilized material that can be used as a source of nutrients and soil conditioner. Maturity of compost is essential for its optimal use as a soil amendment and a source of plant nutrients as well. Immature composts pose problems of malodors and flies and phytotoxicity and pollution during use. Stability and maturity both are required for compost quality control. Compost maturity tests can be classified into physical, chemical, plant, and microbial activity assays. In this study, several methods of evaluating the stability and maturity of composted biosolids were compared based on chemical and biological properties. The sludge used of windrow composting was obtained from the drying beds of South Isfahan wastewater treatment plant. The results showed that, C/N ratio after 100 days of composting reached to 15/1; NH_4/NO_3 ratio decreased with increase of the time dewatered sludge compost, which this loss is 57.3%. The content of volatile solids, 28.8% decreased with composting time. The number of fecal coliforms in the initial sewage sludge compost was 17.9×10^6 and at the end of composting was 898MPN/g of total solids and the compost process provided class A pathogen criteria. Use of chemical and biological parameters exhibited three phases: rapid decomposition (day 40), stabilization (day 80) and maturation (day 100) in biosolids compost. Thus, the biosolid compost was mature and ready for use as an agricultural substrate after about 100 days of composting.

Key words: Maturity, stability, compost, biosolids, wastewater treatment plant

INTRODUCTION

As a promising alternative for biosolids disposal, land application of composted biosolids has increased in the past decade (Goldstein and Steuteville, 1996). One of the important factors affecting the successful use of biosolids compost for agricultural purposes is stability and maturity it. Application of unstable or immature compost may cause slow plant growth and damage crops by competing for oxygen or causing phytotoxicity to plants due to insufficient biodegradation of organic matter. Because extensive research has been conducted to study the composting processes and to develop methods to evaluate the stability and maturity of compost prior to its agricultural use (Jimenez and Garcia, 1992; Mathur *et al.*,1993; Iannotti *et al.*, 1994; Hue and Liu,1995).

The terms "compost stability" and "compost maturity" are frequently used in the scientific literature. Compost stability definition is the rate or degree of organic matter decomposition. As such, compost stability can be expressed as a function of microbiological activity; it can be determined by O_2 uptake rate, CO_2 production rate, or by the heat released because of microbial activity (Chen and Inbar,1993; Iannotti *et al.*, 1994). Compost maturity refers to the degree of decomposition of phytotoxic organic substances produced during the active composting stage; it can be assessed by plant or seed testing (Zucconi *et al.*,1981; Iannotti *et al.*,1994). Understanding and properly defining compost stability and maturity, will assist standardization and regulation of the methods used to evaluate compost quality. To date, no single established method has been developed to measure the relative degree of

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stabilization effectively and reliably. In fact, the very term used for the degree of completion of the compost process is in itself debated by academicians. Hue *et al.*, (1995) stated that stable compost was not necessarily mature as it could still produce inhibility or phytotoxic effects on selected plants. Compost stability has been measured in terms of physical, chemical and biological parameters. The numbers of the more common methods of measuring compost maturity are presented in Table 1 (Inbar *et al.*,1990).

Table 1: The numbers of the more common methods of measuring compost maturity

General method	Criteria
Physical analysis	Temperature, colour, particle size
Chemical analysis	Carbon/nitrogen ratio, Water soluble ions , Water soluble organic Matter, cation exchange capacity
Microbiological analysis	Indicator microorganisms
Plant bioassays	Cress germination test in water extract

In addition, compost stability and maturity depends on the chemical constituents present in a compost feedstock as well as those present in various decomposition stages. Thus, compost chemical properties and feedstock are both potentially important in evaluating compost stability and maturity.

The objectives of the present study included comparing several chemical and biological parameters related to composted biosolids stability, determine stabilization and maturation time of biosolids compost process. Chemical parameters selected were volatile solids, carbon to nitrogen ratio and NH_4^+ to NO_3^- ratio. As for biological parameters, dehydrogenase activity, water-soluble carbon and fecal coliforms were selected.

MATERIALS AND METHODS

The sludge used in this study was obtained from the drying beds of South Isfahan wastewater treatment plant. In this experiment, windrow type of composting was performed to stabilize the mentioned sludge. It should be noted that the height, width and length of windrow were 1.2, 1.5 and 2.5m, respectively. The moisture content of sludge was about 80%. To control and adjust the moisture content to 60%, sludge was mixed with the sawdust. Because of mixing process, C/N ratio increased to 25/1. The turn over of windrow was done manually to provide sufficient amount of oxygen for microorganisms at the start of the composting cycle. Temperature was measured by thermometer at two thirds of the elevation of the windrow, at about 80cm from the top of the windrow.

