Household Waste Bioreactor Modification Based on Anaerobic Decomposition

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Abstract

Volume sampah in Indonesia was 490.000 ton/ day or 178.850.000 ton/ year, Which 50% was household waste (Ministry of Environment of Indonesia, 2012). Anaerobic composting not as popular as aerobic composting in Indonesia. Anaerobic composting is very simple, it dont need turnig, watering etc to decompose waste. The objective of this research is to design bioreactor modification and analyze the compost quality and the effectiveness to reduce waste, so it suitable for urban communities to composting their waste. Anaerobic and aerobic bioreaktor modification was design by plastic mineral drinking water 19 litter. The row organic materials are 3 kg kithcen waste, fruits waste 1 kg (bioreaktor anaerobic 1 and aerobic 3) and 3 kg Kithcen waste, fruids waste 1 kg, added inoculation of micro-organisms as Effective Microorganism (EM4) in 1 cc/ 500 ml water (Bioreactor anaerobic 2 and aerobic 4). Temperature the row material at 20.2℃ (Biorea ctor 1 and 3) and at 25℃ (Bioreaktor 2 and 4); pH value at 4.3 (Bioreactor 1 and 3) and 5.5 (Bioreaktor 2 and 4); moisture at 86.3 (Bioreactor 1 and 3) and 80.1 (Bioreaktor 2 and 4); carbon into Nitrogen ratios (C/N) at 23.4 (Bioreactor 1 and 3) and 18.53 (Bioreaktor 2 and 4). Monitoring temperature and pH value are show at 20℃ and 6.0 (Bioreaktor 3) and at 2.2 ℃ and 6.7 (Bioreaktor 4). Compost Quality appropriate with Indonesia compost Standart (SNI 19-7030-2004). Anaerobic bioreactor modification can reduse organic waste bigger than aerobic bioreactor modification. It is recommendation to applying to the urban community because of simple, no need turning, watering etc and effective to reduce waste.

Keyword: Anaerob, Bioreactor, Household waste

1. Introduction

Human activities produce waste (Tchobanaglous G, Theissen H, Vigil S 1993). Household waste is waste which generated in the day to day operations of a household. Indonesia household was produce waste at 2.6 litter/ day/ person or the same as 5- 6.5 m3/ day/ 500 house with 5 persons (BPS, 2012).

In 2012, volume sampah in Indonesia was 490.000 ton/ day or 178.850.000 ton/ year, which 50% was household waste (Ministry of Enviroment of Indonesia, 2012). The Indonesian Household waste are organic matters (70%) and anorganic matters (30%). Many movements designed to get people thinking about environmentally friendly living have focused on household waste as something which can be easily manipulated to make a difference in the environment.

Management of household waste is also a major issue. Reduce the organic waste in the main source or in every household is one of waste management that appropriate to apply in Indonesia to reduce the waste which thrown away in to the TPA (Indonesia final thrown waste). Every household must be separate the waste that their produce into organic and anorganic waste. The organic waste can be change to be compost and the anorganic waste can be reuse.

Composting is one way to reduce waste and add something beneficial to the earth and health. Composting is the biological decomposition of organic materials by bacteria and other organisms. There are two paths composting can take, aerobic decomposition or anaerobic decomposition. Aerobic composting is very popular method for creating compost. This type of composting emit an unpleasant odor and, with the proper conditions. Aerobic composting uses oxygen to biologically decompose waste materials in a controlled condition until it stabilizes so it can be utilized. But sometime, Aerobic composting not as simpel as we know. We need turning, watering, added some matterials regularly to make sure aerobic decomposition works optimum. Urban communities were hard to do that because of they are too busy. Not only that, but also some insects are come into the organic materials waste when aerobic decomposition occured.

Anaerobic composting not as popular as aerobic composting in Indonesia. Anaerob composting is very simple, it dont need turning, watering etc to decompose waste. So it potential to application in urban community which dont have much time.

The objective of this research is to design bioreactor modification and analyze the compost quality and the effectiveness to reduce waste, so it suitable for urban communities to composting their waste.

2. Method and Material

2.1 Method

Make design the household waste bioreactor from the recycle plastic mineral drinking water 19 litter. This material had been choosen because of cheap, easy to get in, transparant so it easier to observe how the waste degradated.

