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Utilization of Kitchen Food Waste for Physico-Chemical Characterization

Sipra Barik[1] and Kakoli Karar Paul[2]

[1,2]Department Of Civil Engineering National Institute Of Technology, Rourkela, Odisha, 769008, India
E-mail: [1]siprabarik@nitrkl.ac.in, [1]sipra.barik@gmail.com, [2]kkpaul@nitrkl.ac.in, [2]k_karar1@yahoo.co.in

Abstract— *As food waste is a burden for the society, its handling to disposal is a major problem. Food wastes contain an appreciable amount of lipids that can be used for biodiesel production. An attempt has been made in the present research work for detailed physico-chemical characterization of kitchen food waste for their recycle and reuse. Food waste samples as raw materials have been collected from girl's hostel of National Institute of Technology, Rourkela and brought to the laboratory for further analysis. Physico-chemical characterization has been done following the methods mentioned in IS 3025. Metallic properties (Ca, Mg, Cu, Zn, Cr, Fe, Ni) were identified using atomic absorption spectrometer. Calcium (20.356 mg/l) and Mg (3.003 mg/l) dominates the metallic species and thus, these can be further used for pharmaceutical purpose (multivitamin) along with zinc (3.320 mg/l).*

Keywords*: Characterization, dewater, food waste.*

1. INTRODUCTION

Due to the increase of industrialization and urbanisation, waste generation problem has increased significantly. The estimated quantity of municipal solid waste (MSW) generated worldwide is 1.7-1.9 billion metric tons per year [1]. In the year 2011-12 about 1,27,486 tonnes per day of MSW waste was generated in India out of which 89,334 tonnes per day of waste was collected and 15,881 tonnes per day of waste was processed [2]. The MSW contains a considerable amount of food waste. Several billions of gallons of food wastes are produced from kitchens of residential societies, restaurants, hostels, canteens, food and meat processing industries. Food waste harms climate, water, land, biodiversity and causes serious environmental and social problems across the world. According to the report released by the Hong Kong Environment Bureau, 9,000 tonnes of MSW is thrown away every day at landfills containing 40% of putrescibles matters. Approximately, 90% putrescibles are food wastes [3].The most common way of food waste disposal is landfill but it has many disadvantages, i.e. it spread objectionable odour and cause hazardous effect on people, animals and environment. It also generates harmful leachate when rain water fall on food wastes. This leachate may contaminate surrounding water and soil [3].

There is an urgent need for proper disposal and reuse technique for kitchen food waste. Food waste may be recycled in different ways. Among them, use of yellow grease and other waste grease to diesel fuel engines is challenging. In United States, restaurants provide a steady supply of these fuels since they are a by-product of cooking oils, either from animal fats or plant oils. Using this fuel not only avoids generation of more waste but also provides a more eco-friendly fuel which generated half as many greenhouse gases as standard diesel fuels [4]. In Indian cities like Mumbai, a number of families practice vermin-composting since it reduces load on municipal waste transport system and dumping site and at the same time gives good quality compost for gardening [5]. In this paper an attempt has been made to study the physico-chemical properties and metallic analysis for reuse of kitchen food waste which will be eco-friendly and beneficial for human purpose.

2. MATERIALS AND METHODS

2.1 Sampling Site

The girls hostel of National Institute of Technology (NIT) Rourkela with 1200 seated capacity is selected as a sampling location for present research work. Food waste generated from the kitchen of girls hostels of NIT, Rourkela is selected as the raw material for experiment. This study location is chosen for its huge food waste generation and their dumping problem. If these wastes can be reused to give an eco-friendly output, it would be an innovative approach. Mass measurement of food waste samples has been taken by using weighing balance of Sartorius model CP 124S. About 2 kg of food waste is collected for analysis during peak hours, i.e., during lunch and dinner when food waste generation is more. A total of 15 samples has been collected in an air tight plastic bottle from girls hostel of NIT Rourkela and brought to the laboratory for further analysis. Samples are dried by various drying methods such as oven drying (105˚C, 70˚C and 55˚C), freeze drying at -4˚ C and sun drying. The dried food waste samples are crushed into powder form by using grinder and kept in an air tight dessicator for 6h.

