

Design of concrete waste basin in Integrated Temporarily Sanitary Landfill (ITSL) in Siosar, Karo Regency, Indonesia on supporting clean environment and sustainable fertilizers for farmers

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Abstract. A new settlement in Siosar village of Karo Regency has been developed for people whose villages have been completely destroyed by the prolong eruptions of Sinabung. An integrated temporarily sanitary landfill (ITSL) was built there to support the new living environment. The objective of this study is to investigate the organic waste decomposing in order to improve the design of the conventional concrete waste basin installed in the ITSL. The study was last from May until August 2016. The used design was Completely Randomized Design (CRD) in which organic waste was treated using decomposer with five replications in three composter bins. Decomposting process lasted for three weeks. Research parameters were pH, temperature, waste reduction in weight, C/N, and organic fertilizer production(%). The results of waste compost as follows : pH was 9.45, ultimate temperature was 31.6°C, C/N was in the range of 10.5-12.4, waste reduction was 53% and organic fertilizer production was 47%. Based on the decomposting process and the analysis, it is recommended that the conventional concrete waste basin should be divided into three columns and each column would be filled with waste when previous column is fulfilled. It is predicted that when the third column is fully occupied then the waste in the first column already become a sustainable fertilizer.

Keywords : concrete waste basin, temporarily sanitary landfill, fertilizer

1. Introduction

The issue of waste is a serious problem in almost all regions because it creates various problems, especially environmental problems. There is a phenomenon in which people who live in rural areas generally do their own waste handling, for examples open burning, open dumping either on the public area or into water body. In Medan, Indonesia for example, there was \pm 1500 manufacturing, food and feed and household waste, industrial activities producing about 150,000 tons of waste production/day disposed by open dumping system to landfill, some are burned at the back of the house and dumped into rivers or buried in the hole. Therefore, community settlements require facilities and infrastructure for solving waste problems.



The increasing of population is followed by the consumptive lifestyles, resulting in increasing and varied trends of waste Syafrudin [1]. According to Kodoatie [2] growth of urban population caused a non balanced with waste infrastructure, as waste facilities were not enough compared to waste production. Moreover, waste policy are still in argument between governments while waste problems get bigger if it is not handled in an integrated system.

World Bank in 2012 released that the production of solid waste in the world was so fast and also on a very high cost. Solid waste processing costs soared to 375 billion U.S. dollars or approximately IDR 3,54 quadrillion per year from the previous 205 billion dollars, or approximately IDR 1,93 quadrillion in 2025 due to the increase of solid waste to 70% of the original 1,3 billion tons of waste per year to 2,2 billion tons per year.

The best example on waste processing was showed by what has been done by the city government of Surakarta (Solo) Central Java. Sudrajat [3] mentioned that waste from landfill Mojosongo Solo used the open dumping system. They composted organic waste and distributed the compost free of charge for community.

To achieve optimal waste service, it was time to change the transformative paradigma of city waste management. According to Witoelar [4] the paradigma included of processing waste from the approach "end of pipes" where waste discharged directly to landfill towards managing waste in 3R system. Indonesia is far behind than other countries as according to Buclet and Olivier [5] whereas changes in waste processing paradigm in most European countries have been started since 1970.

Karo is a regency which used open dumping system landfill in managing its waste. Domestic solid waste in Karo arised from remnants of the activities of domestic products/household, shops, traditional markets, street sweeping and parks. Meanwhile, waste management planning in Karo already socialized system 3R. Karo regency government insisted for have a minimum of waste management as follows: communal waste tub, garbage trash (1 m³ capacity), manual truck (capacity 6 m³), dump truck (capacity 6 m³).

In 2015, Indonesia government together with Karo regency government constructed new settlement in Siosar, Karo for people who have to be relocated due volcanic eruption of Mount Sinabung. There were 3 new villages which were Sukameriah, Simacem and Bakerah. The new settlement was equipped with integrated temporarily sanitary landfill (ITSL). Every ITSL located in each village is furnished with a compost hose which includes bio-digester having an area of 476 m². According to Ginting [6] agricultural waste must be managed otherwise they produced greenhouse gases like in Karo Regency, green house gases from horticulture waste could be as much as 2.1 x 10⁶ ton CO₂ eq in 2014. Ginting [7] recommended for people in Karo Regency to utilize gasbio technology. As an input was coffee waste (coffee fruit meat) to overcome the scattered coffee waste in the environment because it would trigger the weevil beetle Cherry Borer which harm coffee production. The resident in Siosar grow coffee in addition to horticulture.

As compost house had not operated yet, a research had conducted to investigate the best waste management for Siosar ITSL. There were several considerations in the utilization of waste basin in Siosar as follows: 1. organic waste from household activities must be processed into compost as Siosar was an agricultural area 2. organic waste from agriculture land can be used for compost or for gasbio input 3. waste basin should have a system that accommodate minimal management as there was uncertainty that ITSL would got adequate operational fund. This study aims to find a strategic technical solution for ITSL to has a maximum output, especially for the puIDRose of producing sustainable fertilizer.

