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Waste treatment used as organic fertilizer in Palu city, Indonesia and its effects on several types of plants

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Abstract
One of the techniques for utilizing municipal waste is to process it into organic fertilizer. Municipal waste (market waste and feces) can become organic fertilizer in the form of bokashi. This research aimed to analyze the organic content of municipal waste, especially market waste and feces, and its effect on the growth of several types of plants in and around the region of Palu City, Indonesia. The research consisted of two parts, namely the production process of organic fertilizers and application of the products to several types of plants, namely: sweet corn, shallots, angsana, flower paper / Bougainville, and glodokan plant seeds. The results show that the characteristics of the market waste in Palu City consisted of 85% organic and 15% inorganic matter. Public markets (Manonda and Masomba) have a lower part proportion of organic material (79.8%) than the vegetable market in Petobo (90.2%). The resulting organic fertilizer products have met the compost quality standards with the N content of 1.66%. However, the C / N ratio is still quite high (26.4), which is still above the ideal conditions (12 to 15). The results of the statistical analysis of organic fertilizer application show a significant effect on plant height and the number of leaves of sweet corn; as well as an increase in the number of leaves on the glodokan plant. Meanwhile, some of the other growth variables and all the observation variables for shallot and angsana plants have not been proven.

Keywords: municipal waste, market waste, feces, organic fertilizers, indicator plants

Introduction

The population of Palu City is increasing from year to year, resulting in an increase in the volume of waste in the form of garbage and other impurities. The impacts of this waste include environmental pollution, being an agent for the spread of various kinds of infectious diseases, reducing the comfort of community life, especially around the disposal area, and requiring a wider disposal area.

Waste in the form of goods or discarded objects is the residue result of all forms of human activity [1]. The emergence of waste is a direct consequence of human activities, starting from mining / taking natural resources as raw materials which then continue to become materials made ready for energy or semi-finished materials for goods, and also service activities where these goods are consumed by humans to achieve their welfare. The waste is in the forms of solid waste, liquid waste, and gas / atmospheric waste [2]. Garbage can be defined in a limited way as discarded material, waste, or residual material originating from plants (leftover vegetables, fallen leaves), leftover agricultural activities, or animal waste, as well as other objects that are thrown away. Broadly speaking, all objects that are thrown away are called garbage [3].

Waste production in Palu City is currently estimated at around 700 m^3 per day, approximately 10 percent or 70 m^3 of which was produced from existing public markets, while fecal waste production was estimated at 30 m^3 per day (Interview with officials of Sanitation Agency of Palu City, 2002). The accumulation rate of this waste from time to time is getting higher and is out of balance with the reduction rate able to be achieved by scavengers or natural degradation. This is because there are very few waste materials that can be recycled and other materials are classified as resistant to destruction [4]. If this condition is allowed to continue, the volume of waste will quickly increase and the impact will be even wider and more complex.

The handling of municipal waste is currently not focused upon a best utilization to benefit the government and society. This means that technology is needed to process waste into a useful product while reducing the negative impact that is caused. Municipal waste processing is still classified as difficult because it requires huge costs with high technology. The waste material separation technique is still an obstacle in the processing process so that only part of the waste is actually able to be processed. However, the bags of municipal waste production in general, such as those produced by markets and restaurants, are mostly organic waste which can be destroyed naturally even though it takes a long time [5]. Therefore, with the application of a simple technology, organic waste can actually be utilized through a processing process.

One of the techniques for utilizing municipal waste is processing it into organic fertilizer [5]. A widely applied process is to make compost into a fertilizer. However, this process still requires special treatment and takes a long time, so it requires a lot of money and effort. With a simple process, together with fecal waste, market waste can be made organic fertilizer in a relatively short time, called bokashi [6]. This research aimed to analyze the organic content of municipal waste, especially market waste and fecal matter, and its effect on the growth of several types of plants.

Materials and Methods

The research was done at the Fecal Waste Disposal Installation belonging to the Palu City Government. Research activities and were divided into 2 (two) stages, namely: (a) the production process included for processing market waste and feces; and (b) experiments in the form of demonstration plots.