2.2 Food Waste Analysis

2.2.1 Food Waste Drying Methods The collected food wastes from kitchen outlet have been dried by various methods such as oven drying at 70˚C for 3 days [6], 55˚C for 3 days [7], 105˚C for 2 days [6], freeze drying method for 2 days at -4˚C [8], sun drying method for 10 days [7].

Oven drying methods are performed by Reico hot air oven. Freeze drying method is done by centrifuging the sample at -4˚ C using Eppendorf centrifuge 5702 RH.

2.2.2 Food Waste Digestion Method For detailed physico-chemical analysis, it is necessary to digest the food waste sample. Nearly 0.25 g of powdered samples have been taken in a digestion tube containing 4 ml of HNO_3 (65%), 2 ml of HF (40%) and 2 ml of H_2O_2 (30%). Samples have been digested by using Milestone microwave digester (MODEL START). The digested samples were cooled for further analysis. The acid digested samples were then analysed for physico-chemical properties following IS 3025 and metallic elemental analysis by using atomic absorption spectrophotometer (Perkin Elmer Analyst 200) as per guidelines of MHS (Perkin Elmer, 2006)

Table 1: Physico-chemical parameters and method used

S.N.	Physico-chemical parameter	Methods used
1.	pH	IS 3025:part 11: 1983
2.	Conductivity	IS 3025: part 21: 2002
3.	Total hardness	IS 3025: part 21: 1983
4.	Turbidity	IS 3025: part 10: 1984
5.	Fluoride	Hach DR/890:8029
6.	Residual chlorine	IS 3025: part 26: 1986

3. RESULT AND DISCUSSION

3.1 Physico-chemical Characterization

For detailed study of kitchen food waste physico-chemical characterization was performed. The result of the physico-chemical analysis has been summarized in Table 2.

Table 2: Physico-chemical properties of food waste

S.N.	Parameter	Unit	obtained Concentration (average value)		
			55˚C	70˚C	105˚C
1.	Conductivity	S/m	163.1	167.80	170.20
2.	Total hardness	mg/l	720.00	750.00	830.00
a3.	Turbidity	-	0.61	0.68	0.72
4.	Fluoride	mg/l	2.30	2.50	2.60
5.	Residual chlorine	mg/l	1.80	2.30	3.80
6.	pH	mg/l	6.40	6.50	6.72

The main dominating parameters are pH, conductivity and total hardness. pH is an important factor of physico-chemical parameter. It affects the mineral nutrient soil quality and microorganism activity. The pH was observed in the range from 6.4- 6.8 which determines that the sample is slightly acidic but the pH is within range (5.8-8.3) according to international agricultural standard for soil analysis. A pH range of approximately 6 to 7 promotes the most ready availability of plant nutrients. The measure of conductivity gives the idea of soluble salt present in the sample. Excessive high salinity affects plant growth i.e. high osmotic pressure around the roots prevents efficient water absorption by plants. As conductivity is very high (163 S/m-170 S/m) it can affect soil as well as plant growth [9]. So, conductivity has to check before diaposal .Total hardness is mainly due to calcium and magnesium. Calcium and magnesium can be reused for pharmaceutical purpose

3.2 Data Analysis

3.2.1 Spearman Rank Correlation

A correlation analysis is a bivariate method that describes the degree of relationship between two variables. For this purpose, spearman's rank correlation coefficient has been calculated using physico-chemical parameter of kitchen food waste samples. Spearman's rank correlation coefficient is denoted by ρ (rho) and its value will always be between -1.0 and +1.0. A positive ρ corresponds to an increasing, while a negative ρ corresponds to a decreasing monotonic trend between two water quality parameters. A high correlation coefficient means a good relationship between two variables and its value around zero means no relationship between them [10]. The formula to calculate Spearman's rank is shown below

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}. \quad \ldots\ldots \quad (1)$$

The kitchen food waste generated from girls hostel of NIT, Rourkela is directly disposed of in landfill. To establish relationship between the physico-chemical parameters, Spearman's rank correlation is carried out using IBM SPSS 22 software.

