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Preparation of Industrial Scale of Composting Of Municipal Solid Waste (MSW) Into Compost

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Abstract
Waste is the symbol of inefficiency of any modern society and a representation of misallocated resources. Municipal solid waste (MSW) is still environmental problem in many countries, because the appearance of MSW is not fully in appropriate treatment yet. MSW mostly consists of biodegradable organic compounds that are degraded in open surfaces. Composting of MSW is common processes, that the process was in order of months, but the processing scale was large enough, which can proceed MSW in large amount. The common route was MSW proceeded into compost, compost material is very useful as a soil amendment and fertilizer to increase the crop production. The compost uses in agricultural should be proper mature compost. The composting in industrial scale needs a large amount of budget, therefore, benefit is a big concern to be evaluated.
Key words: MSW, compost, scale, equipment, benefit

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I. INTRODUCTION

MSW was generated mostly by house hold, industries, and public services. The quantity of MSW increases by increasing the population, industries and public services. Waste is the symbol of inefficiency of any modern society and a representation of misallocated resources. Waste is the symbol of inefficiency of any modern society and a representation of misallocated resources.[1] The current treatment of MSW is commonly open dumping, those treatment always spent cost, but do not get any benefits, and we called cost oriented. The open dumping system just removed a problem from one place to another places. A new approach of the MSW treatment always lead to benefit oriented that have vision to zero waste management.

Zero waste is defined as the conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that treat the environment or human health.[2] Zero waste principles contributes to the circular economy.[3] Circular economy is an economic system that replaces the ‘’end-of-life” concept with reducing, reusing, recycling and recovering materials in production, distribution and consumption phase of their life cycle.[4] Zero waste is connected to properties agriculture, design, energy, industrial, economical and community development.[5] The economic and system tools include responsibility of producers for their products. Briefly explained, this means that if a product and its packaging may not be re-used, recycled or composted, then the producer must be responsible for its collection and its safe disposal after the end of its lifetime. In the EU countries, this concept is applied to packaging, oils, electrical waste, accumulators, batteries and single-cell batteries, discharge and fluorescent lamps, automobiles, tyres, and medicines.[6]

The existing solid waste management system schemes have been developed and implemented including systems for recovery and reuse. In this study, zero waste lifestyle is measured by applying 3R theory (Reduce, Reuse, and Recycle). Several studies use 3R principles as the dimensions of waste management or zero waste lifestyle.[2,7,8] The Reduction principle is defined as minimizing the amount of waste through reducing consumption and waste avoidance. [3,9] The Reuse principle refers to using again a product or a component/material of the product according to the original purpose. While the recycle principle refers to the recovery operation when waste is reprocessed into products or materials.

I.1. MSW Properties

The generation of municipal solid waste (MSW) is increasing year by year and there are many options for handling and disposing of these

wastes. Land disposal is the most common practice to deal with MSW. Municipal solid waste (MSW) constitute significant quantities of waste generated in market. Markets produce substantial quantities of fruit and vegetable waste. Typical composition of MSW, such as 45.8% organic, 14.6% plastics, 12.7% paper, 7.3% textiles, 6.4% inert, 4.3% miscellaneous, 2.3% metal, 2.6 glass and 3.9% leather.[10] MSW composition is varies depend on the places and what waste was come form. Typically composition of MSW in landfill as shown in Table 1.

MSW commonly dispose into landfill site. The route, first collecting the MSW in side, and then transfer into arm-roll truck to land fill, and then MSW was disposed. Municipality is responsible for the haulage of wastes to final disposal facilities. Transportation system uses arm-roll trucks or general purposes in various capacities. The arm-roll trucks equipped with lifting mechanism load to the container on it and empty it at the disposal site. The disposal sites are usually located outside of the city. In big cities, the traffic is very heavy, travel time to the disposal site is too long. Thus, daily average number of roundtrips made by vehicle is only two or three. The biggest cost of MSW management is transportation .[11]

The composition of MSW is varies, it's depend on the source of MSW, such MSW from market place is different with MSW from offices. MSW from market place mostly consist of organic waste, and from offices mostly consist of paper waste. But MSW was combination of waste from everywhere that final composition of MSW as shown in Table 1.