2. Materials and Methods

The research began by conducting research composting by utilizing a combination of various kinds of organic waste collected from the settlement. Organic wastes were household organic waste such as the remains of eggplant, jipang, tomato, banana leaf while the community agricultural waste was potato. A lot of organic waste in Siosar were rotten potatoes which were dumped in the trash. Research was

implemented by a Completely Randomized Design (CRD) with 3 treatments and 5 replications. The three treatments were T1: 32.5% rotten potatoes + 67.5% household waste T2: 50% rotten potatoes + 50% household waste T3: 67.5% rotten potatoes + 32.5% household waste. Potato was the main product of Siosar, so in this study potato was used more. Furthermore all organic matters were minced and pH data were taken. Organic matters than were watered with a local fermentor (MOL) and fermented in a composting basket with a height of about 40 cm for 21 days. pH before fermentation of T1, T2 and T3 were range from 7.8, 8.1 to 8.29. pH would less when there was tomato such as in household waste.

3. Results and Discussions

Table 1. Temperature, pH and C/N organic waste composting by MOL

Treatments	Ultimate Temperature °C	pH	C/N	Waste Reduction (%)
T1	30.8	9.2	12.4	52.0
T2	31	9.5	11.1	53.5
T3	33	9.7	10.5	55.1
Mean	31.6			

Table 1 showed that there were no differences ($P>0.05$) between all treatments on temperature, pH and C/N which means that effectiveness of microorganism in degrading organic waste were the same.

3.1. Temperature

The average ultimate temperature was 31.6 °C while M Fachmy et al. [8] found the ultimate pH was of 35°C where Fachmy's research was conducted in the Karo/Tahura highlands with an ambient temperature of 19-23 °C while Siosar had an environmental temperature of 16-22 °C. Kalyuzhnyi et al [9] mentioned that the optimum temperature was 35 °C .

Lower environmental temperatures affect the metabolism of microorganisms in the composting process. According to Adams and Frostick [10] the temperature at the time of maximum degradation did not have to be accompanied by high temperature increases, thermalization process in composting would be followed by physico-chemical condition. In this condition actually more influential was the consumption of O₂ than the change in temperature itself. With the growing population of microorganisms, the need for O₂ would increase. Furthermore, by Campitelli and Ceppi [11] it was said that in physico-chemical condition there was a humic acid in which the humic acid compost had a soil cation exchange capacity and soil buffer capacity was excellent and better than the quality of humic acid produced from vermicompost.

3.2. pH

The pH of this study averaged 9.45 where pH was affected by the pH of compost and metabolism feedstocks that were carried out in the composting process. pH of vegetables was >7, except tomatoes or rotten oranges as the research conducted by Ginting [6], the addition of rotten oranges caused the pH to fall. In a study conducted by Brito et al. [12] to cattle faeces, the pH range was at 6.9 - 9.3. There was a tendency to increase the pH possibly due to the degradation of organic acid bonds. Next by Brito et al. [12] it was also said that at the end of composting, the pH will be high due to the buffering effect of bicarbonate. Compost that has a high pH can be recomposted by adding a material that has a low pH level, and the result will be even better because it will inhibit the volatilization of NH₃ during the composting process.

3.3. C/N

C/N in this study was in the range of 10.5 -12.4. In the composting process, because the work of microorganisms then:

1. with increasing time then organic C decreases
2. with increasing time N total increases
3. with increasing time C/N decreases

In the process of composting microorganisms required energy sources derived from the degradation of C and N for their development and activity. The C/N they need was about 25 - 35 considering microorganisms require 30 parts of C for each N unit.

The content of N increased with increasing time. N comes from reshuffling proteins into simple peptides that eventually become free amino acids, CO₂ and water. In addition, the result of cellulose reshuffle would produce volatile fatty acids and keto acids which then became amino acids. The addition of N also comes from its own microorganisms in which microorganisms were the source of amino acids for compost.

The value of C/N for quality compost was 10 - 20 Sumardi [13] while Sutedjo [14] said that C/N ratio 12 was ideal for compost to be applied to the plant. Compost that still had a high C/N, would harm plants, because immobilization N could occurred.

Brito et al. [12] mentioned that compost stability was indicated, among others, by low and stable temperatures, low C/N ratios. Also Brito et al. [12], did not recommend the reversal of the pile of materials during composting as it would lead to a reduction in NH₃ volatilization. Wrapping the stack of materials with plastic was also not recommended because it would inhibit the circulation of O₂.

3.4. Implication of reseach on TPST System in Siosar

Bekerah Village

The total population of Bekerah Village were	= 112 household
- Assumption / household	= 5 People
- Waste volume / person	= 0.4 kg
- Waste / household	= 5 X 0.4 = 2.0 kg
- Total waste	= 2.0 X 112 = 224.0 kg / day
- Waste basin capacity (design by gov)	= 2.6x2.0x11.0 = 57,200 kg
- Time of filling the waste basin	= 57.200 / 224 = 255 days

As total population in Simacem village were 130 households and when all assumptions were the same, so time of filling the waste basin in Simacem village were 220 days and in Sukameriah village as the population were 128 households, so time to filling its waste basin were 223.4 days.

