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Food Waste Characteristics after Autoclaving Treatment

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***Abstract* - Diverting of food waste (FW) from landfill and recovering it into essential materials is important to prevent environmental issues. In this study, a mixed FW collected from University cafeteria was treated using electric pressure sterilizer under the presence of saturated steam for 60 minute. About 2-3kg of FW consist of the same basic composition was feed into electric pressure sterilizer for the treatment. Wet digested FW from the treatment was dried in oven for 24 hour at temperature of 105°C to make sure the material is completely dry. Then it was ground into a smaller particle to form compost like material. Characteristics such as moisture content, pH, nutrient content and levels of heavy metal (Cd, Cr, Cu, Pb, Hg, Ni and Zn) in this material were examined. Data obtained from this study were compared to the specification and standard for compost material. The results show that the level of heavy metal in this material is not exceeded compost limit value as stated in the standard. Presences of nutrient and low heavy metal show that there are potential for this material to be process into commercial material such as organic fertilizer.**

Keywords: Food Waste, Wet treatment, autoclaving, Heavy Metal, Compost, fertilizer

I. INTRODUCTION

Autoclaving is a system which is involved steam processing in a vessel under the action of pressure. This process has been used for many years to sterilise medical equipment and waste [1]. Recently, autoclaving has been introduced in municipal solid waste treatment. Thus, the deployment of autoclaving in solid waste treatment is still at the infancy stage in comparison to other solid waste treatment [2]. However, this treatment has received a great interest in UK as alternative treatment for diverting solid waste from landfill.

Basic principal for autoclave operation was based on the steam pressure cooker invented by Denis Papin (1647-1712) [3]. Autoclaving process involve the high pressure sterilization of waste by steam which "cooks' the waste and destroys any bacteria in it [4]. Typically, time and temperature for autoclaving are depending on the volume of waste feed into autoclave. Therefore, the temperature and time used for autoclaving usually ranging between 120°C - 160°C within 1 hour. The condition applied is sufficient to sterilize waste and change the characteristics of waste. In this study, FW was treated at saturated steam temperature of 121-127°C for 35-60 minutes.

During autoclaving process, different type of waste will have different physical reaction to the treatment. Biodegradable waste such as FW and paper is broken into a fibre like material while plastics are softened or deformed into unrecognisable state [1, 5]. One way to recover the value of autoclaving waste is by converting fibre like materials into organic fertilizer. Therefore, the level of heavy metal and nutrients content in this material is important factor to be considered in order to produce high quality compost material.

Papadimitriou et al, 2008 has conducting a study which is focus on the sources of potential toxic element (PTE) in 'floc'/fibre like material derived from autoclaved in biodegradable fraction of autoclaved non-segregated household waste. This study concludes that, autoclaving under condition of this study did not guarantee the production of high quality compost from non-segregated MSW. High level of PTE is present in the 'floc' and the sources for PTEs are from non-biodegradable waste such as electric/electronic waste and plastics in household waste.

This paper is focus on the quality of wet digested material derived from FW autoclaving. Feedstock for this treatment is separated from in- organic material before feeding into autoclave. The level of heavy metals is also compared to compost quality standard to seek the potential of this material as an organic fertilizer or soil conditioner.

II. MATERIALS AND METHODS

A. Feedstock

FW feedstock used in this study was collected from USM cafeteria. This feedstock contains of kitchen waste use for cooking and uneaten food that was collected during lunch time which is between 1100 am to 0200 pm. The feedstock composition basically comprise of rice, bones (fish and chicken) and vegetable (include peel skin). Other component such as noodles, egg shell and meat are also present in the feedstock but only in small percentage. Non-pustrecible material (tissue paper, straw, plastic and wrappers) was sorted out manually by hand from the feedstock. Only 2-3kg of FW was taken out from the total FW to feed into autoclave. All sample was contain the same basic component of feedstock.

B. Autoclaving apparatus

Electric pressure steam sterilizer model 50X from All American was used for autoclaving in this study. The total capacity of this autoclave is 24 L. In order to form a steam during treatment process, autoclave was filled with water to depth not more than 7cm high. Sample prepared from feedstock was fed into inner container of autoclave and sealed with cover unit. Then, autoclave was heat to required temperature and pressure. In this study, autoclaving was operated at temperature 121^{o}C to 127^{o}C and pressure of 17psi to 21psi. The temperature and pressure was maintained within 35 – 60 minute.

C. Sample preparation and analysis

There are not many changes in size after FW undergo autoclaving. Wet digested materials form during autoclaving was transferred and spread into aluminium tray for drying process. During this process, the material was leaved in oven for 24 hours at 105^{o}C to allow all the moisture leaving from the material. After that, dried material was ground into smaller particle using grinder. Then, this material was used for characteristics and heavy metal (Cd, Cr, Cu, Pb, Hg, Ni, and Zn) determination. The content of total organic carbon (TOC) was determined by Walkey-Black method and Total Kjedahl Nitrogen (TKN) was determined using semi-micro kjeldahl method while pH was measured in solution condition by pH meter. Heavy metal content was determined using ICP-AES after digesting sample using standard method (EPA 3050B).

III. RESULTS AND DISCUSSION

Table I present the characteristics of FW and autoclaving FW. The data show slightly different in value before and after FW undergo autoclaving. All characteristics show slightly increases in value after treatment except for TKN and moisture content.

