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QUANTIFICATION, CHARACTERIZATION AND FEASIBILITY OF FOOD WASTE FOR ORGANIC FERTILIZER BY COMPOSTING

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ABSTRACT

Municipal solid waste is major factor that contaminates the environment and causes water, air, and soil pollution. Many developed countries are working on recycling organic waste into useful energy potential. The food and yard wastes are openly dumped and burnt in atmosphere which causes environmental pollution. To characterize and quantify food waste, 64 samples were collected from Higher Staff Colony, Junior Staff Colony, Boys Hostels, Girls Hostels and Canteens of the University. The different components of food waste such as kitchen waste, vegetable waste and fruit wastes were segregated, quantified, and characterized by using standard methodology. The percentage of moisture content, total solids, volatile matters, ash contents and fixed carbon as well as percentage of carbon, hydrogen, nitrogen, and oxygen were determined. The results of study showed that food generation rate is 110kg/day which is enough to convert into useful compost by composting process. The characterization results of food waste led to recommend that food waste is more feasible for compost product rather than burning along with other components of waste.

KEYWORDS: Fruit waste, vegetable waste, kitchen waste, environment.

1. INTRODUCTION

The generation rate of municipal solid waste (MSW) has been rapidly increasing because of high product demands due to globalization, increasing population and their way of standard

living over the world. Alarming rapid increase rate of population, increase in economy and lifestyles of people has generated much municipal solid waste. To manage and utilize the municipal solid waste is a major challenge of today's world. Due to improper management of wastes collection also increases the pollutions which contaminated environment and effect living organism health. The major proportion of municipal solid waste contains organic wastes. Organic waste can easily be converted into clean useful products which also reduce waste and pollution. Municipal solid waste contains 39% of food waste.[1] Food waste is undesirable not only from socio-economic and environmental point of view but also from the moral viewpoint.[2] Food waste can easily be converted into useful compost and biogas. The waste generated by food is called food waste. Leftover food or peelings of food which are not eaten are food waste. Generally, food waste consists of kitchen waste, vegetable waste and fruit waste. The food waste is the major proportion of municipal solid waste after yard waste. Three main sources of MSW generations are commercial, residential, and institutional areas.[3] Nowadays, improper management of municipal solid waste in Pakistan is major factor which contaminated the environment and caused water, air and soil pollution.[4] Food waste is major part of environment pollution. Composting material mostly consist of food waste.[5] Due to open dumping and burning of food and yard waste, CO_2 is generated which is later absorbed by atmosphere and has harmful effect on environment, causing global warming. Mostly, the food and yard wastes are openly dumped and burned in atmosphere which causes environmental pollution. Mostly, the food waste is disposed and recycled by various techniques in emerging countries to reduce environment and socio-economic significances.[6] Composting is waste treatment technology which converts biodegradable waste into organic fertilizer called compost. Composting technologies are the only way to convert organic waste into useful final product called compost.[7] Various types of composting processes are used for compost such as aerated static pile composting, windrow composting, in-vessel composting and vermicomposting. Windrow composting is the most preferable technology in order to convert organic waste into useful natural fertilizer called compost. Windrow composting turn into technically and economically cheap due to its good performance and simple equipment results bringing environment and economic profit. This study was carried out to quantify and characterize food waste for converting into useful product like organic fertilizer.

2. METHODOLOGY

2.1 Area of Study

The Mehran University of Engineering and technology Jamshoro is situated on left bank of river Indus in Jamshoro city, Sindh, Pakistan. Mehran UET has 18 engineering departments and 5 institutes. This University also has hostels, canteens, higher staff colony and junior staff colony. Thousands of students and university staff are enrolled in this university. This study is carried out at Mehran University of Engineering and Technology, Jamshoro main campus to calculate the Food waste generation and its quantification and characterization. The Fig.1 represents the map of study area.

Fig. 1: Location of Study Site.

2.2 Collection of Samples

For significant treatment process of waste material, quantification of waste generation rate is essential.[8] In order to characterize and quantify food waste, all samples were gathered from different sites of Mehran UET, including Higher Staff Colony, Junior Staff Colony, Boys Hostels, Girls Hostels and Canteens. Total 64 Samples were collected from different mentioned sites on daily basis for 3 consecutive days.

2.3 Quantification of food waste

Samples of waste generation from dust bins were collected in plastic bags from different sites and weighted by physical balance. Collected food waste components were manually segregated for characterization and calculated composition of each.

2.4 Characterization of food waste

The food waste and other samples were analyzed after separating individually. Samples were characterized individually by using following parameters and methodology.

- Proximate analyses
- Ultimate analyses

2.4.1 PROXIMATE ANALYSIS

Some parameters like moisture content, ash content, volatile matters and fixed carbon were analyzed in the proximate analysis by using oven and muffle furnace.