2.2 Desain and material

2.2.1 Desain

Anaerob Bioreactor Modification (Bioreactor 1, 2)

Plastic mineral drinking water 19 litter, make the a hole with diameter 1 cm on the top of plastic mineral drinking water which had flexibility to open and close the hole. The fungtion of the hole is to appear the gases from waste decomposition. Use the brazier Under the plastic mineral drinking water to harvesting the compost (Figure 1).

Aerob Bioreaktor Modification (Bioreactor 3,4)

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Plastic mineral drinking water 19 litter, cut the bottom for throwing the row organic matters. Use the pipe (diameter 4 cm) with aeration hole. Use the spoon to absorb leachet.(Figure 2)

2.2.2 Formulation

Many factors will determine how long and how nutrient rich your compost will be. They include the matterials used, the temperature, the moisture content, and aeration. This experiments combine the row matterials. Kitchen Household waste had C/N ratio 15:1. The fruits waste had Carbon- to- Nitrogen (C/N) ratios 35:1. We need to account the ideal compocition of C/N ratios in 30: 1. The raw materials used are mixed kitchen household waste and fruids waste to get the C/N ratios 3: 1.

Anaerob Bioreactor Modification

Anaerobic bioreactor 1 : 3 kg kithcen waste, fruits waste 1 kg.
Anaerobic bioreactor 2 : 3 kg Kithcen waste, fruids waste 1 kg, added inoculation of micro-organisms as Effective Microorganism (EM4) in 1 cc/ 500 ml water.

Aerob Bioreactor Modification

Aerob Bioreactor 3 : 3 kg kithcen waste, fruits waste 1 kg
Aerob Bioreactor 4 : 3 kg Kithcen waste, fruids waste 1 kg, added inoculation of microorganisms as Effective Microorganism (EM4) in 1 cc/ 500 ml water.

2.3 Procedure :

Shredding ; Downsizing, or chopping up the materials, is a sound and widely-practised technique. It increases the surface area available for microbial action and provides better aeration. This technique is particularly effective and necessary for harder materials. Downsizing the raw organic materials as small as possible. Open the hole to appear the gases every 3 days. (Bioreaktor 1,2).
Downsizing the raw organic materials aproximately 2 cm. Turning regularly, Watering when dried and stirred when seem humid. (Bioreaktor 3,4)

2.4 Measurements

Samples was analyzed for temperature, pH value, carbon-to-nitrogen (C/N) ratios, Nitrogens (N), (P), (K) and the effectiveness of the bioreactor modification. Surveys and visual inspections also were used to analyzed the decompocition process of waste.

Entranc

drainage

Hole for

water

waste

Brazier for

Fig. 1

Fig. 2

3. Result and Discussion

3.1 Row Organic Materials

The first, build bioreactor modification base on the design. Then prepare the household row organic materials. Household row organic materials are sorted from anorganic househould waste. It was sorted from tin, plastic, glasses, rubber etc. The row materials for the experiments are kitchens waste household and fruids waste.

Kitchen waste are vegetable and other food matter collected from the household, and Fruids waste collected from traditional fruids market such as orange, grape, bananas, melon, papayas. The kinds of fruids waste depend on the season.

Chemical composition are important thing to predicted the succesfully decomposition. The row organic materials must be analyzed first before put into the bioreaktor modification. The complete anaysis can see in Table 1.

Table 1. Row Organic Material Analyzed

Bioreactor	Temperature	pH	Moisture	(C/N) ratio
1	20,2 C	4,3	86,3	23,4
2	25 C	5,5	80,1	18,53
3	20,2	4,3	86,3	23,4
4	25 C	5,5	80,1	18,53

Temperature of row organic materials with inoculasi microbacterial as EM4 (Bioreaktor 2, 4) at 25℃ and without EM4 at 20.2 ℃. Its show that temperature of organic materials with EM 4 is higher. It means that EM4 increase the temperature

pH value ideal for composting is aroud 7 or netral. The measurement of the row organic materials showed that pH value is little bit acid (pH< 7) but still in tolerance. Waste without EM4 more acid than waste with EM4. It means that EM4 increase the pH.

Moisture is necessary to support the metabolic activity of the micro-organisms. All of the raw organic material compos had the moisture more than 65%. Probably, Its because of the fruids waste. The fruids waste had higer moisture. The waste materials which have moisture > 65% are more suitable for anaerobic decomposition than aerobic decomposition.

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Carbon to nitrogen (C/ N) ratios have the important thing for proces composting. The optimum C/N ratio for composting are at 25:1 till 30:1. The waste in bioreactor 1 and 3 showed that C/ N ratios at 23,4. In the other side the waste in the bioreactor 2 and 4 which added the Effective Mikroorganism 4 (EM4) showed that C/N ratio at 18,53. It means that concentration of Effective Microorganism (EM4) 1 cc/ 500 ml water EM 4 reduce the C/N ratios.