Table 1. Composition of MSW in final landfill.[12]

No.	Components	Mass fraction (%)
1.	Organics waste	50.86
2.	Non-recyclable plastic	10.09
3.	Recyclable plastic	11.74
4.	Laminated Aluminium-plastic	1.98
5.	Paper	4.05
6.	Textile (wet)	10.75
7.	Rubber	0.55
8.	Glass	0.26
9.	Metal	0.31
10.	Wood	1.48
11.	Other wastes	7.94

Integrated Municipal Solid Waste (MSW) management is a tendentious task requiring the simultaneous fulfilment of technical, economical and social constraints. It combines a range of collection and treatment methods to handle all materials in the waste stream in an environmentally effective, economically affordable and socially acceptable way.[6]

The issue of the municipal solid waste management was some of the most important challenges to extend the economic circular, environment sustainable protection, any benefits from the MSW management. Zero waste vision requires a change in our way of thinking and establishing of practices. The zero concept is the form of waste management, the zero waste concept including a wide range of steps.[2]

The composting process of MSW in waste management technique to be adopted is to maximize profit from the generated waste and to likewise maintain environmental safety standards, hence there is need in an issue of both profitability, affordability and sustainability.

II. COMPOSTING ROUTE OF MSW INTO VALUABLE PRODUCTS

MSW is to be handled from generating site to end products and used it. MSW is generated every where in many places and sides, collecting of MSW sometime have problems because of highly disparities of places and quantities. The collection of MSW may get a high portion of cost in MSW management.[11] Municipal solid waste (MSW) generated in developing countries usually contains a high percentage of organic material, and usually to be processed into compost as soil amendment.

In the year 2008, Indonesia produced 38.5 million tons of MSW and was estimated increase 2-4 % per year. The waste management system in Indonesia was generally only collected and transported to temporary landfills (TPS) and final landfill (TPA) sites 68,64%, the rest was dumped into soil 9.47, composted 7.1%, burned 4.73%, discharge into rivers 3,55% and others 6,51%. [13]

The water content of organic waste is very large is about 61.32%. It's the biggest obstacle to the utilization of MSW as a fuel. Waste utilization by direct combustion or incineration is difficult to implement due to high water content.[12] Organic waste with high water content has low heating value (LHV), it's not appropriate for fuel utilization. Organic waste with high water content was appropriate to be composted.[14]

Composting is a biological process in which the organic portion of refuse is allowed to decompose under carefully controlled conditions.

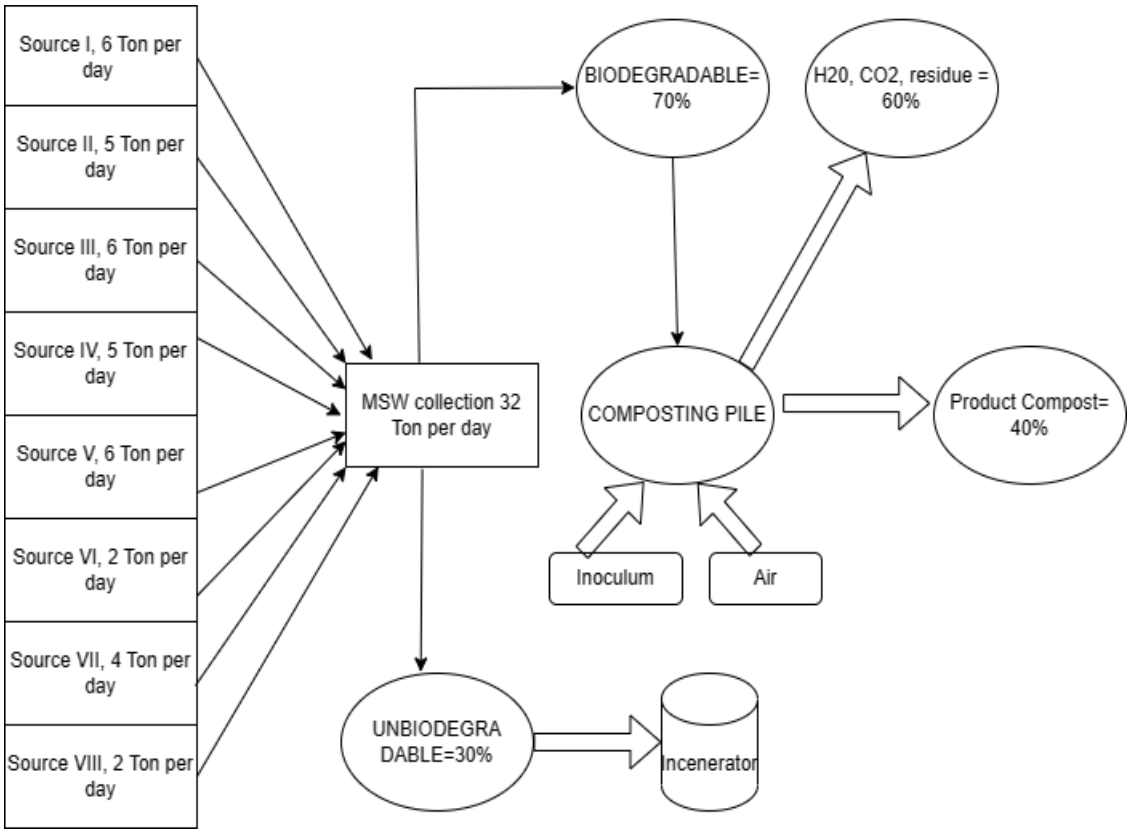

Figure 1. Flow sheeting of composting of industrial scale

MSW composting is the process by which the organic, biodegradable portion of MSW is microbiologically degraded under aerobic conditions. During the process of degradation, bacteria are used to decompose and break down the organic matter into water and carbon dioxide , which produces large amounts of heat and water vapour in the process. Given sufficient oxygen and optimum temperatures, the composting process achieves a high degree of volume reduction and also generates a stable end product called compost that can be used for mulching, soil amendment, and soil enhancement.