The first phase of activity aimed to process waste and fecal matter into organic fertilizer. The final result of this stage was an organic fertilizer product that was ready for use. The stages of activity in this production process are: (1) observing the characteristics of market waste material in Palu City, (2) sorting, which meant separating non-organic material from waste taken randomly at a dumping site or shelter, (3) destruction, namely the destruction of waste material so that the size became smaller and could be further processed, (4) fecal processing, namely feces that were still in the form of large chunks that were still solid and hard taken from the fecal processing installation, crushed to form a fine powder then filtered using a 2 mm sieve, (5) mixing, namely organic waste that has been destroyed mixed with fine fecal matter in a ratio of 4:1 on the basis of volume, (6) processing, namely processing the material into organic fertilizer, starting from stirring, giving microbial solutions, and adding in fermentation to maturity, (7) analysis of the physical and chemical properties of the resulting product carried out in the laboratory of the Faculty of Agriculture, Tadulako University, and (8) packaging, namely the finished product was packaged in a plastic bag and labeled, each packed in a uniform weight of 25 kg/sack.

The second stage of research was to know the effectiveness of the organic fertilizer products produced in the first activity. The research was done in the form of an experiment and at the same time used as a demonstration plot, by paying attention to the location of the demonstration plot which was accessible to people who wanted to see the activity. Types of plants used as indicator plants were sweet corn (*Zea mays saccharata* L.), local shallots (*Allium ascalonicum* L.), Angsana tree (*Pterocarpus indicus*), and Glodokan tree seed (*Polyathea* sp.). Sweet corn and local shallots were planted directly in the field, while other types of plants were planted in plastic polybags. The research period for sweet corn and shallot plants started from seed planting to harvest, while for other plants it was done over a period of two months. The method applied to each type of commodity is as follows:

Shallots (*Allium ascalonicum* L.): The research was arranged in a randomized block design consisting of 5 levels of treatment in 4 replications, namely: B1 (5 tons / ha), B2 (10 tons / ha), B3 (15 tons / ha), B4 (20 tons / ha) and B5 (25 tons / ha). Planting was done on the bed measuring 1 x 1.2 m with a height of 30 cm. The onion bulbs were planted by first cutting the top 1/3 of the plant in order to speed up the germination process. Pest and disease prevention and control was done only physically to maintain environmental safety from chemical hazards. The variables observed were plant height, number of leaves, tuber diameter, tuber fresh weight, and tuber dry weight.

Sweet Corn (*Zea mays Saccharata* L.): The research method applied was a randomized block design consisting of 7 treatments. The treatments that tried are:

A = Control (using NPK [nitrogen, phosphorus and potassium])
B = PO (waste + fecal waste) 1 WBP (week before planting)
C = PO (market waste + fecal waste) 3 WBP
D = PO (market waste) + goat manure 1 WBP
E = PO (market waste) + goat manure 3 WBP
F = PO (fecal waste) 1 WBP
G = PO (fecal waste) 3 WBP

Each treatment was repeated three times so that there were 21 experimental plots in total. The experimental plot is a bed, measuring 3 x 4 meters with a height of 30 cm. All beds were prepared a week before the treatment application. Prevention or control of pests and plant diseases was only done physically, namely by monitoring the presence or absence of symptoms at any time. The variables observed were plant growth including plant height, the number of leaves, and stem diameter; production includes length, diameter, and production (weight of cob).

Angsana (*Pterocarpus indicus*) and Glodokan (*Polyathea* sp.): The research was arranged in a randomized block design consisting of 4 levels of treatment, each of which was: B0 (0 ton / ha), B1 (10 tons / ha), B2 (20 tons / ha) and B3 (30 tons / ha) or respectively equivalent to B0 (0 g / pot), B1 (50 g / pot), B2 (100 g / pot) and B3 (150 g / pot). Each treatment was repeated in 6 groups, so there were 24 experimental pots. Angsana seeds were taken from cuttings planted in polybags. The age of plants used as research material was about 3 months, which were then mixed with an organic fertilizer in the growing medium according to the treatment. The variables observed were shoot length, the base circumference of shoot, and the number of petioles, while the observations on glodokan seeds were: plant height, number of leaves and stems. All of these variables were measured at the beginning and end of the research, so that the data obtained was the difference between the growth in the final observation and the initial observation.

