Earth Sciences Pakistan (ESP)

DOI : http://doi.org/10.26480/esp.02.2019.18.26

ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2521-2893 (Print)
ISSN: 2521-2907 (online)
CODEN: ESPADC

CrossMark

RESEARCH ARTICLE

DEVELOPMENT OF EFFICIENT WINDROW COMPOSTING TECHNIQUE FOR FOOD WASTE AND ITS OPTIMIZATION

Sana Basheer[1*], Maria Nazir[1], Haroon Rashid[1,2], Abdul Nasir[1], Engr. Majid Hussain[2]

[1]Department of Structures and Environmental Engineering, University of Agriculture, Faisalabad, Pakistan
[2]Department of Civil Engineering, Khawaja Fareed University of Engineering and Technology, Rahim Yar Khan, Pakistan
**Corresponding Author Email: sana_basheer96@yahoo.com*

ARTICLE DETAILS

Article History:

Received 21 August 2019
Accepted 23 September 2019
Available online 11 October 2019

ABSTRACT

Urban regions have a critical issue of solid management waste because of its high growing rate of production. Untreated solid waste had caused many diseases in human beings like cholera, yellow fever and dengue fever. Windrow composting for food waste including bio-degradable and recyclable nature were checked for different compositions of food waste. Food waste composting by aerobically was carried out at South East Asian institute of Sciences, UAF. Three different windrows were reinforced with treatments of tap water, sewage water and microbial spray. Aerobic composting required different temperature tolerating microbes to complete the composting process. The analysis have been done in laboratory for many compost effecting parameters. Results showed that organic content analysis have better for composting of food waste. Three composting windrows were developed with three different treatments T1, T2 and T3 for food waste. Windrows were treated with sewerage water, tap water and effective microbial spray using specifically food waste. The compost of food waste prepared by the treatment of microbial spray was found better than the two treatments as having pH 8.63, organic content 68.91%, moisture content 28.09%, carbon 32.38%, nitrogen 0.67%, Phosphorous 1.3% and potassium 0.81%. Physical and chemical characteristics of compost has been analyzed, presented and transformed in graphs to check the relevance in all the composting parameters throughout the three composting piles of waste like M.C, Temperature, pH, O.C, C, N, P, K.

KEYWORDS

Windrow composting, SWM, Waste Disposal, Food Waste.

1. INTRODUCTION

Solid waste was termed as the garbage, refuge and sludge discharged from the wastewater treatment plant and other solid and gaseous materials leading to air pollution. Solid waste has different types according to its source of generation and composition. Municipal solid waste included the residues of food waste, discarded or undesired things created by animals and humans. Increased quantity of solid waste generation in large urban areas were causing a serious issues for the management of organic fraction of solid waste. Big developing countries had faced improper handling and management technologies as major critical concern.

Primary and secondary collection systems were adopted for the collection of waste in Pakistan including 90% openly dumped waste to the undesired sites. Urban areas of Pakistan produced about 1, 33,760 metric tons of waste (SPCB response 2012-13). In the most cities of Pakistan surely collected waste was about 60% out of all the collected waste. Larger cities of Pakistan had about 70% collected waste and 30% from small towns of country dumped on roads [1]. Largely concentrated solid waste was disposed without segregation activity causing issues of global warming and economical problems to human beings. Trash, garbage, other items like food scrapes, product packages, paper, metal, ceramics, leather, textiles, plastics, rubber, bone and ashes were also included in municipal solid waste. Reduce, reuse and recycling systems were used to treat these products in useable forms.

Solid waste management was an important technique involved the waste reducing to some extent, reusing of treated waste and recycling of waste for further again useable products. The generation of food waste and spoilage were a critical problem for the developing nations. Developing countries had no management system that's why waste not disposed of to the sites and remained unmanaged [2]. Total waste collected and generation rate for different cities in Pakistan is illustrated in the table 1.

Table 1: Per capita Municipal solid waste generation in Pakistan

City	Waste generation (tons)	Waste generation rate (kg/capita/day)	% waste collection	%Waste remains uncollected
Islamabad	14000	0.622	84	16
Lahore	5000	0.5-0.65	60	40
Faisalabad	1700	0.45-0.5	55-65	45-35

Faisalabad is one of the most populated city in Pakistan, and the second-largest in the eastern province of Punjab. Total area of Faisalabad is 5856 km² [3]. In Faisalabad most common method of the disposal of solid waste is open dumping which actually not environment friendly method [4]. The structure of peri-urbanization for Faisalabad city being established due to many reasons of irregularities by the settlements of residential areas, new formed towns and industrial functions [5]. Physical composition of Faisalabad waste is shown in Figure 1 and ten its comparison with EMPC estimation is discussed in Table 2.

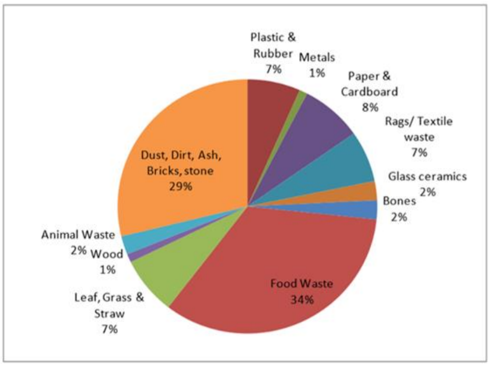

Figure 1: Compositions of waste for Faisalabad city for 2017

Table 2: Physical composition of Faisalabad's waste compared with EPMC

Sr. No.	Waste Component	% by weight	EPMC estimates %
1	Plastic & Rubber	6.60	4.80
2	Metals	1.00	0.20
3	Paper & Cardboard	7.67	3.70
4	Rags/ Textile waste	6.53	5.20
5	Glass ceramics	2.43	1.30
6	Bones	2.40	2.90
7	Food Waste	33.81	17.20
8	Leaf, Grass & Straw	7.36	15.60
9	Wood	1.07	0.70
10	Animal Waste	2.34	0.80
11	Dust, Dirt, Ash, Bricks, stone	28.79	47.60
	Total	**100.00**	**100.00**

Source: Solid waste characteristics study in Faisalabad for 2017

Food waste was the food that lost and cannot be eaten. University of Agriculture, Faisalabad was selected to acquire the research objectives. Phase one of research was to collect information of food waste generation at mess rooms by visiting the hostels. Phase two included the collection and performance of composting technique on food waste due to its rapid production to analyze the parameters effecting the compost. Composting process was developed to reduce the waste and offer practice to manage the waste at UAF.