Associated with this research which pH of composting still 9.3 and needed a maturity before applied as fertilizer, so it was suggested the waste basin to be separated by 3 because each stage of composting until maturity need about 2 months. When the first column of waste basin was full, the second column would be fill in, and followed by the third column while at this time, waste in the first column already matured to be applied as fertilizer. By separating into 3 columns, it would easier in digging out the compost from the basin.

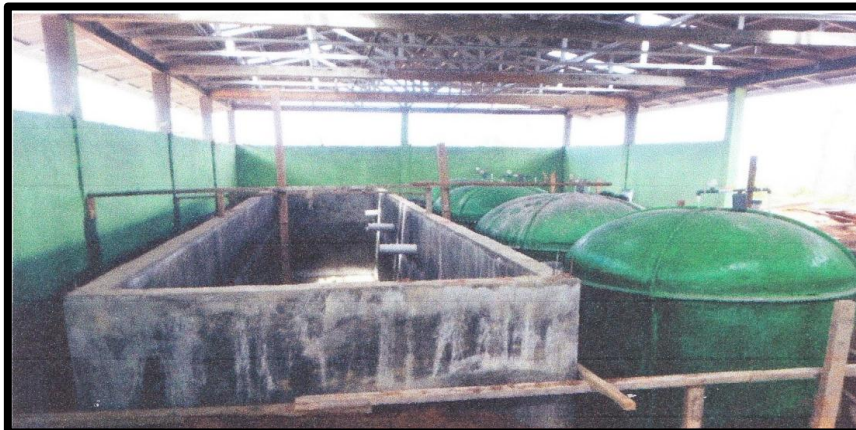


Figure 1. Concrete Waste Basin Size : $2.6 \times 2.0 \times 11.0 = 57,200$ kg

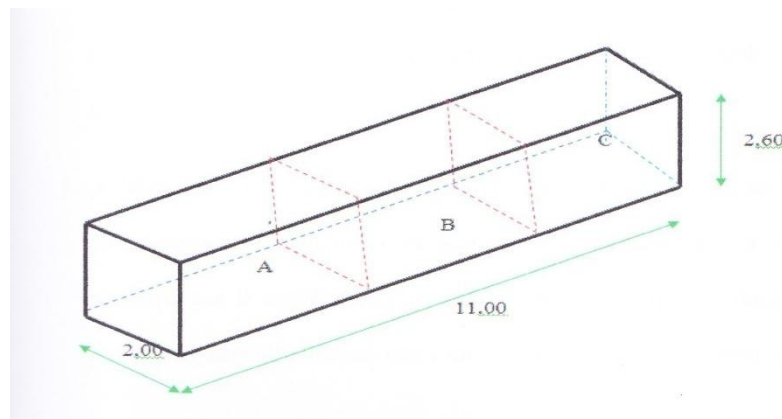


Figure 2. Concrete Waste Basin separated into 3 columns

3.5. Benefits of composting

The benefits that can be obtained from the composting result are:

- Total volume of waste basin in each village = 57,200 kg
- Compost reduction = 53%
- Compost weight after reduction = $53\% \times 5,200 = 30,316$ kg
- Compost price = IDR 600 / kg
- The results can be obtained for composting in each village = $30.316 \times 600 = \text{IDR } 18,189,600$
- So the results obtained from the 3 villages were = $3 \times 18,189,600 = \text{IDR } 54,568,800$

For composting at integrated waste management site (ITSL) Siosar generated a value of IDR 54,568,800

3.6. Benefits of biogas

As mentioned before, the ITSL of each village also facilitated by a biodigester with 1000 litres capacity. While there were a lot of rotten potatoes and other rotten vegetable in Siosar and according to Ginting [6] agricultural waste in Karo help farmers in saving money by using biogas ; Ginting and Rauf [13] also mentioned that biogas slurry made farmers saving money from buying fertilizers. Slurry itself contained microorganisms that could maintain healthy soil. From 1000 l biodigester,

could produced 1500 CH₄ and 30 l slurry. 1500 l slurry was equivalent to 0.9 l karosene Rajakovic [14] and every 250 ml slurry was equivalent to 2.5 g NPK Ginting and Mustamu [15]. So from biodigester in Siosar ITSL the benefits from CH₄ was IDR. 6.975,- (subsidized prize) and IDR. 13,500,- (non subsidized prize) per day as price for every 1 liter subsidized karosene IDR. 7,500,- and non subsidized IDR. 15,000,- and benefits from slurry as much as IDR. 3,600,- per day as the price for NPK was IDR. 12,000,- per kg.

5. Conclusions

Separating the concrete waste basin into 3 column would produced a maturity compost and would easier in digging out the compost from the basin. Benefits from 3 ITSL in Siosar were compost with price IDR 54,568,800 per year and from CH₄ by activated 3 biodigester were IDR. 8,212,500 and from slurry IDR. 3,942,000,- In addition, ITSL would caused clean environment. As all benefits came from environmentall friendly technology, so any other ITSL is recommended to follow what had been done in Siosar.

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