Non-conventional options of managing municipal solid waste towards sustainable solid waste management in Makassar City

S Towolioe¹, A S Permana² and H Kadang³

¹Department of Chemical Analysis, Bantaeng Community College of Manufacturing Industry, Nipa-Nipa, Pa’jukukang, Kabupaten Bantaeng, Sulawesi Selatan – 92461. Indonesia
²Department of Civil Engineering, Faculty of Engineering, King Mongkut’s Institute of Technology Ladkrabang, 1 Thanon Chalong Krung, LatKrabang, Bangkok – 10520. Thailand
³Management and Statistical Laboratory, Department of Economic and Business Management, Universitas Atma Jaya Makassar, Jl. TanjungAlang No.23, Maccini Sombala, Kota Makassar 90224. Indonesia

Corresponding author’s e-mail: towolioesherly@gmail.com

Abstract. The traditional approach of handling municipal solid waste in many cities in Indonesia has led to the failure in certain degree of the solid waste management (SWM). On the other hand, the non-conventional options are the approaches to transform this business-as-usual approach to sustainable SWM that aims at accomplishing the appropriate proportion of the elements in waste hierarchy towards sustainable solid waste management. This study aims at assessing the present non-conventional approaches in municipal solid waste management undertaken by waste authorities in Makassar City. We conducted an in-depth investigation and interview with the actors/members, users, citizens and authorities on current status of non-conventional options of SWM. Four hundred and two respondents have been acquired their opinion and perception. Analysis on their perceptions was done by using 5-point Likert scale, by expecting to represent the respondents’ voices in carrying out the SWM activities. From the study, we confirmed that activities towards sustainable solid waste management are not always cost-intensive activities, a socially-bounded engagement, as reflected in by community in the study area, would also workable. We affirm that a livable city will not be accomplished without sustainable solid waste management.

1. Introduction
Waste is the most unimportant things for our life, but contradictorily it is an important matter in our life. Ignoring it means disaster to our life. Unfortunately, solid waste management in many cities in Indonesia has shown its failure in implementing the sustainable solid waste management (SWM) because of mere conventional approach of collect-transport-dispose-and-forget [1,2]. Many large cities in Indonesia are still employing businesses-as-usual approach, in which the SWM is simply implemented in terms of collects, transports, dispose, without intermediate process of the waste before disposal. Consequently, the amount of solid waste transported to the landfill site exceeds the landfill capacity. With the estimation of the volume of waste generated is constantly increasing. This conventional approach must be changed drastically towards a broad spectrum of sustainable municipal solid waste management, involving non-conventional options. Otherwise, the landfill will be
perpetually and periodically filled up and generated NIMBY. This persistent vicious circle of SWM must be cut, or else, the problems of waste will be developing and snowballing, like what Mayor Rismaharini of Surabaya afraid of [3]. The waste problem in Jakarta seems to reach a point of no return, and it needs very strong political will from the city authorities to solve.

Makassar City, the city that the study is focused on, is a secondary city with 1.6 million people. The city is presently encountering similar problems with its counterpart cities, in which demand for landfill site is a vicious circle of solid waste management. It has been long time the management of solid waste in this city still applying the conventional pattern of waste collection-transporting-disposal. Obviously, there is no systematic and large scale of waste reduction program, waste separation at source, and recycling program, until recently. No wonder if the perpetual vicious circle of demanding disposal site repeating periodically in 5-10 years depending on the capacity of landfill. Amid the limited land in the urban and peri-urban areas of Makassar, the demand for landfill becomes a nightmare for the city authority. This situation could not be ignored, or else the consequences would be beyond imagination, particularly on environment and human health.

A change in direction of municipal solid waste management in Makassar has appeared since 2016 with the introduction of some non-conventional programs and activities on waste separation, waste bank, composting at household level, waste recycling. The recent attempt was the introduction of black soldier flies or maggot of flies to reduce the food waste, prior to be disposed to landfill site. Even though the scale is insignificant in comparison to the volume of waste disposal in the city, but the efforts by city authority is commendable. Sustainable solid waste management is supposed to be able to accomplish the situation in which the waste hierarchy of waste reduction, reuse, recycle, waste-to-energy conversion, and waste disposal are in order of preference [4]. This means the hierarchy must be largest to smallest with respect to percentage of contribution. The waste reduction must therefore be the largest and the waste disposal must be the smallest and zero (Figure 1 left). By this goal, the perpetual NIMBY could be avoided, particularly when a city accomplished zero waste i.e. all wastes are properly managed and utilized for further useful products. No waste a waste is produced.