Food waste collection and management were more complex and difficult. Problems were complex because of urban growth producing large waste. Complexities and difficulties related to technology had been occurred like food waste storage, generation, collection and transportation [6]. Food waste was produced about 38 million tons in 2014 according to US-EPA. Food waste can be reduced by storing and freezing the food like bread, meat and sliced fruits. In Pakistan population rate, growth of urbanization and industrialization had been increased during some couple of years. Solid waste production and treatment challenges had occurred in Lahore [7]. Composition of food waste in different cities of Pakistan from 2008-2013 is discussed in Table 3.

Table 3: Composition of Food waste in different cities of Pakistan from 2008-2013

Cities	Faisalabad	Karachi	Hyderabad	Peshawar	Quetta
Plastic and Rubber	4.8	6.4	3.60	3.70	8.20
Metals	0.2	0.75	0.75	0.30	0.20
Paper	2.1	4.10	2.40	2.10	2.20
Cardboard	1.6	2.4	1.50	1.90	1.30
Rags	5.2	8.4	4.70	4.30	5.10
Glass	1.3	1.5	1.60	1.30	1.50
Bones	2.9	3.00	2.00	1.70	2.00
Food/Kitchen Waste	**17.20**	**21.00**	**20.00**	**13.80**	**14.30**
Animal waste	0.8	3.00	5.80	7.50	1.70
Leaves and Grass	15.60	14.00	13.50	13.60	10.20
Wood	0.7	2.25	2.25	0.60	1.50
Fines	43.00	29.70	38.90	42.00	44.00
Stones	4.60	3.50	3.00	7.30	7.80

Composting includes the stabilization and decomposition of organic fraction of MSW. Less amount of greenhouse gases would be produced than the landfilling of waste materials [8]. Composting could be a well-developed technique of fertilizer generation. Final product of composting had been used as soil conditioner or fertilizer. Fertilizer should have the essential nutrients like nitrogen, phosphorous and potassium for the plants growth. Composting mainly of two types as following: Aerobic and Anaerobic. But there are several types of composting according to the methodology. Following microbes will help to complete the composting process.

- *Psychrophiles-low temperature microbes*
- *Mesophiles-medium temperature microbes*
- *Thermophiles-high temperature microbes*
- *EM technology*
- *Chaetomium*

Decomposition process of food waste will be initiated by the mesophillic microbes. These microbes can help to degrade the organic part of waste rapidly. Thermophillic microbes will carried out the composting process after the mesophillic microbes. Proteins and fats can be decomposed by the thermophilic bacteria at 40^0C temperature. Specific nature of the population of microbes, rate and decomposition process is greatly influenced by the temperature [9]. Therefore temperature is promoting the rate of decomposition and used as a variable of control during the process of operation. Effective microbial spray had been used composed of photosynthetic bacteria. Decomposition of cellulose can be carried out by Chaetomium. According to FWMC, Faisalabad city by a generation rate of 0.45-0.5 kg/capita/day is producing about 1700 tons of total solid waste daily out of which 55-65% is collected only. Total solid waste comprising different concentrations of food waste, kitchen waste, garden waste, plastic waste and wood waste etc. Production of waste is a main problem in each educational institution due to higher population of students in Hostels producing a large quantity of food waste, in faculty canteens and markets. There are so many reasons to concern over food waste composting management technique at University of Agriculture, Faisalabad. The reason of adopting aerobic composting technique is to quantify food waste generation rate at hostels of University of Agriculture, Faisalabad so that waste disposal to landfills and dumping may be reduced by upgrading aerobic composting technique.

The present study on food waste was conducted at the main campus of University of Agriculture, Faisalabad, which is one of the largest institute in Asia occupying about 2100 acres of land. 1400 acre area is cultivated while remaining area is constructional including administration buildings, students faculties, research laboratories, hostels, residential colonies of university employee's linked by roads along with botanical gardens, fruits orchards etc. The study was divided into three phases first phase was to take information about the quantification of food waste generation at UAF hostels by visiting the hostels, second phase was to establish windrow composting system to manage and reduce the food waste production at the hostels, to develop environmental guidelines and third phase was to produce a fertilizer and analysis of N, P, K contents in the compost.

2. MATERIAL AND METHODS

2.1 Research Plan Flow Chart

This research study on Food waste aerobic windrow composting was done firstly to find out the composition of Food waste generated at hostels of University of Agriculture, Faisalabad.

