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Efficient and Eco-friendly Management of biodegradable Municipal Solid Waste (MSW) using naturally aerated Windrow Composting Technique in District Lahore Pakistan

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ABSTRACT

In urban areas, management of solid waste is a big and serious issue because of high amount of waste generated from different sources (industries, domestic etc.). In Lahore solid waste generated daily is about 5000 ton comprising of around 60% biodegradable and 40% non-biodegradable waste. About 70% of waste is collected which is then disposed of in unmonitored dumping sites. It causes severe environmental problems. The present study is for minimizing the solid waste being collected. Composting technique was adopted from Municipal solid waste and garden waste. The aerated composting technique made results more efficient by using an effective microbe's solution which acts as an activator to enhance microbial activity and reduced the composting period. The results demonstrated that compost was good in organic content 25% and carbon-nitrogen ratio 26:1. It was planned to convert organic waste into compost thus substantially reducing the MSW loads being generated in Lahore.

1. Introduction

The municipal solid waste management extensively neglected area for overall management of the most developing Nations. Now a day, developing countries are seriously concerned with the consequences of improper management of municipal solid waste (Sharholi *et al.*, 2008). The present methods of municipal solid waste management are incineration, landfilling, source reduction, reuse, recycling and others (Wu *et al.*, 2014). Both incineration and landfilling are categorized as waste disposal due to which they are least preferred in municipal solid waste management hierarchy. In many areas, landfilling remains prominent method for municipal solid waste disposal because it is economically beneficial (Laner *et al.*, 2012). In most of the developed countries, there is an equipped system on landfill sites for the detection of biogas and leachates. On the other hand, landfilling also lacking in the underdeveloped countries. Nowadays, proper landfilling trend substantially increase in the developing countries also, while dumping in open sites is still common (Hoorweg & Bhada, 2012; Hoorweg, n.d.). Emissions of Greenhouse gases due to MSW decomposition in landfill sites is also serious concern (Pozza *et al.*, 2015). In developed countries, proper maintenance and care of landfill sites demands high capital cost so that more threat to environment and health is found. Moreover, the land limitations and waste amount entering the landfill sites are strong reason to move towards sustainable management of MSW (Marshall & Farahbaksh, 2013).

In Pakistan, municipal solid waste management generally consists of a primary as well as secondary collection. More than 90% waste collected is sent to the open dumping sites. From waste produced in most cities only about 60% is collected and the remaining lies among vacant spaces, roads, railways, storm drains and streets within entire city limits (Batool & Nawaz, 2009).

Lahore has a capacity of generating five thousand tons of solid waste per day (0.5-0.6 kg per capita per day) comprises of 60% biodegradable, nylon 11.6%, textile 9.09%, paper cardboard 2.43%, diaper 3.11%, non-combustible 2.25, combustible 2.13%. Only 3800 tons per day (76%) is collected and arrives at dumping sites (a) mehmoor booti (b) baggarian (c) saggian (Korea International cooperation Agency, 2007; Koica-World Bank joint Study on Solid Waste Management in Punjab Pakistan, 2007; ICEPAK, 2006a; ICEPAK,

2006b; ICEPAK, 2007a; ICEPAK, 2007b). This causes severe problems to ground water and soil. The other uncollected waste (24%) stays along roadsides, streets and vacant areas which threaten human health directly/indirectly (Taylor & Allan, 2006; Suman *et al.*, 2006; Pakistan, 2009). These threats can be minimized by reducing waste quantity. The composting of biodegradable waste is not only a good alternate to reduce the waste amount but also gives the useful end product (compost). In Composting, biodegradation of organic matter takes place. It is a process in which organic matter is converted into a useful product called humus or compost, a wonderful conditioner for a soil (Composting, n.d.). The divergence of organics from landfill minimizes methane emissions. Nutrients are returned back to the topsoil by humus. Humus retains 18-20 times more water than its weight. The top 6 inches' layer of soil having 1% organic matter can hold 27000 gallons of water per acre (Question and Answers for Residents; Metro Vancouver n.d.; Agriculture, n.d.).

The Aim of the present study is to investigate the use of composting for municipal solid waste management in an environmentally beneficial method (composting) instead of using other methods incineration, landfill etc. that causes a serious environmental problem due to the emission of greenhouse gasses and leachates. The ultimate objective is to reduce the solid waste load on landfill sites, to minimize our activities on the sites that affect the quality of the soil and to understand that it is possible to increase the quality and fertility of soil by adding organic material. Greenhouse gasses also emitted in a composting process but in very less amount as in case of other disposal techniques. The composting process is highly favorable in the solid waste management owing to high %age of organic matter in waste composition. Moreover, nearly about 30% of the waste of Lahore consists of only kitchen waste. This amount of waste can be prevented from entering the solid waste management system by following kitchen waste composting in backyards.

2. Material and Methods

The present study was conducted at the Waste Busters composting plant which is operational at Gajjumata, Lahore. It makes benefit of the municipal solid waste coming from the different residential and industrial sites. About 12 tons per day MSW is received at the facility comprises of all types of waste

from which organic waste is separated for composting on daily basis.