3.2 Monitoring

To study the quality of the bioreactor modification, monitoring temperature and pH are needed to measure during the composting process till the stable compos. Bioreactor 1 and 2 are base on Anaerobic decomposition. In Anaerobic composting, decomposition occurs where oxygen (O) is absent or in limited supply. In an anaerobic digester, gaseous oxygen is prevented from entering the system through physical containment in sealed tanks. Under this method, anaerobic micro-organisms dominate and develop intermediate compounds including methane, organic acids, hydrogen sulphide and other substances. In the absence of O, these compounds accumulate and are not metabolized further. Many of these compounds have strong odours and some present phytotoxicity. Anaerobic composting is a low-temperature process. The compounds which develop in anaerobic decomposition must be out in every 3 days (Bioreaktor 1, 2) because no metabolized further. .

Bioreactor 3 and 4 are base on aerob decomposition. Aerobic composting requires large amounts of O. Aerobic composting takes place in the presence of oxygen (O). In this process, aerobic microorganisms break down organic matter and produce carbon dioxide (CO_2), ammonia, water, heat and humus, the relatively stable organic end product. Although aerobic composting may produce intermediate compounds such as organic acids, aerobic micro-organisms decompose them further.

Aerobic composting needs moisture and oxygen in order to decompose properly. The recommended moisture content is between 45 – 65% with a lower moisture content as the compost is completing its cycle. If the compost seems dried, it should be add more water. If compost seems too wet, it should be add more dry materials. Turn the compost for aeration process is important things because it will incorporate more oxygen in the compost. The frequency of turning is crucial for composting time. turning not only distributes air throughout the pile, it also prevents overheating as it kills all the microbes in the pile and terminates decomposition. However, turning too frequently might result in a lower temperature.Turning it once a day assures of a faster rate of decomposition.Temperature and pH monitoring was measure in Bioreaktor 3 and 4 for every 3 days.

3.2.1 Temperature

Temperature and pH used as an indicator of compost stability. Monitoring the temperature (Bioreactor 3 and 4) was measure for 3 days till stable or compost ready to harvesting. A compost is considered stable when the temperature within a static pile remains near ambient temperature for several days,

The process of Aerobic decomposition involve two temperature ranges: mesophilic and thermophilic. While the ideal temperature for the initial composting stage is 20-45 ℃, at subsequent stages with the thermophilic organisms taking over, a temperature range of 50-70 ℃ may be ideal. High temperatures characterize the aerobic composting process and serve as signs of vigorous microbial activities. Pathogens are normally destroyed at 55 ℃ and above, while the critical point for elimination of weed seeds is 62℃. Turnings and aeration can be used to regulate temperature.

This is temperature measurement of bioreactor 3, 4. (figure 3, 4, 5). The temperature of bioreactor 3 was stable in 20 ℃ on day 61. And bioreactor 4 in 22 ℃ on 61 day. For the 1 st day, temperature decomposition process in bioreactor 4 is higher than bioreactor 3 and then decrease regularly. Compost organic mater in bioreactor compost 4, which added EM4 had higer temperature than bioreactor 3 which no added EM4. Maintaining high temperatures for a period of time during the composting process has been the primary approach towards minimizing contaminants