From the table 3 and table 4, it is observed that conductivity and fluoride are highly positively correlated. It means due to presence of fluoride concentration, conductivity concentration may also be high in kitchen food waste. Parameters like total hardness and conductivity (TH-C), turbidity and conductivity (T-C), fluoride and total hardness (F-TH), residual chlorine and total hardness (RC-TH), fluoride and turbidity (F-T), residual chlorine and turbidity (RC- T), turbidity and total hardness (T-TH), residual chlorine and fluoride (RC-F) are moderately positively correlated. Parameters like residual chlorine and conductivity(R C-C), pH and conductivity (pH-C), pH and fluoride (pH-F), pH and residual chlorine (pH-RC) are weakly correlated because the correlation value is less than 0.7. Weak correlation may suggest that the concentration of one parameter has negligible effect of its correlated parameter, i.e., if one parameter is present the other parameter may be or may not be present.

Table 3: Spearman rank Correlation analysis

Parameter	C	TH	T	F	RC	pH
Conductivity (C)	1.000					
Total hardness (TH)	.891**	1.000				
Turbidity (T)	.806**	.758*	1.000			
Fluoride (F)	.915**	.818**	.891**	1.000		
Residual chlorine (RC)	.758*	.806**	.855**	.758*	1.000	
pH	.636*	.624	.552	.697*	.697*	1.000

*. Correlation is significant at the 0.05 level (2-tailed).
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Table 4: Summary of correlated physico-chemical parameter

Correlation coefficient	Correlation type	Parameter
0.9-1.0	Positive	F-C
0.7-.0.9	Positive	TH-C, T-C, F-TH, RC-TH, F-T, RC-T, T-TH, RC-F
< 0.7	Positive	R C-C, pH-C, pH-F, pH- RC

3.3 Heavy metal detection

The microwave digested samples were utilized for the determination of metallic species by using atomic absorption spectrophotometer (AA200, Perkin Elmer). The elemental concentrations are summarized in Table 5.

Table 5: Metallic concentrations of food waste

S.N.	Element	Unit	Concentration		
			70˚C	55˚C	105˚C
1.	Calcium	mg/l	20.356	18.470	22.718
2.	Magnesium	mg/l	3.003	0.703	2.621
3.	Copper	mg/l	0.173	1.187	0.651
4.	Zinc	mg/l	3.320	2.236	2.354
5.	Chromium	mg/l	1.286	0.587	0.985
6.	Iron	mg/l	30.840	29.910	30.473
7.	Nickel	mg/l	0.104	0.056	0.154

Calcium (20.356 mg/l) and magnesium (3.003 mg/l) dominate the metallic species suggesting that this waste can be reused for pharmaceutical purpose along with zinc. Other than calcium and magnesium, iron (30.840 mg/l) is also having greater concentration. Most of the iron in the body is found in the red haemoglobin of red blood cells. People take iron supplement for preventing and treating low levels of iron and its deficiency cause anaemia. As iron content is approximately 30 mg/l, pharmaceutical industry can extract iron for preparing iron tablets and calcium, magnesium to prepare multivitamin tablets.

In human nutrition, chromium is used as a nutritional supplement recommended in impaired carbohydrate metabolism characterised by reduce glucose tolerance and impaired insulin action, weight reduction etc. Although chromium (1 mg/l) concentration is less still it can be used for insulin reduction.

The practical use of zinc-nickel alloy plating is becoming more popular because the plating for car parts needs high corrosion resistance. Zinc (3.32mg/l) and nickel (0.154 mg/l) can be used for alloy plating as it has more corrosion resistance than galvanised plating. Copper (1.187 mg/l) is an essential nutrient for plant growth but only a small amount is needed in agriculture. Copper is an essential nutrient for plant growth but it is required in small amount. So it is considered as macro nutrient. As copper concentration is less approximately1 mg/l and its requirement for plant growth is less, it can meet the demand for plant nutrition.

The above metals i.e. calcium, magnesium, iron, copper, chromium, zinc and nickel can be reused in pharmaceutical and agriculture purpose which may be useful for human purpose and eco- friendly thus minimizing disposal and dumping problem.

4. CONCLUSION

Kitchen food waste causes severe environmental problem to the society, its reuse and recycle can solve the waste generation problem. From the present study it can be concluded that the metals present in kitchen food waste can be reused for pharmaceutical and agricultural purpose. Data analysis of the sample has been done to study the correlation of each parameter by spearman rank correlation analysis. It is observed that the parameter in the range 0.9-0.7 is positively correlated

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