The composite samples were taken from three different points of windrow. Volatile solids (VS) were determined the through measurement of ash which remained in muffle furnace at 550ºC for 30min (APHA, 1992). Total carbon content was determined through combustion in ovens at 750ºC for 2h. Total nitrogen was measured by the Kjeldhl digestion method where the sample was pretreated using salicylic acid and thiosulphate. C/N ratio was calculated by dividing the amount of total carbon to the amount of total nitrogen. The NH_4^+ and NO_3^- were detected using the KCl extraction method (Mulvaney, 1996).

Dehydrogenase activity was determined by the methods described by Tabatabai (1994). According to this method, 0.5g of compost sample was thoroughly mixed with 0.1g of $CaCO_3$. Then, 1mL of 3% aqueous solution of 2, 3, 5-triphenyltetrazolium chloride (TTC) and 2.5mL of distilled water were added.After incubation at 37°C for 24h, 10mL of methanol was added; the suspension was filtered and the amount of triphenyl formazan (TPF) in the filtrate was measured using a spectrophotometer at 485nm. A control without the addition of TTC was included for each sample. Water-soluble carbon (WSC) was extracted with distilled water (solid to liquid of 1/5), and the extracted carbon with pyrophosphate was determined by oxidation with potassium dichromate and measurement of absorbance at 590nm (Sims *et al.*, 1971). Fecal coliforms were determined according to the technique, which is presented in part 9221E of Standard methods for examination of water and wastewater (APHA, 1992).

The windrow turning was done manually with worker. It was turned to ensure availability of sufficient amount of oxygen to be utilized by microorganisms at the start of the composting cycle. The windrow was turned five times, until temperature of compost reached 55ºC, to provide the temperature required for pathogen kill, and then the substrate was cooled. The temperature was measured at two thirds of the elevation of the windrow, at about 80cm from the surface of the windrow by thermometer. The duration of composting biosolids was 100 days.

RESULTS

The results of chemical parameters for the stability-composted biosolids such as C/N ratio, NH_4^+/NO_3^- ratio and volatile solids are show in Figs. 1, 2, 3. In addition, the results of biological parameters such as fecal coliforms and dehydrogenase activity to water soluble carbon (DH/WSC) are show in Figs. 4 and 5.