![Figure 1. Various situation of waste hierarchy.](image-url)

However, in the reality, as reflected in most municipal solid waste management in the cities of Indonesia, which traditionally applies business-as-usual process, the non-progressive business, is demonstrated in the Figure 1 (right). Few local authorities have commenced to ponder towards a half-way of idealistic situation as reflected in Figure 1 (middle). These cities are, for example, Surabaya, Bandung, Surakarta, and Semarang. These efforts are commendable and supposed to be accompanied by large-scale and community-based non-conventional approaches. This study aims at understanding the present non-conventional approaches in municipal solid waste management undertaken by waste
authorities in Makassar City by assessing the extent of contribution of these non-conventional approaches on the waste reduction rate disposed to landfill site.

2. Methodology
The study was carried out in Makassar City, South Sulawesi, involving various stakeholders of the waste management in the city, i.e. citizens as the waste generator, citizens and CBOs as the waste management actors and promoters, and local authority as the waste handlers and policy makers, as well as academics. We distributed 500 questionnaires to randomly selected citizens and CBOs, and returning 402 responses. We also interviewed about 10 local authority officers and academics on waste management matters in Makassar City. The data is then analyzed statistically to support the objectives of the study. The study has actually been done two times in 2015 and in 2018 in the same city, with the same methods, to understand the tendency of the respondents on their perception on waste management in Makassar City in this 3-year period.

3. Persistent problems of municipal SWM
When we identify the issues of municipal solid waste management in all cities in Indonesia, majority of the city authorities pinpointed two major issues that impeded the effectiveness of municipal solid waste management. These two major issues are insufficiency of budget towards ideal municipal solid waste management and lack of equipment to carry out the municipal solid waste management itself. However, when the inquiry was directed to the meaning of ideal municipal solid waste management, again the majority responded that for them the ideal one means that one-hundred percent of waste generated within the municipality could be collected, transported, and disposed to the landfill site safely. This statement implies several consequential issues on municipal solid waste management, for example, the truth of the existence of conventional solid waste management in most local authorities, the simplification of municipal solid waste management into only city cleanliness, the absence of the involvement of primary stakeholder of solid waste management i.e. citizens, the maintenance of the vicious circle of solid waste management, lack of creativity to escape from the routine management.

We may witness that, for them, the accomplishment of municipal solid waste management would eventually be measured, in terms of quantity, by the percentage of total waste disposed to final dumping site, and, in terms of quality, the perception of people on the cleanliness of the city, or precisely bagging city cleanest award from government i.e. Adipura. This old mind-set leads to the insustainability of municipal solid waste management. This issue is considered as the persistent problem of municipal solid waste management. An example of the result of this persistent problem could be reflected in the following living issues in some cities in Indonesia:

- Until 2018, in Bandung City, only 69.6% of total waste volume could be properly managed [5].
- Mayor Rismaharini of Surabaya deliberated the waste problem in Jakarta as terrifying [3].
- Medan is one of the dirtiest cities in Indonesia. NGO: a waste management must be drastically changed [6].
- Malang City is in an Emergency Waste Status [7].
- Bekasi City is an Emergency Waste Status [8].

The above examples seem sufficient to safely say that most cities in Indonesia are presently managing municipal solid waste in non-sustainable ways. In the study area itself, recently, the Makassar City government faced the problem of the Tamangapa disposal site, which will overload in 2020.