Composting can be defined as the biological decomposition of the organic constituents of wastes under controlled conditions. This process can take place in the presence or absence of oxygen. The former is called aerobic composting and the latter anaerobic. If efficiently carried out, aerobic composting can rapidly produce a pathogen-free product, as this review attempts to show. Anaerobic composting by contrast requires much longer decomposition times and is seldom free of pathogen and odour problems.

III. THE MAIN EQUIPMENTS COST INVOLVED IN THE COMPOSTING PROCESS

A.EQUIPMENTS COST

A.1 Process equipment

1. Arm-roll Truck; 2. Belt conveyor sortation; 3. MSW grinder; 4. Compost pile; 5. Aging space; 6. compost sieving; 7. Packaging side; 8. Evacuator; 9. Dumping land; 10. Building; 11. Incenerator

A.2. Work Equipment

1. Boots; 2. Helms; 3. Uniforms; 4. Maskers; 5. Gloves; 6. Medical facilities

B. Operation cost
B.1 Raw material
1. MSW; 2. Inoculum; 3. Packaging; 4 Spare parts;

B.2. Utilities
1. Electric; 2. Water; 3. Compressed air; 4. Fuel; 5. Lubricant; 6. Food and drink

B.3 Labour cost
B.3.1. Main Director, 1 man
B.3.2. Process Director, 1 man
B.3.3. Marketing Director, 1 man
B.3.4 Transportation Director, 1 man
B.3.5 Process man, 20 men
B.3.6 Marketing man, 5 men
B.3.7 Transformation man, 20 men
B.3.8 Workshop man, 5 men
B.3.9 Office man, 5 men
B.3.10. Security, 6 men

C. Revenue
C.1. Selling compost

D. Economic analysis
D.1 Fixed capital = Equipment cost + Operation cost
D.2 Working capital = Raw materials cost + Utilities + Labour cost
D.3 Revenue = Selling compost

E. Benefit or lost
Benefit come from = Revenue – fixed capital – working capital = positive
Lost come from = Revenue – fixed capital – working capital = negative

IV. EQUIPMENTS COST ESTIMATION

Book of plant design and economic analysis was written by Peters (1980),[15] the book talks everything about plant design and economic analysis, construction and operation that resulted benefit or lost. An acceptable plant design must present a process that is capable of operating under condition which will yield a profit. Since net profit equals total income minus all expenses. The responsibility of this task is chemical engineer. Composting flow sheet in industrial is shown in Figure 1.

Before plan was built the design of each equipment must be completely account about the shape, size, dimension, materials used, and the number of equipment can be estimated in proper way. The price of equipment will depend on size, construction material and the complexity of operation. If one equipment was finished to design properly, the price can be estimated from the graph in this book. [15]

All cost of the equipment was called fixed capital. Cost raw material, utilities, and labour were called working capital. Revenue is selling the product of compost. Benefit gets from revenue greater than all expensive.

V. COMPOST USED CRITERIA

Compost uses as soil amendment, organic enrichment to the soil that will improve the soil texture and increase the nutrient supplement, the criteria of the application of compost as shown in Table 2. The most important use of compost is its application to land. This takes several forms: It can be applied to land as a fertilizer, soil conditioner, or mulch, or can be used as a means of land reclamation. Furthermore, the use of compost can range from domestic applications by the home gardener to large-scale applications by commercial farmers to their cropland or by municipalities for parklands. The application of compost to land has several advantages. Its positive effects on plant growth, fruit, crop yields, and other factors compared with the effects of fertilizers alone.

A well-produced, mature compost is free from odour and easy to handle, store, and transport. A raw compost (one that has not matured) does not have these qualities, but will acquire them with time if it is allowed to mature. Table 3 lists some of the differences between raw and mature compost. Mature compost contains trace and essential elements, of which the most important are nitrogen, phosphorus, potassium, and sulphur. These are available to the soil and plants, depending on their initial concentrations in the raw compost materials and on the degree of mineralization.[16]

For an organic fertilizer to be considered compost, it must have undergone a complete composting process. So all semi-decomposed organic fertilizers, fermented or not, that have not yet reached a final compost state, should not be called as such and should simply be considered organic fertilizers.[17]

Among the organic fertilizers mistakenly called compost we have: **Bocashi**. It is a semi-decomposed fermented organic fertilizer, partially stable and maintains a slow decomposition. **Manure**. They are all those herbivorous animal droppings used as compost, either fresh or semi-decomposed. These generally receive the name depending on their origin, for example: chicken manure, swine waste, horse manure, cow dung, and slurry, among others.

