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# Comparison between Windrow and Pit Composting of Poultry Wastes, Leaves and Garbage of Municipal Solid Waste in Damghan, Iran

***Yaghmaeian K [1], Malakootian M [2], Noorisepehr M [3]***

[1]*Dept of Environmental Health, School of Health, Semnan University of Medical Sciences, Iran*
[2]*Dept. of Environmental Health, School of Public Health, Kerman University of Medical Sciences, Iran*
[3]*Dept. of Social Medicine, School of Medicine, Semnan University of Medical Sciences, Iran*

## ABSTRACT

Basic principles of Integrated Solid Waste Management (ISWM) are: Reduction, Reuse, Recycling and Recovery ($4R_s$). Composting as an element of ISWM strategy that can be applied to separately collected or mixed wastes, is a controlled aerobic process carried out by successive microbial populations combining both mesophilic and thermophilic activities and leading to the production of carbon dioxide, water, minerals and stabilized organic matter. In this research, comparing between windrow and pit co-composting methods was studied in the city of Damghan, Iran. Waste proportioning was done based on C/N ratio (about 25:1) and moisture content (about 55%). Mixed wastes were located in windrow and pit with natural aeration tunnel. Sufficient oxygen supply was provided in the piles of compostable materials in two systems through frequent turning of the piles in 7 d intervals during the first month. Temperature reached to maximum level in 10-15 d and then depleted (days: 20-25). It reached to the safety level (about 60˚C) based on U.S.EPA and WHO recommendations. Finally, compost was produced with pH=7.7, dark brown color and 30- 35% moisture content. N, P, K, organic matter and organic carbon were measured by standard methods. Results were compared with WHO and U.S.EPA recommendations showing suitable conditions Also it was indicated that pit method was better for maintaining temperature, nitrogen, organic C and organic matter.

**Keywords:** *Composting process, Windrow, Pit*

## INTRODUCTION

At present, one of the most important threats for human and other living beings is the disposal of different pollutants into the environment. Solid waste disposal creates a problem primarily in high populated areas (ISWA, 1998). Basic and acceptable principles in the Integrated Solid Waste Management (ISWM) are Reduction, Reuse, Recycling and Recovery, defined as $4R_s$ principles (ISWA, 1999). Composting is one of the fastest-growing aspects of ISWM (Davis and Cornwell, 1998). Aerobic composting process has been developed for many reasons such as higher decomposition rate and lower stabilization time, odorless conditions and producing higher temperatures resulted to higher safety from the point of view of pathogens and parasites destruction (WHO, 1985). Windrow and pit methods are done by piling and turning the wastes once or twice a week for more effective aeration and providing

***Corresponding author:** Tel: +98 21 88363845, Fax: +98- 21 88363722, *E-mail:* k_yaghmaeian@yahoo.com

more heat (Sincero and Sincero, 1996). The phases which can be distinguished in the composting processes according to temperature patterns are:latent, growth, thermophilic and maturation phases (Polpraset, 1996), or lag, active and maturation (curing) phases (Kreith, 1994). The purpose of a curing phase is to ensure that the compost is stabilized, allowing the remaining nutrients to be metabolized by the available microorganisms (Landreth and Rebers, 1996). Composting results in a volume reduction of up to 50% and consumes about 50% of the organic mass on a dry basis, by releasing mainly $CO_2$ and water (Kreith, 1994). Composting takes approximately 6 weeks with additional 2 or more weeks for curing and complete stabilization (Sincero and Sincero, 1996).

To increase the porosity of the mass for effective aeration in all methods of composting, this is normally done by mixing the wet and dry materials (Sincero and Sincero, 1996). The suitable size is from 0.5 inch (13 mm) to about 2 inch (50mm) (Kreith, 1994).

Oxygen should reach to the all points of the mass (Sincero and Sincero, 1996; Tchobanoglous et al., 2003). Aerobic conditions must be maintained by turning the compost pile or forcing air through it (Davis and Cornwell, 1998; Tchobanoglous et al., 2003). In windrow or pile methods, this will necessitate frequent turning of the piles in 4 to 5 d intervals (Sincero and Sincero, 1996).