All experimental results data collected were statistically analyzed based on the guidance of Steel and Torrie [7]. The results of statistical analysis which were significant were further analyzed with the Honest Significant Difference (HSD) test at the 95% confidence level.

Results and Discussion

Characteristics of Market Waste

Waste was obtained from several markets in Palu City, namely: Public Market (Manonda Market or Masomba Market) and Petobo Morning Market. Based on the results of observations of the waste composition according to organic and inorganic proportions, the following data were obtained (Table 1).

Table 1: The proportion of organic and inorganic of market waste

Source of Waste	Snippet Number	Snippet Weight (kg)	Organic Part Weight (kg)	%	Inorganic Part Weight (%)	%
Public Market	1	13	10.5	80.8	2.5	19.2
	2	19.5	15.4	79.0	4.1	21.0
	3	22	17.2	78.2	4.8	21.8
	4	10.5	9.8	93.3	0.7	6.7
	5	16.5	11.2	67.9	5.3	32.1
Average %	-	-	-	79.8		20.2

Petobo Morning Market	1	12.0	12.0	100	0	0
	2	21.0	18.5	88.1	2.5	11.9
	3	18.0	17.5	97.2	0.5	2.8
	4	10.5	9.7	92.4	0.8	7.6
	5	10.8	7.9	73.1	3.9	26.9
Average %	-	-	-	90.2	-	9.8
Total Average (%)	-	-	-	85.0	-	15.0

Table 1 shows the large organic proportion of market waste on average reached 85% while inorganic was only 15%. When viewed separately, the proportion between the public market and Petobo morning market clearly shows the difference in the organic proportion of the two sources of waste. Petobo morning market, which was dominated by vegetable merchandise, had a higher organic content than the public market. Conversely, it had less inorganic content than the public market.

The organic part composition of waste in the two types of markets is presented in Table 2.

Table 2: Organic part composition of market waste

No.	Composition	Public Market		Petobo Morning Market	
		Weight (kg)	%	Weight (kg)	%
1.	Leaf vegetables and stalks	20.7	32.3	22.2	33.8
2.	Fruit / tuber vegetables	26.6	41.5	29.5	44.9
3.	Leftover Fish (fresh and dried)	1.7	2.6	-	-
4.	Waste of rice, corn, etc.	0.6	0.9	0.7	1.1
5.	Stems, bunches, and fruit peels (banana, pineapple, etc.)	6.7	10.4	9.5	14.5
6.	Stalks, hard branches of trees	5.8	9.1	1.7	2.6
7.	Etc.	2.0	3.2	2.0	3.1
Total		64.1	100	65.6	100

The inorganic part composition of waste in the two types of markets is presented in Table 3.

Table 3: Inorganic part composition of market waste

No.	Composition	Public Market		Petobo Morning Market	
		Weight (kg)	%	Weight (kg)	%
1.	Paper / Cardboard	4.96	28.5	2.79	36.2
2.	Glass bottles / flakes	1.70	9.7	0.32	4.2
3.	Plastic, rubber	6.23	35.8	3.09	40.1
4.	Textiles	0.45	2.6	0.14	1.8
5.	The rest of the building materials (broken brick / tile, etc.)	1.91	11.0	0.37	4.8
6.	Metal (Iron, wire, etc.)	0.71	4.1	0.21	2.7
7.	Etc.	1.44	8.3	0.78	10.2
Total		17.4	100	7.7	100

Tables 2 and 3 above show that the organic part composition between the public market and Petobo morning market was relatively the same except for the presence of fresh and dried fish leftovers in the public market, where this material was not seen in the Petobo morning market. Likewise, in the inorganic part composition, the data was relatively the same but the content of each component was quite different, such as the rest of the building materials were more commonly found in the public market. In general, it can be seen that the vegetable specialty market waste in Petobo sub-district had higher organic content, thus having the potential to be processed into organic fertilizer. Additionally, the low inorganic content would allow it to be processed more efficiently than waste that had high inorganic material content.