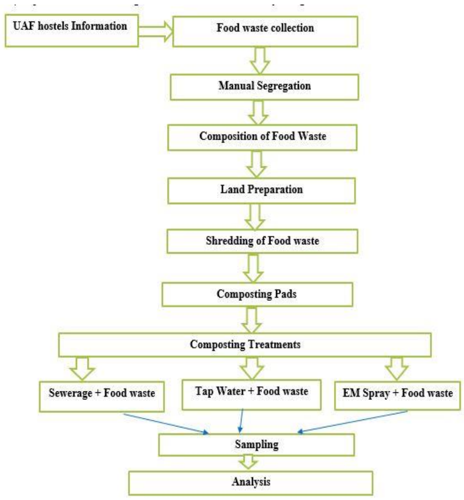

Figure 2: Research plan flow chart

Secondly collection of Food waste from university hostels to perform aerobic windrow composting at the backside of Engineering workshop to establish a waste management technique suitable for the university waste. Research plan flow chart was presented in the Figure 2 that's describes the process to conduct the research project efficiently by making three composting piles of three different treatments and to determine the physic-chemical properties of the ready compost.

Table 4: List of UAF Hostels

No. of Hostels	Name of Hostels
1	Kahkashan hall 1
2	Kahkashan hall 2
3	Khadija-tul-kubra hall
4	Ayesha Saddiqua hall
5	Khalid hall
6	Qasim hall
7	Babar hall
8	Zainab hall
9	Jinnah hall
10	Tariq hall
11	Ayub hall
12	Z.A hashmi hall
13	Kashmir hall
14	Teepu hall
15	Faisal hall
16	Qazzafi hall
17	Sir Syed hall
18	Liaqat hall
19	Afzal hall
20	Fateh hall
21	Kisan hall
22	Fatima-tul-zahra hall 1
23	Fatima-tul-zahra hall 2
Total= 23	

2.2 Materials

The materials used in this research for the preparation of aerobic windrow composting were

- Food waste/ Kitchen waste
- Tap water
- Sewage water
- Effective microbes spray

2.2.1 Food waste/ Kitchen Waste

Food waste was the discarded material that cannot be used for eating purposes and its taken place at the processes of food processing, production, retailing and consumption. Food waste was that type of waste which was removed from the food chain or get spoiled or expired for further use of human beings. Food waste contains a large amount of nitrogenous and carbonaceous rich materials. Food waste and vegetable waste were collected from all the hostels of University of Agriculture, Faisalabad. Kitchen waste includes materials rich in nitrogen like Vegetables peeling and Fruit peelings. There were also a great amount of materials rich in carbon like Tea bags, Egg shells etc.

Figure 3: Food waste produced in mess rooms of UAF hostel

2.2.2 Tap Water

Tap water was used to moisten the composting pads or to maintain the moisture level. Composting process was sufficient at moisture level (45-55%), required by the microorganisms present in the compost. Water should be added to the composting piles by some external source if it drops below this range of moisture content. Tap water was applied to all three composting pads. Tap water was fetched from the Soil Science farm in small plastic baskets of 5-10 liters. Tap water characteristics had been find out as pH=8.65, TDS=1704mg/L, EC=2745mS/cm, Fecal coli form=0.

2.2.3 Sewage Water

Sewage water was carried waste in solution or suspension form. It mostly present in grey water and blackish water called as municipal wastewater. Sewage was a complex mixture of chemicals like high concentrations of Ammonia, nitrate, phosphorus, high conductivity and pH. Sewage contains high content of organic matter that can be determined by its biological oxygen demand and chemical oxygen demand. Sewage water for this research project was collected from the gutter of agricultural Engineering workshops. Sewage water characteristics had been find out as pH=8.95, EC=2450mS/cm, TDS=1868mg/L, Turbidity=51.

2.2.4 Effective Microbes Spray

Erlenmeyer flask of 1000 mL had been taken to prepare the TSB (Tryptic Soy Broth) solution of 10% by selecting the strains of bacteria to introduce in this solution. Inoculated bacterial flasks had been incubated at 100 revolutions per minute for 72 hours at temperature of 28^0C (Firstek Scientific, Tokyo, Japan). To get the bacterial uniform population, the density of broth should be adjusted at 0.5. Spectrophotometer had been adjusted at 600 nm to form units of colony of bacteria at 108-109m/L. Effective microbes spray required for this research project had prepared from Soil Science department by Sir Naveed. This application applied to third composting pad at starting of project and after 4 weeks later on. This spray have pH from 5-7.

2.3 Methodology

Several steps were performed to initiate the aerobic windrow food waste composting research project.

2.3.1 Selection of Site for the Food Waste Composting

Food waste composting technique had been adopted to reduce the waste and prepare a final compost. Land to establish this research project was selected at the backside of Agricultural Engineering workshops by the permission of Chairman of the department of Structures and Environmental Engineering.

2.3.2 Food Waste Collection for Composting

Food waste was collected manually from all University of Agriculture, Faisalabad hostels.

Cite The Article: Sana Basheer, Maria Nazir, Haroon Rashid, Abdul Nasir, Engr. Majid Hussain (2019). Development Of Efficient Windrow Composting Technique For Food Waste And Its Optimization. *Earth Sciences Pakistan*, 3(2) : 18-26.

Figure 4: Manual collection of food waste in sags from university hostels

Food waste was collected daily from each hostel in the big sags and then transported to the selected site for composting operation for dumping. Waste collection activity continued till to gain required quantity of food waste for composting.

2.3.3 Weighing of Collected Waste

Weight of collected food waste from university hostels was done daily to estimate the daily production of waste. Food waste was collected from the mess of all hostels including residues of fruit peelings, vegetable peelings, tea bags, eggshells, bread pieces, spoiled food items etc. Graduated weighing scale was used to find out the weight of collected waste. Weighing scale was graduated from 0-50 kg.

2.3.4 Dumping of Food Waste

Waste was dumped to the selected site daily after weighing. Dumping of waste was remained continued daily when required quantity of waste was obtained.