Fig.1. Windrow turning through mechanical turner

Composting needs the availability of two types of material nitrogenous and carbonaceous. The proportion of nitrogenous and carbonaceous depends upon the quality of compost required. Ratio 1:1 was prepared for this municipal solid waste used for nitrogen requirement and dry garden waste for carbonaceous requirements along with nitrogen and carbon. Aerobic degradation was also required to decompose the waste into compost and for the microorganisms to work efficiently. Aeration was provided through mechanical turner to maintain proper oxygen level as shown in figure 1.

3. Raw material

Raw material used depends upon the quality of compost required. Keeping in view different parameters, material used for the composting were greens (garden waste, vegetables, food waste, cow manure, chicken waste) and browns (sawdust, straw, leaves, fruit waste Shredded newspaper). These carbonaceous substrates were mixed with nitrogenous ones at a ratio of 2:1 (on a dry weight basis). The greens have more nitrogen content while the browns are rich in carbon content. Both these materials were mixed together in alternating layers to prepare the compost windrow. The carbon-nitrogen ratio of material used is given in table 1 (Relationships, 2009).

Table 1: carbon nitrogen ratio of feed material used

Sr. No.	Green	C/N Ratio	Browns	C/N Ratio
1	Garden waste	103	Saw dust	325/1
2	Vegetable	214	Newspaper shredded	175/1
3	Food waste	120	Straw	75/1
4	Cow manure	121	Leaves	60/1
5	Chicken	210	Fruit waste	35/1

3.1 Layout for windrow

A composting technique was used for the study. Therefore, an area of 100 × 12 feet was acquired at the facility. The area was cleared for the experiment and required waste was added to windrow. The layout of the experiment is shown in figure 2. A total waste amount added to windrow was 10 tones comprising of municipal waste, kitchen waste and garden waste. The tap water was used to maintain the moisture content of 42%. The measurement of moisture content was done to evaluate the water amount to be added to obtain the required moisture content of 60%. A brown humus material has appeared after 16 days. After this period a brown humus material obtained shows the completion of composting process and curing time had started. Hence no more water addition and moisture content measurement was done. Turning of windrow was carried out to provide required level of oxygen during the curing period. After the curing period, product was sieved through a sieve size of less than 5mm to get the final product. Natural decomposition process was adopted for the degradation of a material.



Fig.2. Layout of windrow

Briefly, three phases observed during the composting process.

1. Initial activation
2. Mesophilic/maturation and
3. Thermophilic phase.

Most of the degradation of organic matter took place during thermophilic phase. Beginning of maturation phase and end of thermophilic phase was observed as the temperature of composting pile decreased. The stabilization of organic waste was achieved as compost temperature reached the ambient air temperature. The schematic diagram of all the procedure adopted during the process is given in figure 3.

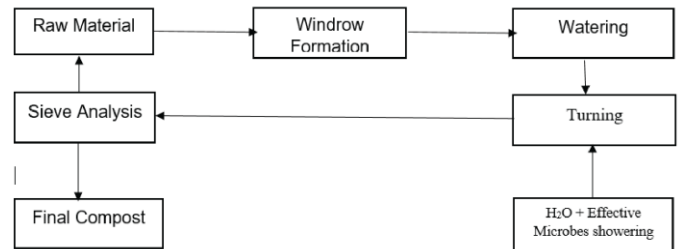


Fig.3. Schematic Diagram of the procedure adopted during the process (one sieve analysis, sieve size < 5mm)

3.2 Time for Composting

Mixed greens and browns materials in alternating thin layers to prepare of heap and applied a water such that water was dripping out of the bottom. To start the composting process, applied the activator in the middle of the compost heap. Effective microbe's solution of molasses was used as an activator.

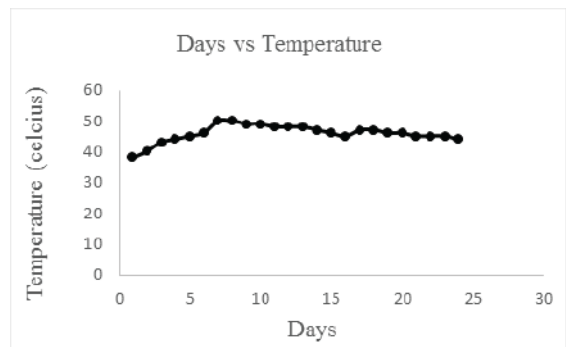


Fig.4. Graphical presentation of temperature

One liter of instant effective microbe solution was made by mixing 10 ml of effective microbe, 40 ml of molasses and 950 ml of water and leave it for five to seven days, depending on temperature. This solution was then added to 1 liter of molasses and 98 liters of water to obtain 100 liters of ready-to-use effective microbe solution. This solution was then added to the windrow to enhance the microbial activity and to reduce the composting period. Turning of windrow was started on day 6 to onward. The feed material of windrow was mixed together with the help of mechanical turner. Ensured that moisture level was constant. The temperature was checked by thermometer that was about 50 degrees Celsius on day 6. The daily changes of temperature are shown in figure 4. During 6-8 days the temperature went high (maximum) and gradually cool down up to day 24. The compost process was Completed in 24 days instead of 18 days because the optimum temperature ranges 55-65 degree Celsius was not attained. It was due to certain environmental conditions and factors. Sample from final product of Composting windrow was analyzed in the laboratory for the measurement of Chemical parameters nitrogen, potassium, phosphorous, moisture contents, organic matters, and pH. All these tests were performed in the Waste Buster Q.C & environmental lab Lahore. The kjeldhal, precipitation, flame photometer and loss in ignition were the standard methods used for the analysis of N P K and organic matter present in the final product.