Properties of Organic Fertilizer Products: The laboratory analysis results of the chemical-physical properties of organic fertilizers are N-total of 1.66%, C-organic of 32.85%, phosphorus of 0.0346%, potassium of 0.56%, iron (Fe) of 0.104%, Magnesium of 0.013% and C / N of 26.39%. And, a material density of 0.65 with the air-dry moisture content of 11.2%. Based on these results, it shows that the content of macroelements, especially N and K, was sufficient to increase the needs of plants, while phosphorus was relatively low. Microelements such as Fe and Mg were high enough that they could be expected to provide a large supply to the soil. The C / N value meant that organic fertilizer was still in the process of further weathering so that the potential for nutrient mineralization still could be expected to supply nutrients to the soil. The quality of processing results that were already in the form of organic fertilizers could be categorized as meeting the requirements for production. Although in Indonesia there is no standard, the national compost quality standard in Japan requires a minimum N compost content of 1.2% [8]. With the N content of 1.66% noted in this study, it reveals that Palu City is above those set requirements.

The C / N ratio of the product of 26.4 shows that the decomposition process has not been going well, however, it could be improved upon with the further decomposition of C-organic so that the ratio becomes smaller by increasing composting or fermentation time. The fermentation time applied to this product lasted only two weeks, so to lower the C / N value, this time could be extended to 3-4 weeks. In composting straw, which is inoculated with a mixed culture of synergistic cellulolytic bacteria + Azaspirillum culture for 5 weeks after composting, a C / N value of 17.58 could be achieved [9]. In contrast to straw, organic waste was estimated to be faster at composting because this material was mostly vegetable residue containing less hemicellulose and lignin so it was easier to break down. The additional fermentation time relatively did not significantly reduce the production capacity because the process could be rotated so that the product harvest could be adjusted daily, by adjusting the fermentation blocks appropriately.

Field Experiment Results

Sweet Corn (*Zea mays* L. saccharata): The research results in the field show that the treatment of organic fertilizer application from Palu City waste, fecal matter, and manure applied at different times show a significant effect on the growth in height and number of leaves of corn plants, while other variables such as stem diameter, cob length, cob diameter, and cobs yield per hectare did not show significant effects (Table 4). Based on the HSD test at the 95% confidence level in the two influencing variables, it provided an indication that NPK fertilization treatment was not significantly different from other fertilizer application treatments except for the fecal application treatment applied 1 week after planting (WAP) (F). The observation data in Table 4 also shows that the plant height and the number of corn leaves from the fecal application treatment of 1 WAP did not differ significantly from the fecal application treatment (G), application of waste organic fertilizer + feces (B), and application of waste organic fertilizer + manure (D) applied at 1 WAP. This shows that the 1 WAP application time was considered insufficient to produce nutrients resulting from the decomposition of given organic fertilizers and, in fact, the application of 3 WAP generally resulted in better growth.

Table 4: Growth and yield of sweet corn through the combination ff various organic matter and application times

Treatment	Plant Height (cm)	Number of Leaves	Stem diameter (cm)	Cob length (cm)	Cob diameter (cm)	Cob yield (t/ha)
A	133.6b	10.28b	3.38	16.23	5.77	9.57
B	112.2ab	10.23b	3.17	17.35	6.13	10.36
C	129.3b	10.34b	3.31	17.63	5.98	11.01
D	97.1ab	8.95ab	3.05	15.52	5.32	8.98
E	126.5b	9.84ab	3.22	18.26	6.11	11.15
F	84.9a	8.56a	2.82	18.87	5.89	9.34
G	115.8ab	9.51ab	3.1	18.48	6.25	11.19
HSD 0.05	41.48	1.42	-	-	-	-

Note: The numbers followed by the same letter in the same column are not significantly different in the HSD 95% test

Shallots (*Allium ascalonicum* L.): The expected effect on the growth of shallot plants after they received various doses of organic fertilizer, was not achieved according to the results of this research. The average results of observations of growth and plant production are presented in Table 5. The table indicates that the application of organic fertilizer of municipal waste and fecal waste at a dose of 5 to 25 tons/ha did not provide a significant difference, so the use of low-dose organic fertilizers (5 to 10 tons/ha) was considered more efficient.