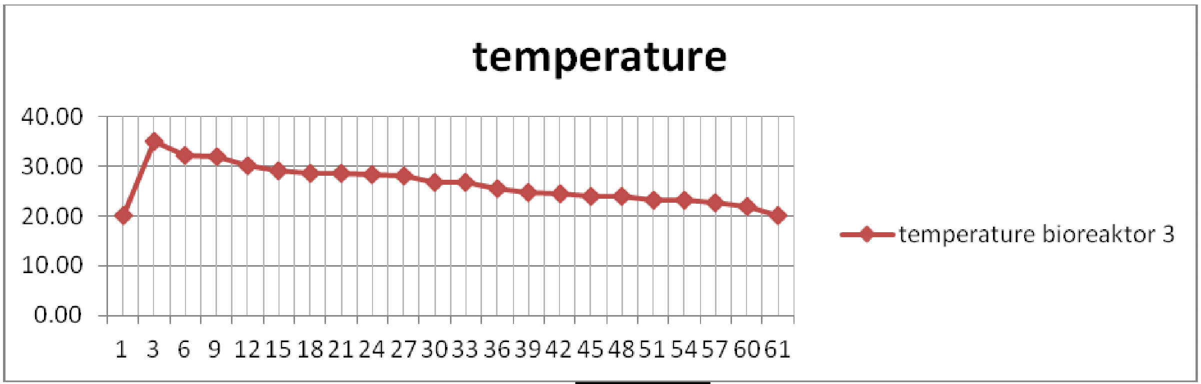

Fig. 3

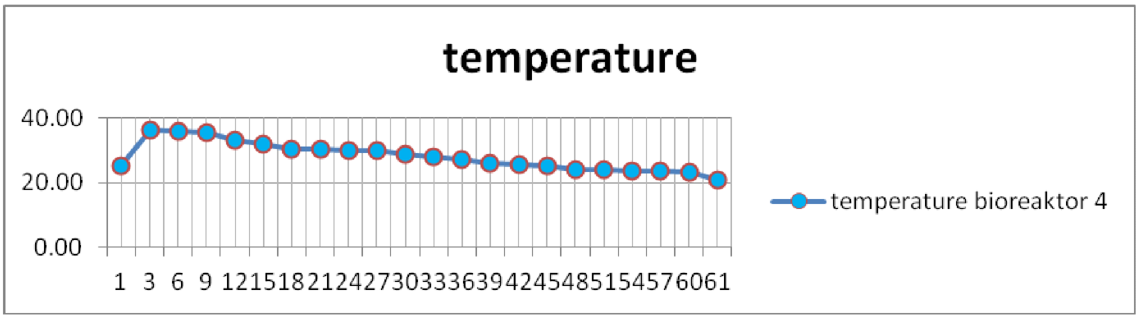

Fig. 4

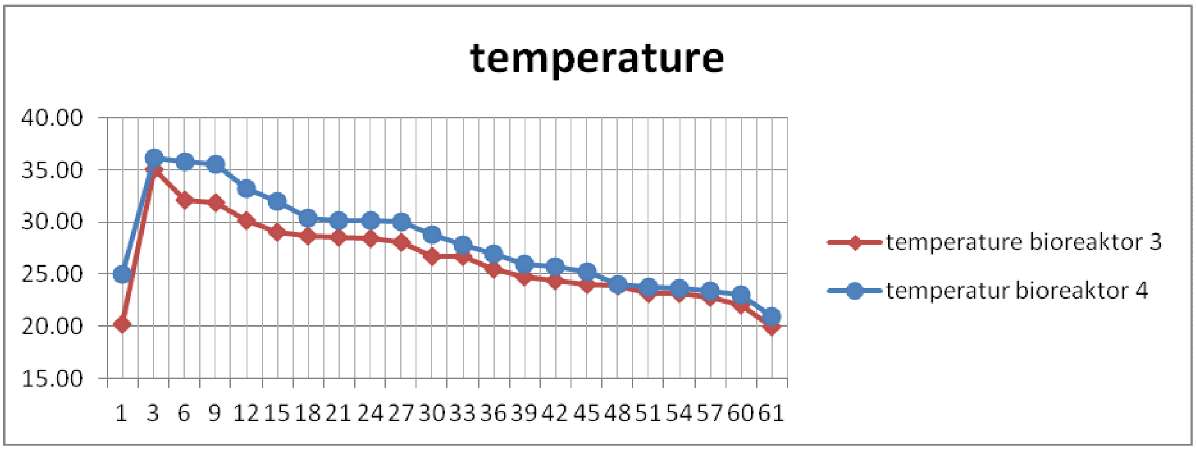

Fig. 5

3.2.2 pH Value

Monitoring pH values was measure in bioreactor 3 dan 4 during the composting every 3 days. (fig.). D*ecomposition* proceeds more quickly when *pH* is neutral. For the firs day, pH value on bioreactor 4 is higher than bioreactor 5. The both of them increase regularly. In the day 61 the pH value of bioreactor 3 and 4 at 6.00 and 6.7. The raw organic materials are little bit acid, but EM4 can make the pH value more stable (Fig. 6, 7, 8).