The ranges for optimum moisture content greatly depend on the type of feedstock, its particle size and the rate and type of composting desired (Landreth and Rebers, 1996). Generally, ranges of 50 to 60 percent are desirable (Landreth andRebers, 1996; Sincero and Sincero, 1996; Davis and Cornwell, 1998).

The most important nutrient parameter is the C/N ratio. P, S, Ca and trace quantities of several other elements all play a part in cell metabolisms (Polprasert, 1996). Ratio of 25/1 to 35/1 for C/N is generally agreed upon as optimal for composting (WHO, 1985; World Bank, 1987; Landreth and Rebers, 1996).

Past experiences have showed that temperature reaches to maximum level during 8-12 d and is depleted after 20-25 d, after process start up. It is recommended by WHO to maintain the temperature of 60˚C for many hours (WHO, 1985). A U.S. EPA regulation for Processes to Significantly Reduce Pathogens (PSRP) recommends 5 d in 40˚C or 4 h in temperature over 55°C. Based on the recommendations of U.S. EPA for Processes to Further Reduced Pathogens(PFRP) the minimum time of 15 d at 55˚C or over in windrow is needed and during this period, turning the pile must be done (Haug, 1991).

pH drops during the initial stages of the composting cycle as a result of the breakdown of carbonaceous materials by microorganisms and production of organic acids. Synthesis of organic acids is accompanied by the increase in the population of microorganisms capable of utilizing the acids as a substrate. This will cause the pH to rise (Landreth and Rebers, 1996). Finally pH in the compost product is reached to 7-8 (Merkel, 1981). It should be noted that if the pH rises to 9, N is converted to ammonia and becomes unavailable to microorganisms (Landreth and Rebers, 1996).

Compost has a variety of beneficial properties: it provides the return of organic-rich materials to the land, helps soil retaining moisture and nutrients, increases soil fertility, reduces erosion and soil compaction, suppresses plant diseases (Landreth and Rebers, 1996), reduces leaching of soluble N , increases the buffer capacity of the soil and improves soil structure (Davis and Cornwell, 1998).

This research was conducted for comparison between windrow and pit composting methods, municipal solid waste, poultry wastes and leaves in Damghan city and investigated physical and some other characteristics of compost products.

## MATERIALS AND METHODS

In this survey with the use of perforated brick and cement, a pit with natural aeration channel and dimensions of 4 m length, 2.7 m width and 1 m depth, was constructed, as shown in Fig.1. Also a windrow with natural aeration tunnel (Fig. 2) was constructed with dimensions of 3 m length, 1.5 m width and 2 m depth. Two methods of composting were performed by mixing garbage poultry wastes and leaves (1400, 10 and 6 kg, respectively) to achieve the C/N ratio of 25/1 and moisture content of about 50 percent.

For measuring the moisture content and pH, 1 kg mixed sample was prepared from 10 samples from different parts of windrow and pit. Moisture content of the sample was measured by drying the sample in oven in 105˚C during 24 h and was repeated weekly. pH measurement by electrometric method was done during the first 8 days of the process and for compost products. In order to control the temperature during the process, a thermometer connected to a timber was used daily in two depths of 10 and 35 cm of pile surface. Characteristics of the compost product in two methods were investigated through 3 samples prepared by mixing 10 primary samples from different parts of the pile. Samples were analyzed for N, P, K, organic C, organic matter, moisture content and pH. Methods for the measurement were as follows: N: kejeldahl method, P and K: extraction method, organic matter: incineration; organic C: oxidation with potassium bichromate; pH: electrometric method and moisture content: drying in oven.