Figure 5: Daily dumping of food waste

2.3.5 Land Preparation

To prepare the composting pads, selected site area was cleaned properly from the grass, weeds and stones. Land was prepared manually by soil digging device. According to the research plan, land was made clean for three windrow composting piles. Area of 18ft^2 length and 6ft^2 wide was selected and cleaned. Land measurement was performed with the help of measuring tape. The dimensions of composting pads for length, width and height was done by measuring tape.

2.3.6 Preparation of Composting Pads

Under this research work three windrow composting piles were prepared of defined dimensions having 4.5ft length, 2.5ft width and 1ft height. Three composting pads were prepared having a 2ft distance with respect to each other and from sides. Width of composting pile was twice of its height [10]. Digging of ground was done up-to 1ft deep during establishing composting piles. Deep soil was rich in microorganisms, required for beneficial composting operation. Layout of three composting piles presented in Figure 6.

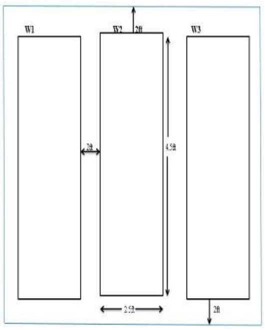

Figure 6: Field view of composting piles

2.3.7 Covering of Composting Piles

After preparing the windrow composting pads, they need to cover with plastic sheets. Composting piles were covered with transparent plastic sheet. The main purpose to place plastic sheets into composting piles was to avoid the leaching and percolation of applied water, nutrients and filling waste.

2.3.8 Shredding of Food Waste for Composting

Food waste was shredded after dying to gain minimum size as it was most necessary for the rapid and quick decomposition of food waste during composting operation. Food waste was shredded with the help of cylindrical electric shredder at the Faculty cage lab.

2.3.9 Formation of Composting Windrows

After shredding, food waste was again filled in sags to move it at the research area of composting piles and again weighted in equal proportion to fill in three windrow composting piles with three different composting treatments. Equal manual mixing of all shredded food waste was performed to fill it in composting piles.

Table 5: No. of windrows, treatments and kg of food waste

No. of Windrows	**Treatments**	**Food waste (kg)**	**Total weight (kg)**	**Ratio %**
W1	Sewage	22	22	100
W2	Water	22	22	100
W3	Microbial solution	22	22	100

2.3.10 Filling of Composting Piles

Food waste after balance mixing was placed in three composting piles with three different composting treatments. Sewerage water treatment was applied on first composting windrow, Tap water treatment applied to the second windrow and effective microbe's treatment applied to third composting windrow. After applying treatments, initial waste samples were collected from each three windrows to find out the moisture content of piles, to observe the microbial activity of microorganisms on weight loss method in drying oven [11].

Figure 7: Weight of shredded waste

Figure 8: Mixing of shredded waste

2.3.11 Turning of Composting Waste Piles

Scheduled turning of composting waste was done accordingly, to retain the moisture content in limits. Turning was done immediately after the rain, when moisture content exceed the 60%. Manual system of turning was adopted. Aeration would be a significant parameter to done in Food waste composting operation in the respect of microbial growth mechanism and emissions of gases [12]. Turning has great advantage of doing aeration at the bottom side of waste that required surface aeration for the proper activity of microorganisms. Optimum amount of aeration to make composting process more effective [13].

2.3.12 Final Compost

Final soil conditioner was prepared after 2:15 months. Humus material was passed through sieve of 6mm size. The screened material was obtained for final compost analysis. It was taken to soil lab of Ayyub Agriculture Research Institute Faisalabad and three compost samples were analyzed for physic-chemical properties.

2.4 Analysis of Final Compost

Following physic-chemical parameter were analyzed from the final samples of prepared compost.

1. Moisture Content
2. pH
3. Temperature
4. Organic Matter
5. Carbon Content
6. Nitrogen Content
7. C/N ratio
8. Phosphorus
9. Potassium

3. RESULTS AND DISCUSSIONS

3.1 Quantification of Food Waste

The study of research project and analysis of samples from the composting windrows yielded the stated results as described below. First of all information about UAF hostels were collected then after permission from Chief hall warden, all UAF hostels were visited to gain the knowledge about the food waste generation rate at university hostels mess rooms. Food waste collection was done on daily basis.

Table 6: Quantity of Food waste generated in a week at UAF hostels

Days	Food Waste (kg)/day
Mon	1380
Tue	920
Wed	1610
Thu	1725
Fri	1265
Sat	1035
Sun	805
Total Food waste/Week(kg)	8740
Total Food Waste/Month(kg)	262200

Daily collected waste weighted and dumped to the research site. Quantification of daily generated food waste at UAF hostels was presented in the table 6.

3.2 Monitoring Throughout Composting

Composting technique had been chosen according to research proposal to reduce the food waste generated at UAF hostel's mess rooms. Composting research project being established at the back side of engineering workshop. Three windrow composting piles were established with three different treatments. First windrow composting pile with 22 kg food waste was treated with sewage water, second with the tap water and third with the Effective microbial spray to decompose the waste. Environmental, physic-chemical parameters like moisture content, temperature and pH throughout the research experiment were monitored at the interval of days.

3.2.1 Analysis of Temperature

Temperature analysis was done for three windrows W1, W2 and W3. Composting temperature rise at the initial days of composting process till the 30-40 days. Highest temperature was recorded from all the three windrows with the help of probe temperature sensing device. Temperature typical range was from 45-60^{0}C. After 30th day temperature of all windrows started to decrease. For first 1 month microbial activity was at its peak on temperature based analysis. Mostly recorded temperature for first one month was highest in all windrows ranged from 43-52^{0}C. Temperature analysis of all the three windrows were presented in the Figure 8 in the shape of graph. Temperature for W1, W2 and W3 were collectively plotted against each other as shown in Figure 8. Colum chart shows the trend of temperature a little bit different from each other. Highest value of temperature were noticed in W1 treated with sewage water and W3 treated with EM spray as 51.34^{0}C.