4. Municipal SWM in Makassar City
Based on our observation and interview with the parties associated with municipal solid waste management in Makassar City, for example, city authority, NGO, citizens, the general picture of waste management in the city is still at the stage of business-as-usual towards halfway sustainable solid waste management. This can be assessed through the trends of some waste management variables such as waste volume, percentage of organic waste, percentage of waste collected, recyclables processed or utilized, composting product, and waste to energy, as exhibited in Table 1.
Table 1 shows a sign of, even though insignificant, better waste management, as several positive signs appear. The decrease tendency of the quantity of organic waste might indicate the decrease of waste disposed to landfill site, and also the potential opportunity to process more recyclables, and thus reducing waste disposal. There is also a trend of increasing composting products, although insignificant. The insignificance production of waste composting in Makassar city is because of several reasons, for instance, the activities were purely carried out in community basis, local authority does not strongly pay attention on this product, and the product is competing with chemical fertilizer, while the farmers mostly trust on modern chemical fertilizer to boost the products of their farming activities. The positive side of this state is that is a right momentum for waste authority in Makassar City to expedite towards sustainable solid waste management.

Table 1. Trends of waste variables in Makassar City

| No. | Waste variables                  | In 2014 | In 2015 | In 2016 | In 2017 | In 2018 |
|-----|----------------------------------|---------|---------|---------|---------|---------|
| 1   | Average Daily volume (m³)        | 4,235   | 4,308   | 4,496   | 4,548   | 4,678   |
| 2   | Organic (%)                      | 68      | 65      | 62      | 60      | 58      |
| 3   | Inorganic (%)                    | 32      | 34      | 37      | 40      | 42      |
| 4   | Daily Percentage of collection   | 76      | 82      | 84      | 85      | 88      |
| 5   | Daily Recyclables processed/utilized (ton) | 0.2 | 0.5 | 0.5 | 0.6 | 1.2 |
| 6   | Estimated composting product (kg) | 22     | 26      | 25      | 27      | 30      |
| 7   | Waste to energy [kWh]            | 0       | 0       | 0       | 0       | 0       |

5. The non-conventional approach of SWM in Makassar City

5.1 Waste segregation at sources

The city did not a program of waste separation at source, which is a very basic but powerful impacts on overall results of solid waste management if it is extensively carried out by all citizens with sufficient support from the authority. Permana et al. [1] asserted that the percentage of citizens who did waste separation at source is only 2.2% at certain and almost certain level plus 27.1% of the citizens who are at the level of ‘sometimes’, which is sometimes did and some other times did not do the waste separation, depending on the situation. Their level of dedication in doing waste separation can be assessed through their motivation, whether on the basis of personal social responsibility to the city environment or just usual economic motives. Looking at their motives, the majority of them do their actions on the basis of adding personal or household incomes. Whatever the motives, the city authority can explore their actions on doing waste separation to help the city achieving sustainable solid waste management.

5.2 Waste composting

Composting is an aerobic degradation of organic fraction of the waste to yield stable humus like product which can be used as a soil conditioner [9,10]. Using composting as a treatment of solid waste can significantly reduce the solid waste volume especially in countries where organic waste and yard waste is predominant The city has intensively promoted composting practices by setting up a dozen composting centers and distributing compost baskets to residents, and has actively involved residents and community groups in waste reduction activities by co-organizing a community cleanup campaign with local NGOs, private companies and the media. It is worth mentioning that the amount that the city has spent for a series of activities was only one to two percent of the total solid waste management expenditures.

In many developed cities, composting is not a preferable option in reducing the organic waste, instead they are focusing on the solution through advance technology, for example, using biogas digester to process the organic waste to produce energy. The residues of the digestive process are
disposed to the surrounding forest to feed the soil as they are biodegradable. However, in Makassar City, handling the organic waste is done through three modes: direct disposal, waste composting, biogas digesters. The direct disposal is certainly the largest because of easiness and inexpensive, meanwhile converting organic waste by biogas digester requires large amount of fund, even at household level. A mini biogas digester for household, for example, will cost around USD 250, and municipal biogas cost around USD 20,000. Thus, the selection of composting as alternate solution of organic waste is logic since it requires at almost no costs.

Our survey shows that only 0.2% of the respondents surveyed did the composting at household level. An effort to introduce Takakura portable waste composter at household level is creditable. The price is affordable with only around USD 15-20 per unit. Waste authority must take action now by subsidizing the purchase of this handy waste composter, at least to 1000 pilot households, while searching for the market of composting product for the sustainability of the program. With a prospective market of compost produced by households, the subsidy could be avoided, and the organic waste disposed to landfill site could be reduced.