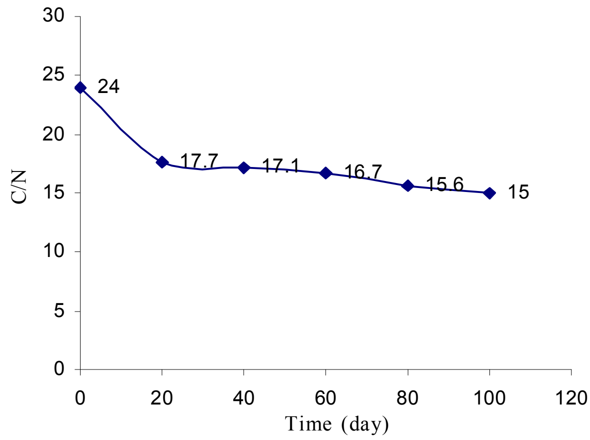

Fig. 1: Variation of C/N ratio in biosolids composting process

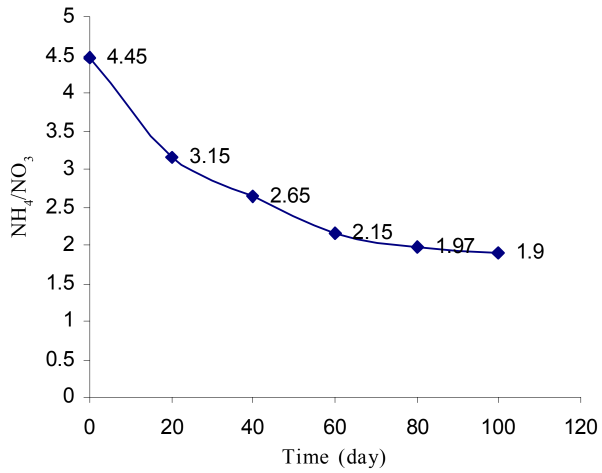

Fig. 2: Variation of NH_4/NO_3 ratio in biosolids composting process

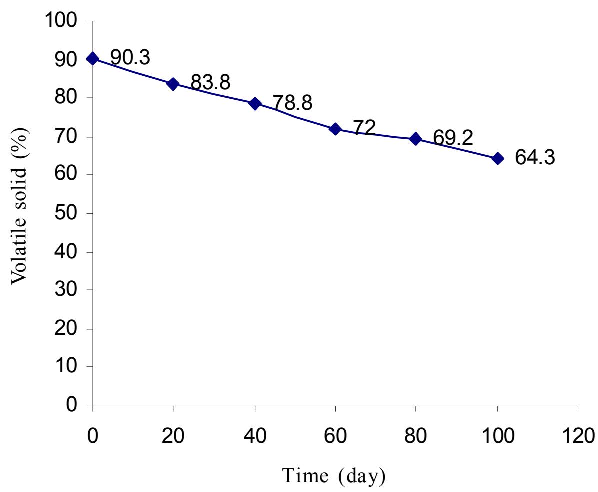

Fig. 3: Variation of volatile solids in biosolids composting process

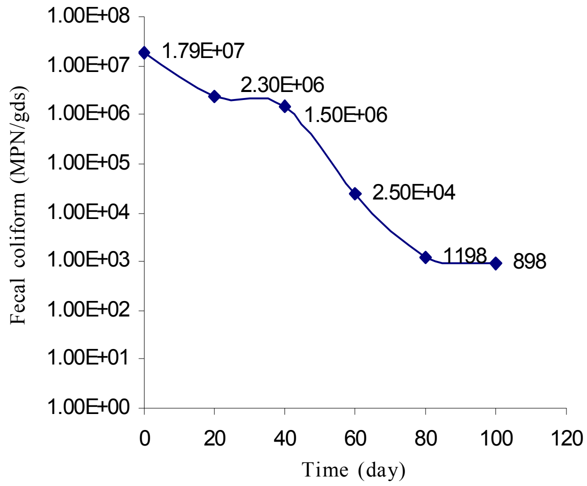

Fig. 4: Variation of Fecal Coliforms in biosolids composting process

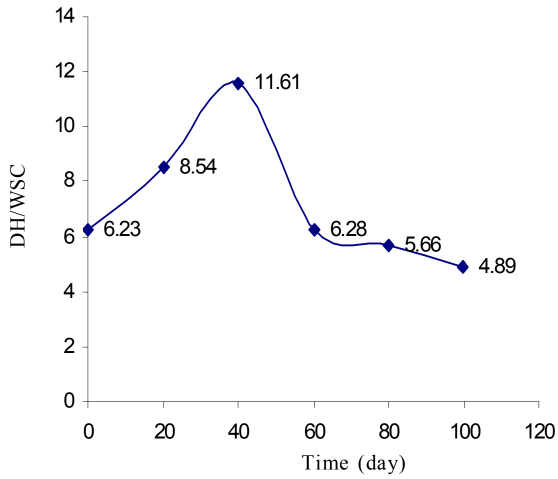

Fig. 5: Variation of DH/WSC in biosolids composting process

DISCUSSION

The initial C/N ratio of the composting materials was adjusted at about 24 (Mathur, 1993; USEPA, 1994; Mulvaney, 1996) and decreased gradually to 15 after 100 days of composting. The maximum reduction in the C/N ratio happened during the early stage (0-20 day) of composting. (Wu, 2000; Cedric, 2005). NH_4/NO_3 ratio decreased during the dewatered sludge compost, with the loss of 57.3%. The maximum reduction in NH_4/NO_3 ratio happened during the early stage (0-20 day) of composting.

The content of volatile solids, decreased with composting time due to the loss of organic matter through microbial degradation. Contents of 28.8 percent declined from an initial 90.3 to 64.3 at the end of the composting period (100 days).

The number of fecal coliforms in initial sewage sludge compost was 17.91E+6 and at the end of composting was 898MPN/g of total solids, indicating that the compost process was extremely effective in inactivating fecal coliforms.

The maximumof the DH/WSC happened during the early stage (20-40 day) of composting. The high initial activity of dehydrogenase enzyme reflected the high microbial activity. The water extract from fresh sewage sludge composting was yellow in color and the intensity of this color increased to dark black at day 40 and decreased to light brown at the end of composting (100 days). These changes in color imply changes in the type and concentration of water-soluble organics (Inbar, 1990; Chen, 1993; Mathur, 1993).

The compost maturity depends on the chemical constituents present in a compost feedstock. In this study several chemical and biological parameters related to composted biosolids maturity were compared and the stabilization and maturation time were determind.

The results from Fig. 1 indicate that C/N ratio of sewage sludge compost after 100 days of composting reached to 15/1(Mathur, 1993; USEPA, 1994; Mulvaney, 1996); thus, sewage sludge composting reached to maturation. According to Fig. 2 , if NH_4/NO_3 ratio reaches to 2, compost will be mature (Mulvaney, 1996; Wu, 2000). Thus sewage sludge composting reaches the maturation between 60 to 80 days. According to Fig. 3, the USEPA (1994) uses the value of 38 percent reduction of volatile solids as the threshold for considering the sludge stabilized, based on the work of Koers and Mavinic (1977). Thus sewage sludge composting reach the maturation after 100 days.

According to Fig. 4, the class A pathogen criteria requires that fecal coliforms density must be less than 1000 for MPN/g of total solids (USEPA, 1994). Thus sewage sludge composting reaches the to maturation between 80 to 100 days. According to Fig. 5, after 40 days, the index value slightly decreased and this phase is called the maturation phase. All chemical and biological parameters exhibited three phases:

-Rapid decomposition during the first 40 days
-Stabilization until day 80
-Maturation from day 100

Hence, the compost in this study was mature and ready for use as an agricultural substrate after about 100 days of composting.

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