Table 5: Growth and production of shallots at various doses of organic fertilizer

Doses of Organic Fertilizer (ton/ha)	Plant Height (cm)	Number of Leaves	Number of Tillers	Tuber Diameter (cm)	Fresh Weight (g/plant)	Dry Weight (g/plant)
5	21,17	29,90	6,92	1,27	8,97	3,40
10	22,50	29,95	6,48	1,45	11,67	3,58
15	20,68	26,60	6,08	1,43	10,62	3,05
20	21,32	28,70	6,79	1,41	12,28	3,32
25	20,69	26,35	6,14	1,30	9,03	2,32

Angsana plant (*Pterocarpus indicus*): The average results of growth observations of Angsana plants are shown in Table 6. Although the results of the statistical analysis did not have a significant effect, quantitatively there tended to be an increase in growth with organic fertilizer application compared to those plants without such fertilization. This was particularly evident in the number of petioles and the shoot base circumference of the shoots given organic fertilizer at a dose of 10 and 20 tons/ha, increasing the growth rate between 30-100 percent.

Table 6: Increase in shoot length, number of petioles, and shoot base circumference of the angsana plant seed at various doses of organic fertilizer

Doses of Organic Fertilizer (ton/ha)	Shoot length (cm)	Number of petioles	Shoot base circumference (cm)
0	12,10	10,33	0,63
10	13,37	14,33	0,90
20	11,53	18,00	1,30
30	13,73	15,67	1,10

Glodokan Seeds (*Polyathea* sp.): Based on the analysis of various treatments of various doses, organic fertilizer only had a significant effect on the increase in the number of leaves, while plant height and stem circumference were not significantly impacted. The average data of the three observed variables are shown in Table 7. Table 7 shows that the number of leaves was significantly affected by the application of organic fertilizers.

Table 7: Average increase in number of leaves, plant height and stem circumference of glodokan plant seeds at various doses of organic fertilizer application

Doses of Organic Fertilizer (ton/ha)	Number of Leaves	Plant Height (cm)	Stem Circumference (cm)
0	5,33a	9,47	1,03
10	8,00ab	10,77	1,37
20	7,33ab	11,30	1,50
30	11,83b	14,07	1,33
HSD 0.05	5,33	-	-

Note: The numbers followed by the same letter are not significantly different in the HSD 95% test

The results of the HSD test at a 95% confidence interval indicates that only administration at a dose of 30 tons/ha resulted in a significant increase in the number of leaves as opposed to without the application, while the doses of 10 and 20 tons/ha were statistically not significant without the application of organic fertilizers. Vice versa, there was no significant difference between the doses of 10, 20, and 30 tons/ha with one another.

Conclusions

The characteristics of Palu City market waste consisted of 85% organic parts and 15% inorganic parts. Public market (Manonda and Masomba) had a lower proportion of the organic part (79.8%) than the vegetable market in Petobo (90.2%). The resulted organic fertilizer products have met the compost quality standards, with the N content of 1.66% above the 1.2% requirement. However, the C / N ratio was still quite high (26.4), which was still above the ideal conditions (12-15). The results of statistical analysis of the application of the organic fertilizer show a significant effect on plant height and number of leaves of sweet corn; the number of shoots and the total shoot length of the Bougainville plant and the increase in the number of leaves on the glodokan plant. Meanwhile, some of the other growth variables and all the observation variables for shallot and Angsana plants have not been proven. In order to increase the quality of organic fertilizers from municipal waste, especially from the C / N ratio indicator, the composting or fermentation time needed to be extended from 2 weeks to 3 to 4 weeks so that optimal C / N could be obtained.

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