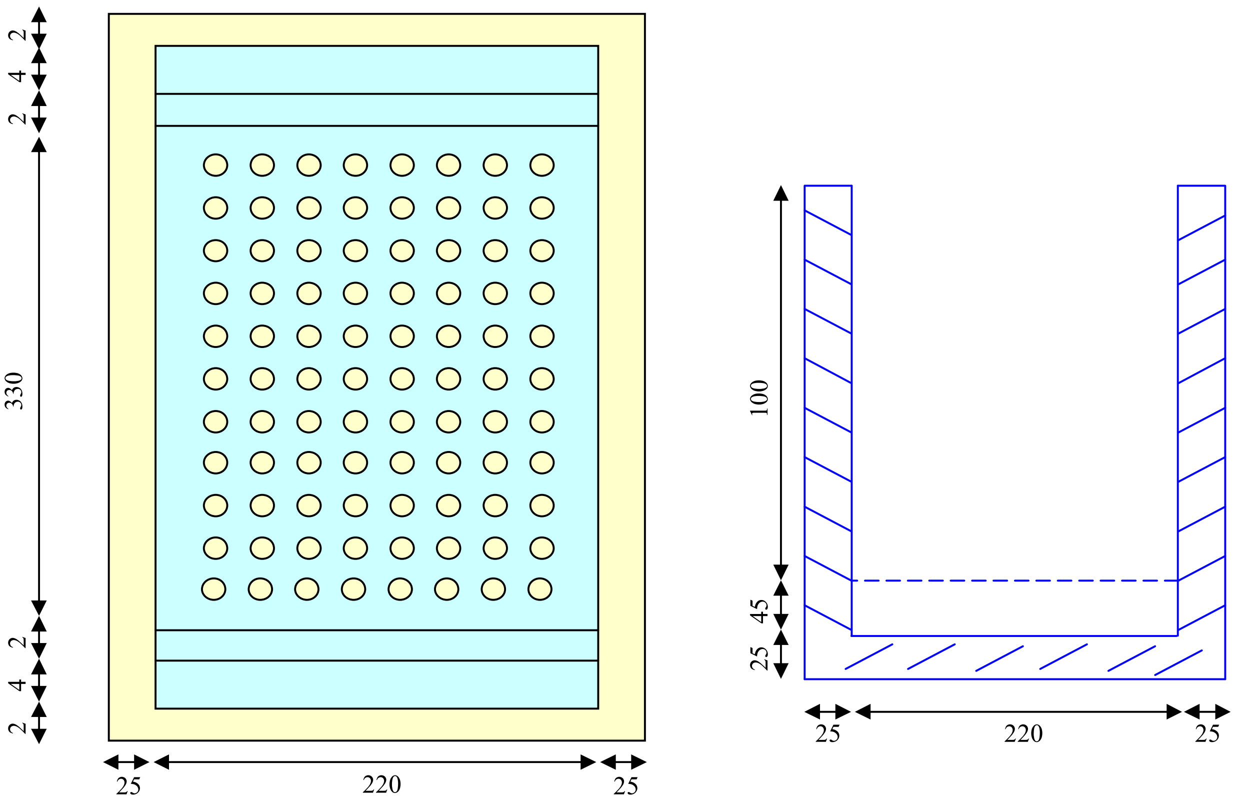
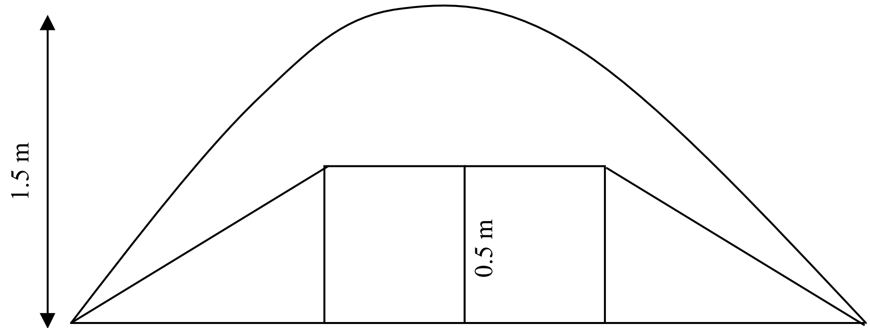



**Fig. 1:** Plan and cross section of pit system; dimensions are as mm



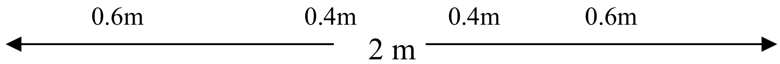



**Fig. 2:** Section of windrow system

## RESULTS

Results of the calculation for C/N ratio are shown in Table 1.