5.3 Waste bank
Waste bank does not directly reduce the waste instead provide facilitation to ease the recyclable waste flow from waste generators to waste recyclers before producing a final product. There are three types of waste bank according to the management: waste bank run by community associations (Rukun Warga, RW), waste bank managed by schools, waste bank run by private companies/business. The total number of waste bank in Makassar, which are currently actively in operation in Makassar City is 896, which consists of 621 waste bank run by community associations, 246 waste bank managed by schools, and 29 waste bank run by private companies/business.

The waste bank is operated like conventional bank, in which the money is substituted by recyclable waste valued with monetary unit, based on current price of the recyclables. The customers have waste bank passbook without an ATM card stating amount of money can be drawn almost any time at the bank but not at the conventional Automatic Teller Machine, since the Waste Bank does not have sufficient capital to operate a hundred percent like conventional bank. The Bank itself can sell the recyclables to the recycling companies. The weakness of current system is that, the Bank’s management are volunteers, they do not get salary. It makes the Bank unsustainable. In the future, the management can have salary from the operational cost of the bank taken from the difference between customer price and recycling company price of recyclables. However, this system might not work, as the price difference is insufficient to cover Bank’s operational costs, considering present volume of the recyclables, and also, the citizens are able to sell directly the recyclables to recycling companies or other persons with better price than waste bank does. One of the most active Waste Banks in the city is PelitaHarapan waste bank operated by community of RW 04 Ballaparang, Rappocini District, Makassar City. The volume of recyclables managed by this bank alone is around 50-100 kg per day.

The emergence of waste bank into the municipal solid waste management in the city is considered a non-conventional solution in addition to business-as-usual waste management of collect-transport-dispose. The large waste bank turned to be a large recycling company has shown by Wongpanitch Recycling Company in Thailand. It has been operated since 30 around years ago. Its head quarter is in Pitsanulok Province Thailand.

5.4 Reducing waste by maggot of flies
This is a way to reduce the quantity of food waste or kitchen waste by employing larvae of special species of flies called Black Soldier Fly (Hermetiaillucens). The advantages of this process, the maggot has high productivity to reduce the waste, as well as other function of maggot as protein source for domesticated animals like birds, chickens, and fish. Some conditions that need special attention for the economic sustainability of the organic waste reduction by employing BSF [11] are:

- Scale which will dictate the capital and operational cost
- Temperature and humidity of the place where the program is being undertaken
• Tipping fee of the activities i.e. provision of the larvae
• Income from the selling of the products i.e. larva
• Income from the selling of the residual waste

The ‘capacity’ (the appetite) of adult fly’s larva (imago) in consuming various kind of organic waste is quite incredible, depending on the types of waste, the appetite of imago is about 20-200 mg/larva/day. The smallest waste appetite of the imago is vegetable-derived waste i.e. 20 mg/larva/day, and the largest is on cassava leaves i.e. 200 mg/larva/day. In average, the imago’s waste consumption is about 50-80 mg/larvae per day. It is a significant quantity of waste reduction. In terms of total waste reduction, which is efficiency of the larvae, in general the percentage of reduction is shown in Table 2.

Table 2. Waste reduction by BSF (imago) for different kind of waste. [12]

| Waste types                      | Average reduction (%) | Waste types          | Average reduction (%) |
|----------------------------------|-----------------------|----------------------|-----------------------|
| Vegetable with predominantly fruit | 54.0                  | Cassava’s leaves     | 49.0                  |
| Vegetable+fruit+fish             | 49.0                  | Banana               | 52.0                  |
| Predominantly fish               | 33.0                  | Food waste           | 60.0                  |
| Pig manure                       | 39.0                  | Cucumber             | 53.0                  |
| Chicken manure                   | 50.0                  |                      |                       |