2.4.1.1 Moisture Content and Total Solids

The oven is used to calculate the percentage of water present in food waste samples. It is an important parameter of physical characterization of food and other organic wastes. Moisture contained samples were dried at 105 ^{0}C for 24 hours in oven.[9] The moisture content was calculated by putting final and initial weights in Eq.1. Percentage of total solids were calculated by using Eq.2

$$\mathbf{MC\ \% = [(A-B)/A]100} \quad \mathbf{(1)}$$

$$\mathbf{TS\% = 100 - MC\%} \quad \mathbf{(2)}$$

MC % = percentage of moisture content

A = initial weight of sample

B = final weight of sample after drying

TS% = percentage of total solids

2.4.1.2 Volatile Matters

Volatile matters are an important physical characteristic of food waste. The percentage of volatile matter is determined by using muffle furnace. After calculating MC% the same samples were placed in a muffle furnace at 950 ^{0}C for 7 minutes in a covered lid.[10-11] After cooling the crucibles were weighted and their weight values were put in Eq. 2 and 3

$$\mathbf{V.M_{(WB)}\ \% = \{(B-C)/A\}100} \quad \mathbf{(3)}$$

$$\mathbf{V.M_{(DB)}\ \% = \{(B-C)/B\}100} \quad \mathbf{(4)}$$

Where,

$V.M_{(WB)}$ % = percentage of volatile matters, wet base

$V.M_{(DB)}$ % = percentage of volatile matters, dry base

A = initial weight of sample

B = weight of sample before muffle furnace

C = weight of sample after muffle furnace

2.4.1.3 Ash Conten

Ash content is residue of the food waste remained in crucible after heating. The sample is placed in muffle furnace at 750 ^{0}C for 1 hour with open lid.[11-12] After heating, the values were put in the Eq. 4

$$\mathbf{AC\ \% = (D/A)\ 100} \qquad \mathbf{(5)}$$

Where,

AC% = percentage of ash content

A = initial weight of sample

D = final weight of sample

2.4.1.4 Fixed Carbon

Fixed carbon is nonvolatile residue remaining in the crucible with ash content after heating. Percentage of fixed carbon is calculated by subtracting the percentage of moisture content, volatile matters and ash content from total percentage.[11-12] Eq. 5 is used to calculate fixed carbon percentage in food waste.

$$\mathbf{FC = 100 - (MC\% + VM\% + AC\%)} \qquad \mathbf{(6)}$$

Where,

FC = fixed Carbon

MC = moisture content

VM = volatile matter

AC = ash content

2.4.2 ULTIMATE ANALYSIS

In the ultimate analysis the percentage of carbon, hydrogen, nitrogen, oxygen, and sulphur are analyzed. The percentage of carbon and hydrogen can be analyzed by Eq. 7 and 8.[13-14-15-16] The percentage of oxygen was determined by using Eq.9.[17-18]

$$\mathbf{C\% = 0.637FC\% + 0.455VM\%} \qquad \mathbf{(7)}$$

$$\mathbf{H\% = 0.052FC + 0.062VM\%} \qquad \mathbf{(8)}$$

$$\mathbf{O\% = 100 - (C\% + H\% + N\% + S\% + Ash\%)} \qquad \mathbf{(9)}$$

For sulfur content, sample of food waste was placed in oven at temperature of 105 ^{0}C for 24 hours in order to dry and remove moisture content. Then particles size were reduced by cutting in smaller pieces manually and ground in grinder machine. In order to obtain

percentage of sulphur in food waste, 10 mg of the ground sample in powder form was dissolved in 15ml of distilled water in beaker. The solution was put on orbital shaker for 15 minutes at 800 rpm. The solution was then filtered to remove the sold particles from it. The solution was put into spectrophotometer at dilution factor 2.5. The absorbance of solution was noted as suggested by.[11] The Sulphur contained was calculated Eq.10.

Sulphur % = (A x R x DF) / Mass of sample **(10)**

Where,

A = Sulphate, mg / L which was determined by A = (B-0.0408) / 0.0126, B is absorbance, R = total volume of sample, ml and DF is Dilution Factor.

3 RESULTS AND DISCUSSION

3.1 Quantification of waste

The waste in kg was collected for 3 consecutive days from 64 different sites of Mehran UET Jamshoro. The waste samples of dustbins were collected from Higher Staff Colony, Junior Staff Colony, Boys Hostels, Girls Hostel and Canteens of Mehran University of Engineering and Technology, Jamshoro. The collected waste was quantified and segregated for the characterization. The average weight was calculated as shown in Table 1 and also in Fig.2.

Table 1: Average Total Food Waste Generation at Campus.