**Table 1:** Proportioning of wastes for C/N ratio adjustment

| Type of waste | N% | C/N ratio | N(Kg) | C(Kg) |
|---|---|---|---|---|
| Garbage from municipal waste | 2 | 25 | 0.02x1400=28 | 25x28=700 |
| Poultry waste | 6.4 | 7.5 | 0.064x10=0.64 | 7.5x0.064=4.7 |
| Leaves | 1 | 41 | 0.01x6=0.06 | 41x0.06=2.5 |
| Sum | - | - | 28.70 | 707.2 |

$$\text{C/N ratio of the mixture} = \frac{707.2}{28.7} = 24.7$$

Moisture content of mixed wastes at the beginning of the process was 65 percent and in the end of each week was as follows:
In windrow: 60, 55, 48, 40, 36, 31 and 28 percent.
In pit: 60, 58, 50, 44, 42, 38 and 36 percent.
Results of temperature measurements in 35 cm depth of piles in two systems are presented in Fig. 3 and 4.

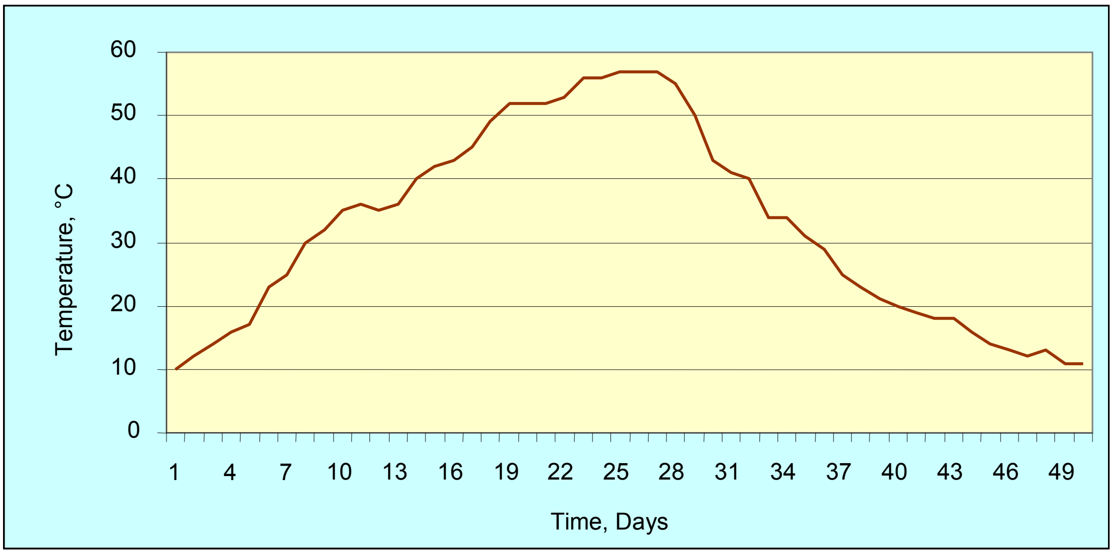



**Fig. 3:** Temperature variations in 35 cm depth of windrow

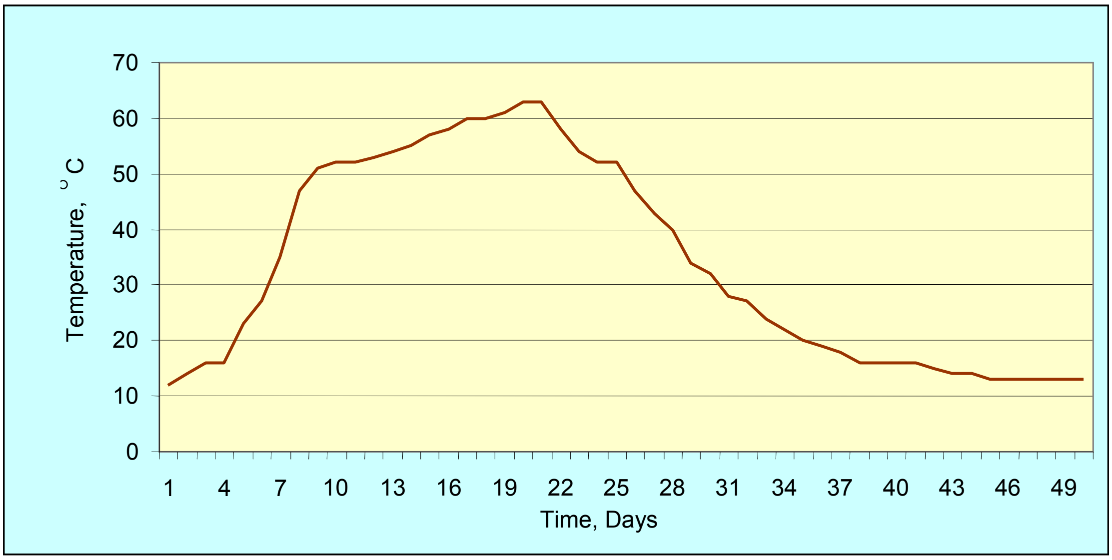



**Fig. 4:** Temperature variations in 35 cm depth of pit

Results for pH measurements in two systems during 8 d after start up were as follows:
In pit: 6.2, 6.2, 6.0, 5.8, 5.5, 5.9, 6.1 and 6.5.
In windrow: 6.2, 6.2, 6.1, 6.0, 5.7, 5.6, 5.9 and 6.3
Table 2 shows the mean values for the characteristics of samples from compost product.

**Table 2:** Characteristics of compost product

| Parameter \ System | Windrow | Pit |
|---|---|---|
| N as N (%) | 0.62 | 1.03 |
| P as $P_2O_5$ | 0.72 | 0.8 |
| K as $K_2O$ | 0.25 | 0.3 |
| Organic matter (%) | 24 | 43 |
| Organic C (%) | 14 | 25 |
| pH | 7.7 | 7.8 |
| Moisture (%) | 29 | 34 |

## DISCUSSION

Data from the research showed that proportioning of mixed wastes had resulted to desirable C/N ratio (24.7) as generally agreed by many researchers (WHO, 1985; World Bank, 1987; Landreth and Rebers, 1996) and moisture content (about 65%) which had been recommended by other researchers (Landreth and Rebers, 1996; Sincero and Sincero, 1996; Davis and Cornwell, 1998). Also, comparison between pit and windrow temperature variations (Figs. 3, 4) showed that temperature in pit reached to high level (about 55-60˚C) in a shorter time (about 15 d) and higher level of temperature might be obtained in pit process (63˚C compared with 57˚C in windrow).