Figure 2. Residual Waste after consumed by BSF

There is no information on feeding the imago by mixed bulk organic waste and the percentage of waste reduction. By the data presented in Table 2, to accomplish optimum percentage of organic waste reduction, another problem may arise, which is organic waste separation. However, this is not a big deal, as the mixed bulk organic waste can still be consumed by imago (BSF), even though the consumption rate and waste reduction are unknown.
As an illustration of the waste reduction by employing BSF, when it gets one-hundred percent support from the local government in terms of budget, equipment and other facilitation, if 30 percent of the households in Makassar City involved voluntarily, which is around 100,000 households, and each involved household equipped with initial BSF of 50,000, which needs around 36 square meter of processing building. The potential quantity of waste reduction is $100,000 \text{[household]} \times 50,000 \text{[larvae/household]} \times 80 \text{[mg waste/larvae/day]} \times 0.3 \text{[efficiency]} = 120 \text{tons per day of organic waste.}$

Another non-conventional approach to reduce the waste is waste to energy program. This program can be done by co-generation system i.e. heat and electricity, and biogas digester. Actually, the local authority while planning and discussion the co-generation system, the biogas digesters, which is much cheaper than co-generation, can be started without very much worry about fund. The issue is only execution and will of the decision making. The usual reason of reluctance of local authority in executing the plan and program of waste to energy is lack of will, courageous and budget, because so far, no example even failed example, for the implementation of waste to energy program. As a result, most of the waste is still disposed to final disposal site, which creates a perpetual NIMBY for the surrounding people and headache for the local authority.

6. **The NIMBY created by disposal site**

The most economical simplest, easiest, and cheapest method of solid waste disposal in the world is landfilling, particularly open dumping. However, NIMBYs (not in my backyards) and land issues are the strongest opponents that prevent this open dumping system. Final disposal site (FDS) is Tamangapa in Makassar. It is an open dumpsite. It is far from a sanitary landfill. According to Department of Parks and Cleanliness – *DinasPertamananandanKeindahan Kota Makassar* -the FDS can only be used until 2020 because the heap stack of the waste generation is now more than 8 meters. The lifespan of the landfill varies from urban centers. One indicator is the size, the location and the cost requirement in establishing a landfill.

If all current active programs by communities are getting a hundred percent support and or augmented through various incentives and subsidies by the government, the disposal site will be double or triple longer than current periodic demand for landfill site. Once this demand of landfill site is created then NIMBY and the need of land will follow. This is certainly not a sustainable solid waste management that we expected to be implemented by every local government in Indonesia.

7. **Perception of the citizens on current SWM Program**

Based on the survey, majority of citizens perceived that current implementation of municipal solid waste management by city authority is insufficient as exhibited in Table 3.

| Perception, based on 5 point Likert scale | Frequency 2015 | Frequency 2018 | Percent 2015 | Percent 2018 | Statistics 2015 | Statistics 2018 |
|-----------------------------------------|----------------|----------------|--------------|--------------|----------------|----------------|
| Extremely insufficient, 1               | 11             | 15             | 2.7          | 3.7          | Mean:2.48      | Mean:2.52      |
| Insufficient, 2                         | 222            | 198            | 53.9         | 49.3         | Mode:2         | Mode:2         |
| Neither sufficient nor insufficient, 3  | 151            | 153            | 36.7         | 38.1         |                |                |
| Sufficient, 4                           | 25             | 36             | 6.1          | 9.0          |                |                |
| Extremely sufficient, 5                 | 3              | 0              | 0.7          | 0.0          |                |                |
| **TOTAL**                               | **412**        | **402**        | **100.0**    | **100.0**    |                |                |

Comparison of two surveys with 3 years’ interval shows a very thin and insignificant improvement of the policy, program and implementation of municipal solid waste management in Makassar City. This insignificant improvement can be ignored and consider a stagnant waste management considering the close interval of the survey, even though with perhaps different respondents. This also shows the consistency of perception of the citizens. This is a big challenge for
the local government of Makassar City to make a breakthrough and significant changes on their present implementation of the SWM.

8. Conclusion and way forward

The first and foremost suggestion based on the findings of this study is that local government of the Makassar City must find innovation on the implementation of municipal solid waste management, by promoting and augmenting present available both conventional and non-conventional approaches, particularly non-conventional ones as they also contain potential waste reduction to accomplish sustainable solid waste management. The engagement of BSF to cope with organic waste can be commenced by either totally carried out by community or partly community and partly government with bigger roles of the government at the initial stage.

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