S.No	Sample point	Quantity of FW, Kg/d	Food waste components	Weight of Components, Kg/d	TQ %
1	Higher Staff Colony	20.62	Kitchen waste	10.23	49.61
			Fruit waste	5.22	25.32
			Vegetable waste	5.17	25.07
2	Junior Staff Colony	32.8	Kitchen waste	18	54.88
			Fruit waste	7.64	23.29
			Vegetable waste	7.16	21.83
3	Boys Hostels	24.23	Kitchen waste	13.56	55.96
			Fruit waste	6.07	25.05
			Vegetable waste	4.6	18.98
4	Girls Hostels	8.88	Kitchen waste	5.73	64.53
			Fruit waste	1.89	21.28
			Vegetable waste	1.26	14.19
5	Canteens	23.47	Kitchen waste	13.65	58.16
			Fruit waste	7.07	30.12
			Vegetable waste	2.75	11.72
Total food waste generated				***110***	

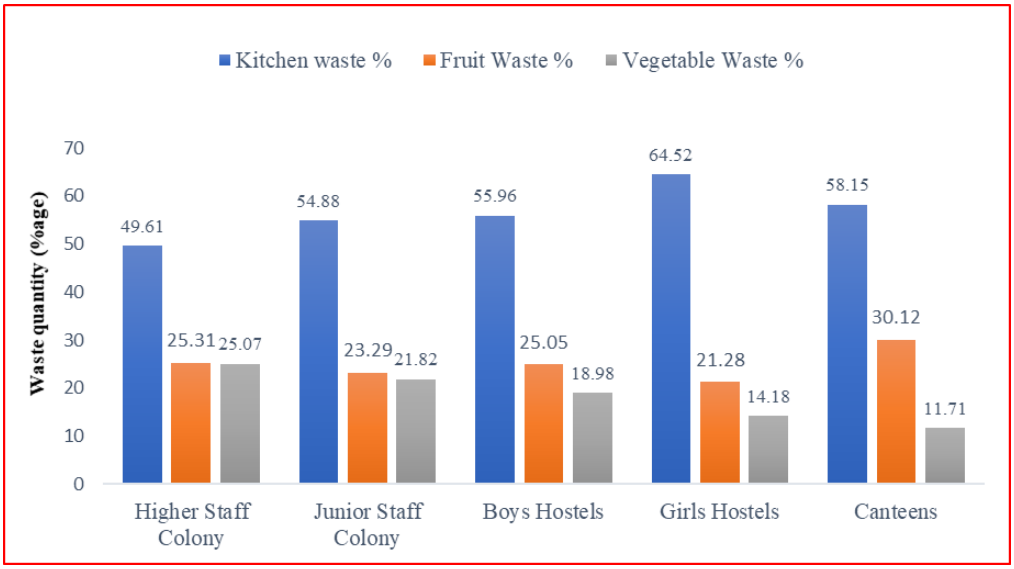

Fig. 2: Average Total Food Waste Generation at Campus.

3.2 Characterization of Food Waste at Campus

3.2.1 Proximate analysis

In the proximate analyses moisture contents, volatile matters, total solids, ash content and fixed carbon were determined from food waste collected from different sites of Mehran University of Engineering and Technology, Jamshoro.

Table 2: Average Proximate Analysis of Food wastes at Campus.

S.No	Sample point	Food waste					
		MC%	TS%	VM%(db)	VM%(wb)	AC%	FC%
1	Higher staff colony	81.74	18.26	90.73	16.59	2.79	1.17
2	Junior staff colony	81.02	18.98	90.08	17.1	3.13	1.3
3	Boys Hostels	80.97	19.03	91.82	17.5	3.27	0.91
4	Girls hostels	80.87	19.13	90.27	17.28	2.89	1.3
5	Canteens	82.43	17.57	91.87	16.2	2.63	0.91
Average		**81.41**	**18.59**	**90.95**	**16.93**	**2.94**	**1.12**

These characteristics were analyzed by using of oven dry and muffle furnace. Moisture content, total solids, volatile matters (wet base and dry base), ash content and fixed carbon were analyzed as shown in Table 2 and also graphically represented in Fig.3.

