A Study to Improve Effectiveness of the Solid Waste Management in the City of Banjar, West Java Province

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Abstract. The purpose of this study is to assess the development of the municipal solid waste management in the City of Banjar, West Java Province. Municipal solid waste management in the City of Banjar has been developed as a system that is expected to implement the 3R concept of reduce, reuse, recycle. However, implementation of the 3R concept through solid waste sorting and composting as well as the service coverage are still very low. Effectiveness of the municipal solid waste management in the City of Banjar could be improved by gradually increasing solid waste sorting, organic waste composting, and the level of service. Improving solid waste sorting from 5% to 70% will produce recycled goods from 16 to 687 ton/month in 2030. Increasing the level of organic waste composting from 5% to 90% will increase the compost production from 35 to 1,905 ton/month, respectively. As a result, the volume of solid waste hauled to final disposal site which increases from 1,129 to 1,440 ton/month in 2026, will gradually decrease to 1,008 ton/month in 2030. It can be concluded that improving effectiveness will result sustainable solid waste management in the City of Banjar.

1. Introduction
In 2017, Indonesia has 416 regencies and 98 cities [1]. Municipal solid waste is a serious problem in those regencies and cities. A big challenge in managing solid waste in urban areas, are not only faced by large cities, but also by small cities, included solid waste management in regencies that have different geographical setting which consists of small towns spread out in the area of the regency. Increasing population growth and economic activities of small cities in Indonesia has caused increasing solid waste generation. For those small cities, municipal solid waste management is just started. Consequently, their capacity in solid waste management is still low. The development of the city change environment from rural areas to urbanized areas. People behaviour to solid waste and its management in the city level must be developed accordingly.

A literature review to solid waste management problems in regencies and small cities in Indonesia indicates that conventional approach in solid waste management were still practiced, while integrated solid waste management which is based on the concept of 3R (reduce, reuse, and recycle) have not been implemented well. For example, Sahil et al reported that in 2012, City of Ternate with total population of 172,559 was estimated to generate solid waste of 413 m³/day. However, only 214 m³/day or 52% of the waste were hauled to final disposal site, due to limited transportation facilities [2].

Yustikarini et al analysed trash handling in Magetan Regency which covered 63% of its urban areas. The regency was facing problems of increasing waste generation whereas landfill capacity is decreasing which implies the need to increase its treatment management. To solve the problem, they suggested to implement composting technology and 3R mechanism, which were expected to improve landfill optimization and efficiency, reduce landfill load, decrease pollution level, and add contribution from renewable energy [3].

Aziz et al reported that the level of solid waste management services in the West Pasaman Regency was only 9.13% of total solid waste generated. The reasons for this low level of service are still high...
levels of unserved solid waste, inadequate operational facilities and infrastructure for solid waste management, uneven handling of solid waste in service area coverage and the low practice of waste minimization and utilization. To improve the level of service, the author suggested the implementation of reduce-reuse-recycle approach in temporary solid waste handling station (TPS 3R) in domestic areas and improving solid waste handling in the Integrated Solid Waste Treatment Station (TPST) at the landfill site, which will reduce the solid waste volume taken into the landfill site up to 22.40% in 15 years [4].

Pertiwi et al mentioned that solid waste management system in the Badung River catchment area is still similar with other areas, which is divided into waste generation, storage, collection, transfer disposal and waste disposal. Attention of the community in this area to the integrated solid waste management systems, such as solid waste sorting and implementation of the 3R concept, are still very limited [5].

The purpose of this study is to assess the development of the municipal solid waste management (MSWM) in the City of Banjar, West Java Province. The City of Banjar represents small cities that is still improving its capacity in the municipal solid waste management, in which the system has been designed to implement the 3R approach. Preliminary data related to municipal solid waste management in the City of Banjar during the period 2017 – 2018 was taken from the National System of Solid Waste Management (Sistem Informasi Pengelolaan Sampah Nasional) of the Ministry of Forestry and Environment, Republic of Indonesia [6]. However, further study was done through a field visit, observation, and secondary data collection which will be explain in more detail in the methodology.

2. Methodology

Methodology of this study consists of five stages as follows: (1) Field study on MSWM in the City of Banjar; (2) Data analysis of monthly solid waste collected, sorted, and composted 2017-2018; (3) Evaluation of the effectiveness of MSWM; (4) Formulating strategy to improve effectiveness; and (5) Projection of solid waste generation, service coverage, sorting, and composting 2020-2030.