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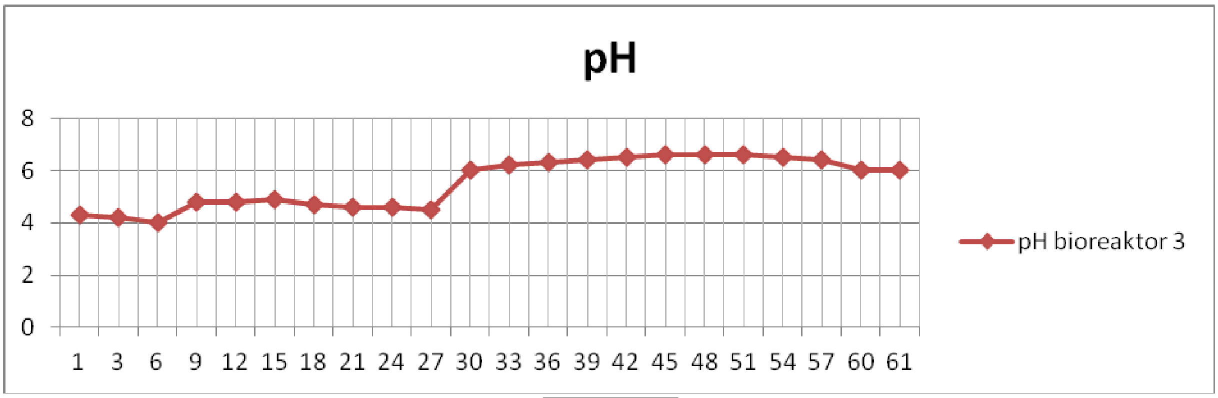
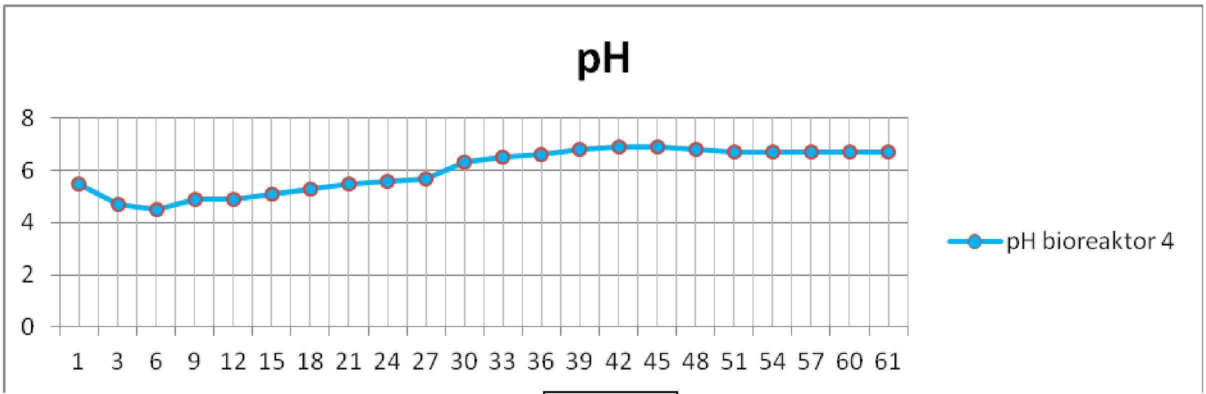


Fig. 6



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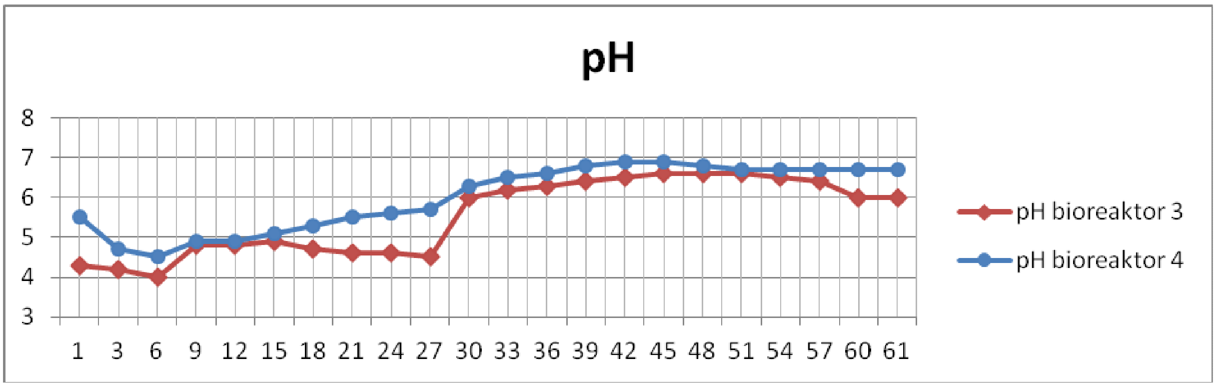