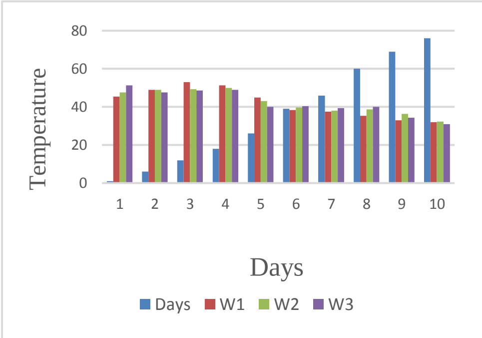

Figure 8: Temperature analysis of all the Windrows

3.2.2 Analysis of Moisture Content

Moisture analysis showed that requirement of microbes was satisfied as moisture typical value ranged from 40-60%. Moisture content of three windrows were measured by oven dry method. Moisture content during monitoring process for W1 (treated with sewage water), W2 (treated with tape water) and W3 (treated with EM spray) were plotted collectively to find out the best microbial activity as shown in Figure 9.

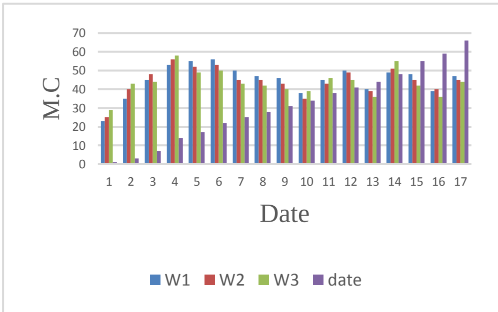

Figure 9: M.C analysis of all the Windrows

3.2.3 Analysis of pH

Rate of decomposition of organic matter would be faster in pH controlled operation of composting than the experiment without pH control. pH range for food waste composting as 7-8 [14]. Final pH analysis showed that 2nd composting pile treated with tap water have less pH then the other two composting piles. pH of 3rd pile treated with Effective microbial spray have more pH then the 1st composting pile treated with sewage water showing the more organic formations for the breakdown of cellulose and lignin. Relation between these pH values are displayed in the Figure 10.

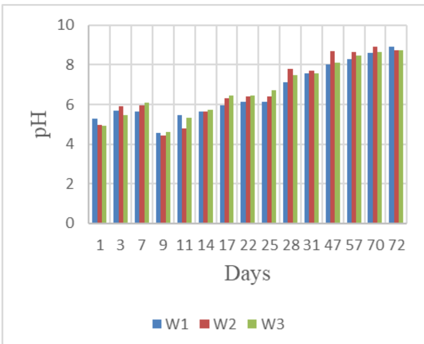

Figure 10: pH analysis of all the Windrows

3.3 Analysis of Final Compost

3.3.1 Analysis of Moisture Content

Final compost moisture content analysis of all the composting piles were satisfactory but pile 3rd treated with EM spray should have more moisture content for microbial activity then the composting piles 1st and 2nd. All composting piles having food waste in equal proportion with swage, tap water and microbial spray with 22 kg waste. Moisture content of all the composting piles were in the range of standard values. Results of moisture analysis on final ready compost product were recorded as presented in the Figure 11. Final moisture analysis of three composted piles were computed and showed in Table 7 given below. Final moisture of product for packing should be less as possible to sale it in the market as fertilizer. Standard value for the compost packing lies between 26-73%. Final moisture content value for W3 treated with EM spray lies in standard range and find better than the other composting piles.

Table 7: Moisture Content of final compost

Windrow No.	Sample No.	M.C value (%)
W1	S1	23.51
W2	S2	25.01
W3	S3	28.09

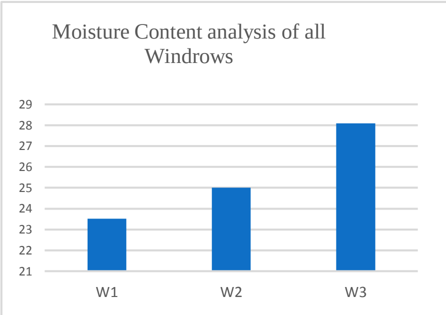

Figure 11: Final compost Moisture content analysis of all Windrows

3.3.2 Analysis of pH

Standard values of pH ranged 8.5-9.6. pH of 1st and 2nd pile treated with sewage water and tap water were not lie in this range while pH of 3rd pile value lies in the standard range. The pH of final compost product were listed in the table 8 and to differentiate between these pH values of W1, W2 and W3, graph was plotted which shows the higher pH value for the W3 as 8.63 which is shown in Figure 12. So fertilizer formed with EM spray treatment was of better quality than the other treatments.

Table 8: pH analysis of final compost

Windrow No.	Sample No.	pH value
W1	S1	8.07
W2	S2	7.81
W3	S3	8.63

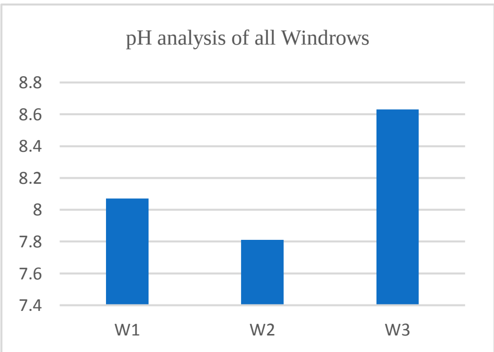

Figure 12: Final compost pH analysis of all Windrows

3.3.3 Analysis of Organic Content

Organic content of 2nd pile was measured lower than the 1st and 3rd pile. 1st pile have O.C of 40% while 2nd and 3rd piles have 39.75% and 68.91%. Typical range of organic content lies between 16.7-90.7%. Final organic content analysis results were shown in table 9.