Achievement to maximum temperature (over 55˚C) in both systems in related times (6 d in windrow and 9 d in pit) ensured hygienic characteristic of compost and destruction of pathogens and parasites according to WHO criteria (WHO, 1985) and U.S.EPA regulations for PSRP and conditions in pit system, according to PFRP regulations of U.S.EPA (Haug, 1991).
Measurements in both systems showed that, moisture content in active phase of composting process did not reach to less than desirable level, 50-60% (Landreth and Rebers, 1996; Sincero and Sincero, 1996; Davis and Cornwell, 1998) and depleted in curing phase. PH in mixed wastes was 6.2 and after starting up of the processes, decreased to about 5.5 and in compost products reached to 7.7 in windrow and 7.8 in pit system which were in accordance with Merkel researchs (1981).
Analyzing the compost products from both systems showed that color was dark brown, mentioned by WHO as one of the important physical properties (WHO, 1985); size of particles was suitable and 60% weight reduction

was obtained. Chemical characteristics of compost from the point of view of N, P, K, organic C and organic matter agreed with WHO criteria (WHO, 1985) and Germany Quality Control Organization-RAL (Shirzady, 2003). Comparison of the data presented in Table 2 showed that the pit system was more effective for nutrients maintaining.
Considering the high volume of garbage, animal and poultry wastes and agricultural wastes in Damghan, composting may be considered as an important it could be concluded that element of municipal solid waste management. In this regard, pit system may be recommended for better nutrients and moisture maintaining.

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