Technically, according to the types of composting, we would have three types of compost: 1.Microbiological compost. Which was formed by a composting process with microorganisms and where there was or not an increase in temperature. 2. Vermicompost. It is the compost from the vermicomposting process, in which the transformation of the waste is carried out by

earthworms. 3. Larvicompost. It is the compost from the larvicomposting process, in which the transformation of the waste is carried out by insect larvae.

Table 2. Criteria for the specific Applications of compost. [16]

Application	Frequency (Years)	Quantities (Ton per hectare)
Grain crops	2-4	29-60
Root crops	2-4	40-100
Grassland	2-4	20-50
Fruit growing	3	100-200
Vine growing	3-4	50-100 (Light soils 80-240 (Heavy soils)
Vegetables (outdoor)	2-4	50-100
Vegetables (greenhouse)	2-4	10-15
Landscaping slopes	2	100-300 20-40
Pig feed	-	30 kg
Control of erosion	-	Up to 300

To be used as organic fertilizer, compost must be stable and mature enough to ensure that it is safe for agricultural application. The stability and maturity of compost can be viewed from physical, chemical, and biological parameters.

Mature compost is crumbly and dark brown and you should not be able to identify the former materials. It should smell earthy / musty. It is said to be mature, as the majority of bacteria are no longer active, (they have consumed what they can). In this state, compost will provide nutrient rather than rob nitrogen from your soil and plants.

It can actually be broken down into three parts – cooling, curing and maturing. First, the temperature drops down as thermophilic activity reduces. Crucially, though, just because the compost has cooled down it is not finished. After it has cooled down, other decomposers, such as fungi, worms and beetles, really get to work, further improving the quality of the compost. This process is often known as curing, although some people distinguish between this curing stage and a longer stage called maturing. Finally, you end up with a stable compost that will improve your soil.[18]

VI. THE BENEFIT OF EXISTING A COMPOSTING PROCESS

Even the composting process was not resulted big moneys, there are another benefits that can be got such as:

1. The converted of waste into useful products is good conducted. Waste usually is proceeded into valuable products, the waste generated always to be raw materials of another process, such as MSW to be processes into compost.

Table 3. Differences between Mature and Raw Compost.

Mature compost	**Raw compost**
Nitrogen as nitrate ion	Nitrogen as ammonium ion
Sulphur as sulphate ion	Sulphur still in part as sulphide ion
Lower oxygen demand	Higher oxygen demand
No danger of putrefaction	Danger of putrefaction
Nutrient elements are in part available to plants	Nutrient elements not available
Higher concentrations of vitamins and antibiotics	Lower concentrations of vitamins and antibiotics
Higher concentrations of soil bacteria, fungi, which are decomposed, easily degradable substances	Higher concentration of bacteria and fungi, which decompose organic materials

Mineralization is about 50%	High proportion of organic substances not mineralized
Higher water retention ability	Lower water retention ability
Clay-humus complexes are built	No clay-humus complexes generated
Compatible with plants	Not compatible with plants

2. Compost is improved the soil conditions. Compost is very useful for
soil amendment. Compost improve the soil texture, increase the nutrient supplements.
3. Compost will increase the crops production. If the soil properties is getting better the crops will grew perfectly and resulted good production.
4. Maintain environment sustainability. Waste is usually to be disposed from the environment, because dirtiness, un- comfortable, waste must be disposed as soon as possible.
5. Reduce the insects and rats population. The environment dirtiness is comfortable of insects and rats to grow, the population was increased very fast. It's very disturb for human being.
6. Made environment sight seeing is tidy. The environment for human being should be comfortable and tidiness, it's happen if environment cleanness from waste.
7. Reduce bad odours come from degraded MSW.

VII. CONCLUSION

The management of MSW to produce compost that used in agricultural field is very useful, and the end product is crop production. The impact of MSW in better treatment, waste was converted into useful material that used in appropriate land, the sustainable environment has guarantee perfected, create the economic circular, and hopefully, the management of MSW would got many benefits. The composting in industrial scale needs a big money, the local government should be create this project in order to manage of MSW properly.

Built up of industrial scale of composting got many benefits compared to dump MSW to landfill. All waste is converted into useful materials that used in agricultural activity, for soil amendment. Sustainable environment is warranties about the cleanness, tidiness and lower insect and rat population.

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