Table 9: Organic Content analysis of final compost

Windrow No.	Sample No.	O.C value (%)
W1	S1	40
W2	S2	39.75
W3	S3	68.91

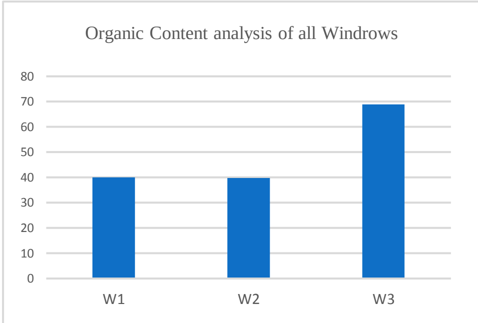

Figure 13: Final compost Organic Content analysis of all Windrows

3.3.4 Analysis of Carbon Content

Final compost carbon analysis showed the results for all the three composting piles W1, W2 and W3. Carbon content of 1st pile was recorded as 18.8% less than the other two composting piles having carbon content values as 18.68% and 32.38%. Carbon content of 3rd pile treated with Effective microbial spray was more as showed in table 10. Figure 14 illustrates the relation between three windrows values of carbon content. More carbon content mean better quality of compost to be sold. W1 and W2 have less carbon content to balance this carbon content dry leaves, sawdust and straw should be added that are rich in carbon content.

Table 10: Carbon content of final compost

Windrow No.	Sample No.	Carbon value (%)
W1	S1	18.8
W2	S2	18.68
W3	S3	32.38

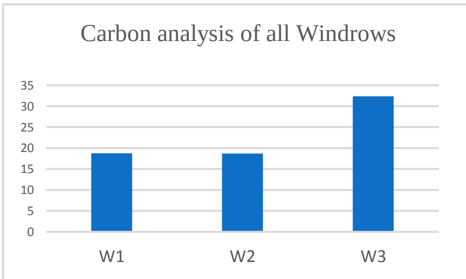

Figure 14: Final compost Carbon analysis of all Windrows

3.3.5 Analysis of Nitrogen Content

Nitrogen analysis showed the results of three composting piles. Nitrogen content of 3rd pile treated with EM spray was measured more than the 1st and 2nd pile as 0.67, 0.56 and 0.43%. Nitrogen content ranged from 1-2% considered good in quality according to Lahore compost standards other than that nitrogen have no typical value for compost. Nitrogen analysis values listed in the table 11 showed that W3 treated with EM spray have more nitrogen value as 0.67. Figure 15 shows that nitrogen values of all the three treated windrows W1, W2 and W3 were not lie in the standard range but in comparison with other windrows W3 treated with EM spray have better value of nitrogen. Less values of nitrogen showed that urea should be added at the time of treatment of composting. Gardening

Cite The Article: Sana Basheer, Maria Nazir, Haroon Rashid, Abdul Nasir, Engr. Majid Hussain (2019). Development Of Efficient Windrow Composting Technique For Food Waste And Its Optimization. *Earth Sciences Pakistan*, 3(2) : 18-26.

materials or grass clippings can be added in the windrow W1, W2 and W3 to balance the nitrogen content in the compost.

Table 11: Nitrogen analysis of final compost

Windrow No.	Sample No.	Nitrogen value (%)
W1	S1	0.56
W2	S2	0.43
W3	S3	0.67

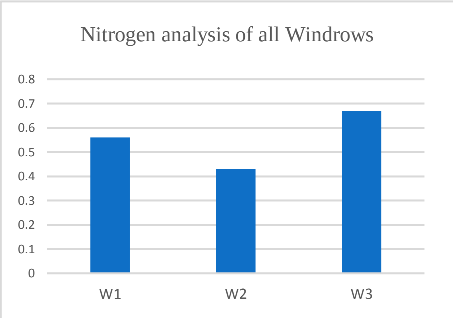

Figure 15: Final compost Nitrogen analysis of all Windrows

3.3.6 Analysis of C/N ratio

Requirement of bulking agent would be reduced with low carbon to nitrogen ratio but needed a long time for composting [15]. C/N ratio of three composting piles W1, W2 and W3 were being determined having values as 1st pile with sewage treatment have C/N ratio 33.57:1 less than the other two piles. Tap water treated pile has C/N ratio as 43.44:1 and EM microbial spray pile's value as 48.32:1. Typical value of C/N ratio varies 5-30:1. Microbial spray treated pile has highest value of C/N ratio. Larger value of C/N ratio represent that great amount of nitrogen would be added for the growth of plants. C/N ratio values for W1, W2 and W3 were listed in the table 12. Figure 16 developed the relationship graphically between all the three windrows. The C/N ratio for W1, W2 and W3 for out of range so more nitrogen should be added to take the C/N ratio in the standard range.

Table 12: C/N ratio of final compost

Windrow No.	Sample No.	C/N ratio (%)
W1	S1	33.57
W2	S2	43.44
W3	S3	48.32

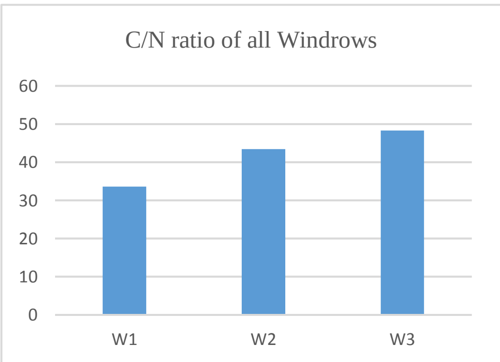

Figure 16: Final compost C/N ratio analysis of all Windrows

3.3.7 Analysis of Phosphorous

Phosphorous analysis showed the results as 3rd pile treated with Effective microbial spray have more phosphorous than the 1st and 2nd composting pile. Typical value of phosphorous content lies as 0.9%. Phosphorous value of 3rd composting pile was more as 1.3% illustrated in table 13 than the 1st and 2nd composting piles with the values as 1.08% and 0.85%. Graphical relation between phosphorous values of W1, W2 and W3 were plotted in Figure 17. Greater organic content leads to the higher quantity of phosphorous in the compost. Phosphorous in W2 treated with tap water has less value of phosphorous so manure should be added in the composting pile at the time of starting of treatment.