4. Results and Discussion.

The results obtained from final product are given in table 2.

Table 2: Results of chemical parameters

Sr. NO.	Parameters	%age Purity
1	Total nitrogen	1.21
2	Potassium	0.083
3	Phosphorous	0.0095
4	Moisture Content	42
5	Organic Matter	25
6	pH	7.5

The final product is shown in figure 5. As discussed in material and methods some chemical parameters in final compost product are of serious concern. The pH value of the compost windrow was 7.5. It can be observed that pH of sample lies between the basic ranges. Usually the pH values from 7 to 14 are basic in nature. A small change can be observed in pH values. This change is due to characteristics of feed material used. In municipal solid waste there are certain material which are acidic in nature.

Fig.5. Final product

The organic content of the compost windrow was 25%. The quality of compost prepared depends upon the organic content present in it. Organic



content of feed material from municipal solid waste is less in organic matter than kitchen waste (food and vegetables waste). Hence good quality compost can be obtained by using kitchen feed stock. The Moisture Content of compost sample was 42%. Moisture content may be less for animal dung in dry form if mixed in the windrow feedstock. Initially, during the composting process the moisture content of 60% was maintained.

Table 3: characteristics of water used to maintain proper level of moisture content

Sr. no.	Parameters	Value
1	pH	7.4
2	Total dissolved solid	202
3	Hardness (as CaCO ₃ , mg/L)	188
4	Chlorides (mg/L)	16
5	Iron (mg/L)	0.3
6	Total coliform/100ml	2 to 5
7	Fecal coliform/100ml	0

The tap water was used for this purpose. The pH and total dissolved solids were measured with the help of pH and TDS meter, while hardness, iron and chlorides measurements were taken by using titration method. Most probable number technique was used for the measurement of total coliform and fecal coliform. The characteristics of the water used are given in table 3. The nitrogen contents of compost sample were 1.21%. But nitrogen content alone is of no use rather it used to find the carbon-nitrogen ratio. The carbon-nitrogen ratio of compost sample was 26:1. Within the limit, higher the carbon nitrogen ratio better is quality of the product. The compost under study was prepared from municipal solid waste but the kitchen waste has higher carbon- nitrogen ratio than the municipal solid waste. Hence, the compost prepared from suitable addition of kitchen waste with municipal solid waste is of higher carbon-nitrogen ratio. But using higher quantity of kitchen waste increases the nitrogenous matter and thus reducing carbon-nitrogen ratio causes release of ammonia whereas, using lower quantities results in the increase of carbon-nitrogen ratio which effects the decomposition process during the composting period (Taylor & Allen, 2006).

Conclusion

Organic waste collected from District Lahore constitute 60 % of the total Municipal waste which depicts high potential of availability of biodegradable organic waste which can be escaped from entering the disposal system in district Lahore. From the results, as obtained from the research conducted, it is obvious that high volumes of municipal solid waste being generated in District Lahore can easily be handled by collecting it at a predefined frequency and can be converted into Compost, which is equally efficient as commercial green fertilizers available.

Some products available in market to be used for gardening are flower grown and lawn grow which have organic content 12.5% and C/N ratio 20:1. The compost formed as an end product of the windrow composting was good in organic content 25% and carbon nitrogen ratio 26:1, conducted at Waste Buster facility showed almost equal or more ingredients as required by the above-mentioned standards. N, P, K values obtained in the compost are equally efficient as other available standards and completely reliable to be used as bio manure.

Recommendations

- ✓ There should be implementation of two bin and three bin system to segregate the organic waste from municipal solid waste during the collection phase to get good quality compost at composting plants.
- ✓ All landfill sites should have composting plant at the facility to minimize municipal solid waste load on the facility and hence to reduce its potential impacts on environment.
- ✓ Since all material required for composting is available at homes, an awareness campaigns regarding backyard composting can be encourage to facilitate the composting process at homes with very little efforts.
- ✓ Mainly there are two benefits for the backyard composting.

- (1) It minimizes the load on solid waste management system.
- (2) On site treatment of waste can be achieved.

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for the good results of EC and TDS. The studies is also to be continued on increasing the adsorption capacity of the red brick dust by treating it with other acids .it have to be further continued to find out if red brick dust can also be used for removal of other dyes. Conclusively, the expanding of red brick dust in field of adsorption science represents a viable and powerful tool, leading to the superior improvement of pollution control and environmental preservation.

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