Fig. 8

3.3 Compost Quality

Maturity is an important concept that is closely related to the quality of compost. compost is considered mature (i.e., finished) when the energy and nutrient-containing materials have been combined into a stable organic mass. Mature compost has decomposed enough to promote plant growth. Objective indicators of maturity have been established. Making sure that a compost is finished before adding it to the soil is very important. Application compost of an unfinished, carbonaceous compost could affect plant growth adversely since the compost may have its own demand for nutrients as the breakdown to maturity continues in the soil. In addition, immature composts made from nitrogen-rich feedstocks are often high in ammonium which can be toxic to plant growth. When the compost is ready, the pile will reach the ambient temperature, no odors, no production of phytotoxic Compounds. the compost will become dark brown or black and the consistency will become soil-like.

Table 2. Compost Quality Analysis

No	**Parameter**	**Bioreactor**				**Standart (SNI 19-7030-2004)**
		1	**2**	**3**	**4**	
1.	Temperatur	23	23.5	20	22	Normal
2.	pH value	6.8	6.8	*6.0*	6.8	≥ 6.8 -7.49
3.	Nitrogen (N)	0.41	*0.34*	1.3	1.42	≥ 0.4 %
4.	Phosporus (P2O5)	0.1758	0.404	0.224	0.208	≥ 0.1 %
5.	Potasium (K2O)	0.125	0.120	0.245	0.151	≥ 0.2 %

Mature compost from all bioreactor (1,2,3,4) reach the ambient temperature and no odor. pH value are little bit acid (bioreactor 3; pH at 6.0). In general, composts will not raise soil pH to undesirably alkaline levels because of the low total alkalinity of composts.
Base on standart national Indonesia (SNI 19-7030-2004), good quality compost must have Nitrogen (N) ≥ 0,4 %, but Bioreaktor 2 show that nitrogen is lower than standart. The nitrogen content of composts will vary according to the source material and how it is composted. In general, nitrogen becomes less available as the compost matures with nitrogen-rich feedstock but more available with carbonaceous feedstock. Nitrogen in the form of ammonium (NH4+) or nitrate (NO3-) is readily available for plant absorption. However, these constituents are low in composts. A finished compost has little ammonium, as it is oxidized to nitrate during composting and curing, and any nitrate that is produced could be leached, lost to the air, or consumed by the organisms performing the composting. The majority of the nitrogen in finished compost (usually over 90%) has been incorporated into organic compounds that are resistant to decomposition. Rough estimates are that only 10% to 30% of the nitrogen in these organic compounds will become available in one growing season. Some of the remaining nitrogen will become available in subsequent years and at much slower rates than in the first year.

The compost from all bioreaktor show that phosphorus (P) appropriate with SNI but not in pottasium (K). Phosphorus (P) content of compost can vary considerably and can also be dependent on feedstock (Prasad munoo, 2006). Similar to nitrogen, much of the phosphorus in finished compost is not readily available for plant uptake since it is incorporated in organic matter. However, not all of the phosphorus mineralized from organic matter is available for crop uptake, because some of the phosphorus released from organic matter by microbial and chemical action is quickly made unavailable by binding with other elements in the soil.

Potassium is not known to have harmful or toxic effects on human beings and it helps in plant growth as an essential nutritional element. Potassium in finished compost is much more available for plant uptake than nitrogen and phosphorus since potassium is not incorporated into organic matter. However, much of the potassium can be leached from the compost since it is water soluble.

3.4 Amount of Compost

Amount of compost was analyzed in every bioreactor. Anaerobic Bioreactor modification can reduce hosehold waste till 93 % and 87% (Bioreactor 1 and 2). The row organic materials without inoculation microorganism EM4 is better than added EM4 to reduce waste. However anaerobic bioreactor modification effectif to reduce the household organic waste (Table. 3).

Table 3. Waste Reduction

No	**Bioreaktor**	**Amount of Compost**	**% Waste Reduction**
1.	1	0.275 Kg	93 %
2.	2	0.5 Kg	87 %
3.	3	1.6 Kg	60 %
4.	4	0.75 Kg	81.2 %

4. Conclusions

Bioreactor modification base on anaerobic decomposition effective to reduce the organic materials than bioreactor modification base on aerob decomposition. Anaerobic decomposition have much advantages to application in community because of simple, dont need turning every day, watering and have good quality etc. These are effective to reduce the household organic waste.

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