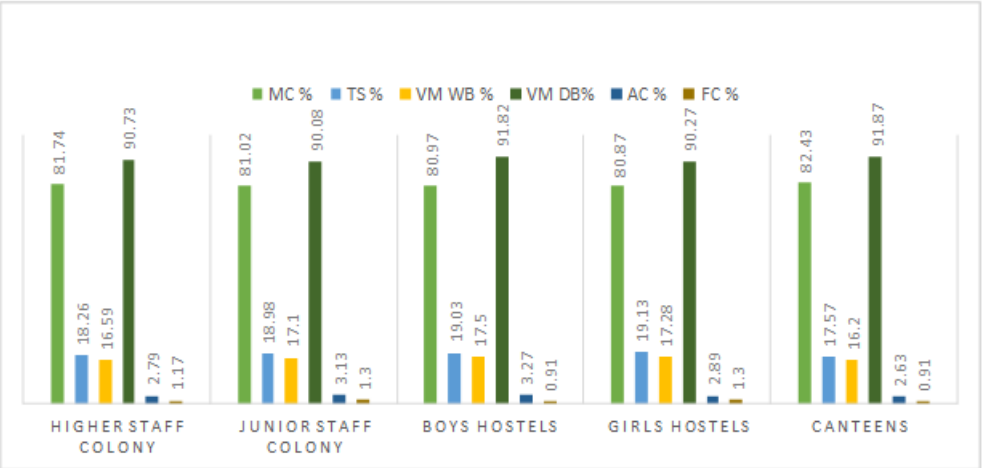

Fig. 3: Average Proximate Analysis of Food waste at Campus.

3.2.2 Ultimate Analysis

Percentage of carbon, hydrogen and oxygen present in food waste were calculated via equations taken from previous research.[18] Food waste samples from 64 different sites at Mehran UET Jamshoro were collected and mixed in order to determine percentages of Sulphur present in food waste. Percentage of Nitrogen as 2.2% was taken same from previous research.[19] Based upon carbon and nitrogen value, C/N ratio of food waste was calculated as 19 which is in the range as previous study[20] shows the C/N ratio must be in between 16.2 and 19.6. The percentages of carbon, hydrogen, oxygen, nitrogen and sulphur of mixed food waste were determined by using different formulas as mentioned and results of these parameters are given in Table 3 and Fig.4. Previous study[19] expressed the percentages of Carbon, Hydrogen, Nitrogen, Oxygen and Sulphur of food waste as 39.92%, 5.96%, 2.2%, 46.25%, 0.11% respectively. Therefore, the results of present study show the similarity with previous study. The C/N ratio is an essential factor which affects the composting process.[21-22]

Table 3: Ultimate Analysis of Food Waste at Campus.

Sampling Points	C%	H%	S%	O%
Higher Staff Colony	42.01	5.68	0.18	46.08
Junior Staff colony	41.8	5.64	0.16	46.58
Boys Hostels	42.34	5.73	0.17	47.1
Girls Hostels	41.07	5.65	0.16	47.2
Canteens	42.36	5.73	0.18	46.98
Range	41.07-42.36	5.64-5.73	0.16-0.18	46.08-47.2
Average	41.91	5.68	0.17	46.79
Standard deviation	0.53	0.04	0.01	0.46

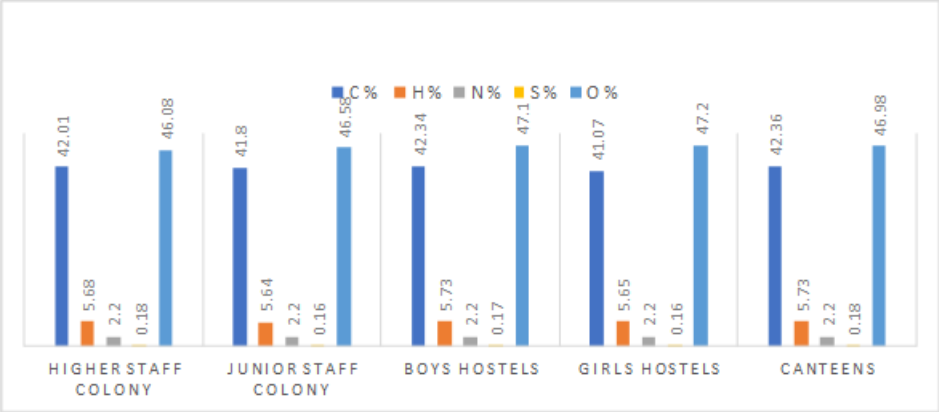

Fig. 4: Average ultimate values of food waste from different sites of Campus.

4 CONCLUSION

This work was carried out at Mehran University of Engineering and Technology Jamshoro main Campus. The food waste is organic waste and is better for composting. In this study, food waste was collected from Canteens, Girls Hostels, Boys Hostels, Junior Staff Colony and Higher Staff Colony at the Campus. The different components of food waste such as kitchen waste, vegetable waste and fruit wastes were segregated, quantified, and characterized by using standard methodology. The percentage of moisture content, total solids, volatile matters, ash contents and fixed carbon as well as percentage of carbon, hydrogen, nitrogen, and oxygen were analyzed. The results show that food waste is generated at the rate of 110kg/ day, which is very high to convert into useful energy sources such as biogas and organic fertilizer by anaerobic digestion and composting respectively. The C/N ratio was found as 19 which is in the optimized range for biological conversion process. The findings of study realized that food waste may be converted into either biogas by anaerobic digestion or organic fertilizer by composting.

5 RECOMMENDATIONS

Proper arrangements should be made for the segregation and collection of food waste for conversion into useful product like organic fertilizer by composting process.

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