Table 13: Phosphorous analysis of final compost

Windrow No.	Sample No.	Phosphorous (%)
W1	S1	1.08
W2	S2	0.85
W3	S3	1.3

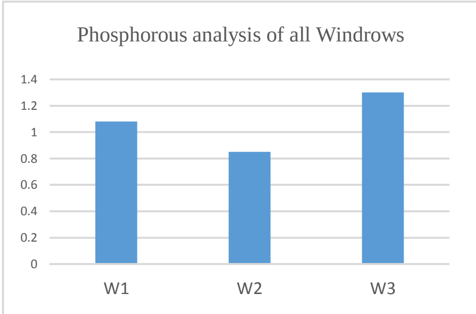

Figure 17: Final compost Phosphorous analysis of all Windrows

3.3.8 Analysis of Potassium

Potassium content also analyzed for this compost. Potassium content of all the three windrows samples were analyzed as 0.57 for the sewage treated pile, 0.62 for the tap water treated pile and 0.81 for the Effective microbial spray treated pile. These three results showed the good result of the ready compost/ fertilizer. Potassium analyzed values for W1, W2 and W3 were incorporated in the given table 14. W3 have higher value of K than the pile W1 and W2. Figure 18 demonstrates a clear comparison between K values of all windrows. Results showed that compost prepared by the treatment of EM spray have better results for K parameter. Typical range of potassium in compost should be 0.5-1.5meq/100gm. less potassium in W1 and W2 were noted so Banana peels, Wood ash and green sand should be added in these piles to balance the potassium content in the Compost.

Table 14: Potassium analysis of final compost

Windrow No.	Sample No.	Potassium (%)
W1	S1	0.57
W2	S2	0.62
W3	S3	0.81

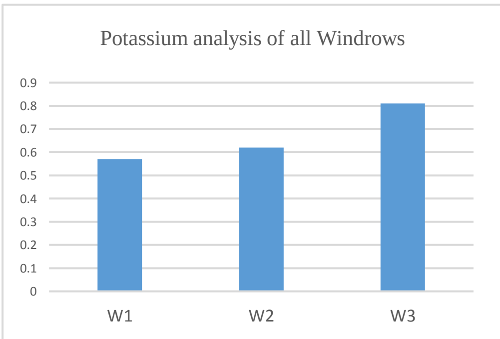

Figure 18: Final compost Potassium analysis of all Windrows

4. DEVELOPING GUIDELINES FOR WINDROW COMPOSTING

Composting of organic fraction of municipal solid waste like food waste, green waste, fish waste, sewage sludge and animal manure had received a greatest interest in waste reducing system works. The aim and objective of presenting these guidelines were to gain information for composting processes along with siting and operation of composting [16]. These guidelines must be helpful in ensuring the public health and animal health during the production of compost by aerobic windrow composting.

4.1 Guidelines for Composting Parameters

Following guidelines were suggested on the basis of food waste composting process for the physic-chemical properties of waste as:

- Time requirement for the completion of composting period must be an important parameter. Compost will be completely prepared when original material cannot be identified and it should have earthy smell. Time for the final compost will directly depend on the nature of waste material like animal manure and food processing waste would take 6-10 weeks to compost. Time of composting can be reduced by adding bulking agent like urea, rice husk etc.
- Temperature required was also an important parameter. The temperature of piles had reached between 55-60^{0}C at highest degree of microbial activity. Highest temperature was reached and identified in first 30-40 days then it gradually starts to reduce at its initial stage in 6-8 weeks. If temperature was too high, then specific action should be taken to minimize the temperature by aeration or some other practices.
- Moisture content would be an important parameter to be identified, ranged between 45-55%. Too much lower moisture will cease the microbial activity and too much high moisture will prevent the air supply to the microbes.
- Aerobic composting operation will require oxygen that should be considered more reliable, efficient and tolerant of environment. Aerobic composting system will produce less odor but if pile was producing foul odor then it mean there is not enough oxygen.
- Nutritional requirements are also necessary to develop in the composting piles. Organisms like all living things need moisture, air and a source of nutrients. Most important nutrients supplied to microbes were carbon and nitrogen. Ideal carbon to nitrogen ratio was 5 to 30 parts carbon and 1 part nitrogen.
- Particle size of composting material was also an important parameter considered in these guidelines. Rate of decomposition will be faster as smaller the size of particles. The maximum size of green plant materials like food waste, fruits and vegetables should be less than 5cm and maximum size should be as large as 15cm.
- Mixing requirement should be necessary to decompose the composting material uniformly throughout the piles. Mixing will destroy some pathogens and done according to schedule.
- Acidity of all composting piles depending on pH should be 5 as composting process taken place. Gradual increase in pH level was noted till the end of composting process like 7-8.5. If pH level was low then lime should be added in the composting piles.
- Odor problems were mostly associated with composting under aerobic conditions due to the production of sulfur, carbon and nitrogen compounds. During aerobic conditions the emitted gaseous compounds may be carbon dioxide and organics having woody and earthy odor. Odors may be reduced or minimized by odor scrubbers and diffusion of biogas mixtures through fresh compost.