Nutrient content is critical factor in measuring compost material quality especially if it is going to be use as soil conditioning or organic fertilizer. Excellent quality compost generally contains high concentration of nitrogen, N but no specific value set for phosphorus, P or potassium, K [6]. Therefore, too high or too low of nutrient content will lead to a plant damage. Matured compost should have a value of C: N about 15 in order to avoid nitrogen immobilization when it will apply to soil [7]. The results obtained in this study show that C: N ratio of treated FW is in the range of 18-19. This value is essential to provide enough N nutrients to the soil for planting purpose.

Meanwhile pH value for both untreated and treated FW is within acidic phase. This might be because less of protein decomposition and more organic acid were formed [8]. Thus, pH lower than neutral is able to dissolved certain heavy metal such as Cd, Cu, Pb, Ni and Zn which might help in reducing contamination to soil and plant. Therefore, there is no ideal pH value for compost material. It is depending on the application of the compost and soil condition where the compost is going to be use.

TABLE I. FOOD WASTE AND TREATED FW CHARACTERISTICS

Analysis	Unit	FW 1	FW 2	FW 3	Sample 1	Sample 2	Sample 3
Moisture Content	% (wb)	74.68	73.11	70.88	64.16	60.64	64.36
pH		4.59	4.90	4.81	5.03	4.95	4.84
Nutrient Content							
TKN	% (db)	1.6	1.8	1.5	1.5	1.6	1.5
TOC	% (db)	26.2	26.8	28.9	26.8	28.6	29.3
C:N	% (db)	16.4	14.9	19.3	17.9	17.9	19.5
Phosphorus, P	% (db)	0.50	0.50	0.51	NA	NA	NA
Pottasium, K	mg/L	2.33	2.33	2.33	3.33	3.33	2.67

NA: Not Available

High level of heavy metal content will increase the overall burden to the soil and cause phytotoxicity to the plant [9]. Therefore the levels of heavy metals found can vary depending on the sources and composition of the feedstock used [10]. Table II show the value of heavy metal content found in different sources of feedstock. Household floc from autoclaving process has higher value of chromium, cooper, nickel, and zinc compared to Autoclaving FW that used FW as feedstock in this study. Meanwhile, value of Cd in Autoclaving FW is higher than Households floc. This is happen because of the variation in composition of household waste and FW collected. In this study, FW used for the treatment is separated from in-organic materials. Meanwhile household waste is a mix municipal solid waste (MSW) containing variety of solid waste including in- organic materials such as electric/electronic component and batteries which is known as external sources of heavy metal to the floc [5]. This material is main contributor to the cadmium, chromium, cooper, plumbum, and zinc [5]. As shown in Table II, presence of zinc in Autoclaving FW is so much lower than Households Floc. This is because main sources of zinc are from wood, scrap metal, and batteries where the presence of these materials is barely exist in FW feedstock.

Even though there are no presences of external sources, heavy metal was still detected during analysis of autoclaving FW and FW. The heavy metal obtained mostly inherent from native constituents of the feedstock which is kitchen waste and uneaten food.

Presence of heavy metal is the main factor that restricted application of compost materials for agriculture [9]. Results of autoclaving FW obtained in Table II were compared to the standard compost in a few countries as shown in Table III. Heavy metals content in autoclaving FW obtained is within the range of compost standard shown. Lower value of heavy metal content in autoclaving FW will ensure the safety of this material for application in agriculture.

TABLE II. HEAVY METAL CONTENT IN TREATED SAMPLE FROM DIFFERENT SOURCES OF FEEDSTOCK

Sample	Heavy Metal						
	Cd	Cu	Cr	Hg	Ni	Pb	Zn
Households Floc [a]	0.65	61	39	0.14	16	61	720
Autoclaving FW	0.76	2.61	ND	NA	0.64	NA	41.2
Food Waste	0.55	4.93	ND	NA	1.54	NA	42.4

[a] sources : [2]
NA: Not Available
ND: Not Detected

TABLE III. COMPOST QUALITY STANDARD

Compost Standard	Cd	Cu	Cr	Hg	Ni	Pb	Zn	References
UK compost standard (BSiPAS100)	1.5	200	100	1	50	200	400	[5]
Italian compost standard	3	300	NA	3	100	280	100	[11]
Korea compost standard	5	500	NA	NA	NA	150	NA	[7]
Washington, USA compost Standard	2	750	NA	NA	210	150	1400	[7]
France compost standard	3	NA	NA	8	200	800	NA	[12]
Netherlands compost standard	0.7-1.0	25-60	50	0.2-0.3	10 - 20	65-100	75-200	[12]
Austria compost standard	0.7-3.0	70-500	70-250	0.4-3.0	25-100	45-200	200-1800	[12]
Germany compost standard	1.0-1.5	70-100	0.7-1.0	0.4-1.0	35-50	100-150	200-300	[12]

IV. CONCLUSION

Nowadays, production of environmental friendly products is become priority. Treating FW has many benefits to the environment. There will be less solid waste that goes to the landfill and as the result extended the lifespan of landfill. Whilst, reducing problems which cause by FW such as underground water contamination and green house gases. Autoclaving is a treatment that preserving the actual nutrient in FW while sterilizing bacteria in the waste. Presence of nutrient, shown in table 1 indicates that this material is suitable to be use as soil conditioning or organic fertilizer. Meanwhile, separating process has contributed to the high quality of feedstock used. Absent of in-organic materials in feedstock has lowered the content of heavy metal in autoclaving FW. The analyses show possibility for this material to be use as organic fertilizer without further treatment.

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