4.1.1 Operational Requirement Guidelines

Following composting operation guidelines have been suggested on the basis of research windrow composting project as:

I. The food waste composting must be developed to maintain satisfaction level of environmental conditions as composting release green house and ammonia.
II. The food waste composting operation must have security to prevent illegal dumping of waste and vandalism.
III. Composting operation must involve mixing, turning, allowing for the leachate collection and recycling it into the composting piles again.

    - Pre-processing operation can be done to produce a good recipe material for composting to maintain nutrients level and moisture level. To control the nuisances on site and of site like odor, dust, litter and birds.
    - Processing operation can be done to maintain the high rate of decomposition during composting, aerobic conditions, completion time and temperature requirements.

IV. The final composted product should be hauled to the disposal site.
V. Operational controls should reduce the amount of bio-aerosols to protect the environment from risk like

    - Through complete mixing and aeration of composting windrows the amount of air polluting aerosols can be reduced.
    - Concentration of dust can be reduced by maintaining moisture content above 45% in all the composting piles.
    - Wet down dry composting piles.

4.1.2 Design Consideration Guidelines

Design considerations for processing operations of compost should include

- Sufficient retention time should be provided to assure the pathogen reduction and solid decomposition.
- Ventilation or natural air providing system should be assured to maintain aerobic conditions.
- Rehydration of composting piles to maintain the moisture content at 40-60%.
- Volume reduction compensating by composting material applying treatments.
- Curing and finishing operations of composting piles should include the mature end product as fertilizer including the balanced N, P, K contents according to standards and its market value.

5. CONCLUSIONS

Solid waste management is a more globally critical issue anywhere in Pakistan. First main problem is the open dumping of waste without segregation causing environmental pollution and economic issues to the communities. Collection of waste from the Faisalabad city was about only 55-65% and other waste openly dumped to the landfills and streets causing smell, odor and inflectional diseases. The research work study was carried out at UAF hostels on food waste by adopting aerobic windrow composting. This composting system was adopted to manage the daily produced waste at UAF hostels by the residential students. To enhance the disposable system of waste composting system was introduced for managing the waste. First windrow was treated with sewage water, second was treated with tap water and third was treated with microbial spray. Reduction in waste was 40% and samples from each windrow were analyzed for the N, P, K contents. Temperature analysis was in the range from 28-53^{0}C and moisture content was in the range from 25-29% for all the windrows. Samples analysis showed the better results for the 3rd windrow samples treated with microbial spray with the pH 8.63, M.C 28.09%, O.C 68.91%, C.C 32.38%, N.C 0.67%, C/N ratio 48.32:1, P 1.3%, K 0.81%. The ready product used as a fertilizer for the growing plants. Composting not only reduce the waste volume also produce the soil like compost used as fertilizer.

REFERENCES

[1] Masood, M. 2013. Status of solid waste management practices in developing countries – a case study on Lahore, Pakistan, Schlumberger Faculty for the Future Fellows Forum, Cambridge.

[2] Korhonen, J. 2004. Industrial ecology in the strategic sustainable development model: Strategic applications of industrial ecology. J. Clean. Prod,12, 809–823.

[3] Wiki https://en.wikipedia.org/wiki/Faisalabad

[4] Basheer, S., Rashid, H., Nasir, A., Parveen, Z., Ashgar, M. Z. 2018. EIA Guidelines for Landfill Site in Faisalabad Using an Integrated Solid Waste Management Approach. Ekoloji, 27 (106), 1467-1477.

[5] Webster, M.D., Babiker, M., Mayer, M., Reilly, J.M., Harnisch, J., Sarofim,

M.C., Wang, C. 2002. Uncertainty in Emissions Projections for Climate Models, Atmos. Environ., 36 (22), 3659-3670.

[6] Eid, J.A.A.A.A. 2007. Evaluation of Solid Waste Management in Qalqilia District (Doctoral dissertation, National University).

[7] Environmental Protection Agency. 2007. Solid waste Management Glossary. Pak-EPA: 217-222.

[8] Lou, X.F., Nair, J. 2009. The impact of landfilling and composting on greenhouse gas emissions-a review. Bioresource Technology, 100, 3792-3798.

[9] Kumar, M., Ou, Y.L., Lin, J.G. 2010. Co-composting of green waste and food waste at low C/N ratio. Waste management, 30, 602-609.

[10] Tchobaneglous, Vigil, S. 1993. Integrated Solid Waste Management Engineering Principles and Management Issues. McGraw-Hill Kogahusha Limited, Tokoyo, Japan Edition.

[11] Khurshid, A. 2009. Techniques in Environmental Sciences and Management. A-one publishers.2nd edition. Pp. 297-497.

[12] Jiang, T., Schuchardt, F., Li, G.X., Guo, R., Zhao, Y.Q. 2011. Effect of C/N ratio, aeration rate and moisture content on ammonia and greenhouse gas emission during the composting. J. Environ. Sci., 23, 1754-1760.

[13] De-Guardia, A., Petiot, A., Rogeau, D., Drullhe, C. 2008. Influence of aeration rate on nitrogen dynamics during composting. Waste Management, 28, 575-587.

[14] Nakasaki, K., Akiyama, T. 1998. Effects of seeding on thermophilic composting of household organic waste. J. Ferment. Technol., 66, 37-42.

[15] Huang, G.F., Wong, J.W.C., Wu, Q.T., Nagar, B.B. 2004. Effect of C/N on composting of pig manure with sawdust. Waste Manage, 24, 805-813.

[16] Faisal, I.H., Ashraf, M. 2005. A Study on Solid Waste Management System of Dhaka City Corporation: Effect of Composting and landfill location. UAP. J. Civil & Engg., 18-26.