2.1 Field study on MSWM in the City of Banjar

The purpose of this field study is to understand the problems of solid waste management in the City of Banjar. It was done through observation of the daily activities, interviewing persons involved, and completing secondary data from the Department of Environment, who is responsible to MSWM in the City of Banjar. During the field study, researcher visited important site for the solid waste management such as temporary solid waste collecting sites (TPS) and final disposal site (TPA) to see how daily activities of solid waste management are practiced in this city. The other thing that researcher did at this field study is interviewing the people who involve directly or indirectly in municipal solid waste in City of Banjar, like the Government especially the Department of Environment, the coordinator of solid waste collecting sites in City of Banjar, person in charge for some solid waste collecting sites and landfill, and environmental activist, and others. During the visit, the Department of Environment also provided monthly operation data on solid waste management for the period 2017-2018.

2.2 Data analysis of monthly solid waste collected, sorted, and composted 2017-2018

The information on solid waste generation sources and composition was taken from National Solid Waste Information System (Sistem Informasi Pengelolaan Sampah Nasional) of the Ministry of Forestry and Environment, Republic of Indonesia [6]. Assessment to the effectiveness of solid waste management of the city was based on the monthly operational data on solid waste management, which figure out the performance of the MSWM in the City of Banjar in the period of 2017-2018. Comparing the monthly data of collected waste with potential solid waste generation provide an indication to the service coverage, while comparing the solid waste collected and hauled to final disposal site provide information on solid waste sorting. Comparing monthly compost production with organic waste content indicate effectiveness of the composting process in the temporary solid waste collection site (TPS).
2.3 Evaluation of the effectiveness of MSWM in the City of Banjar
To estimate service coverage of the municipal solid waste management in the City of Banjar, the monthly data of solid waste collected by the Department of Environment during the period of 2017 - 2018 was compared to the estimated solid waste generation by the total population of the city. The estimation of potential solid waste generation was based on Indonesia National Standard on Specification of Solid Waste Generation for Small and Medium Cities in Indonesia (SNI S-01-1993-03), which informed that solid waste generation for small cities are between 0.625 to 0.700 kg/capita/day [7].

2.4 Formulating strategy to improve effectiveness
A strategy to improve effectiveness of the solid waste management should be developed comprehensively based on the assessment to municipal solid waste management that included service coverage, solid waste sorting, and organic waste composting. Those three approaches are selected, due to the fact that present service coverage is still very limited, while the implementation of the 3R concept through reduce, reuse, and recycle in the ten TPS-3Rs have not worked well.

2.5 Projection of solid waste management in 2020-2030
To show the impacts of the municipal solid waste management strategy for the City of Banjar, estimated solid waste generation, service coverage, solid waste sorting, and organic waste composting are projected for the period of 2020 – 2030. Projection of the population growth was based on the rate of growth taken from the BPS Banjar City [8]. Estimation of solid waste generation was based on Indonesia National Standard on Specification of Solid Waste Generation for Small and Medium Cities in Indonesia [7]. Service coverage, solid waste sorting, and organic waste composting are expected to grow from present condition of 30%, 3%, and 3% to 80%, 70%, and 90%, respectively.

3. Municipal Solid Waste Management in the City of Banjar
City of Banjar is located in the eastern edge of the West Java Province, in the border with the Central Java Province. This city has been enacted as a city since 2003 with total population of 204,100 and population growth rate of 2.94% in 2018 [9]. The city consists of four districts, i.e. Pataruman, Banjar, Purwaharja, and Langensari.

![Figure 1. Locations of TPS-3Rs and final disposal site of cibeureum in City of Banjar](image-url)
Municipal solid waste management in the City of Banjar has been developed as a system that is expected to implement the 3R concept of reduce, reuse, recycle. As shown in figure 1, the ten temporary solid waste collecting sites (TPS) have been designed as TPS-3R, which can implement solid waste sorting and organic waste composting. However, only TPST-3R Cibodas and TPS-3R Bagusantri did those functions.

Figure 2. Daily operation of the municipal solid waste management in the City of Banjar

Figure 2 demonstrates the daily operation of the municipal solid waste management in the City of Banjar. Solid waste generation from the household sources are usually collected to TPS using tricycle motors or handcarts, while solid waste from traditional markets and business centres are collected in containers and directly hauled to final disposal site (TPA) using arm rolls. In some areas, solid waste from sources are collected using tricycle motors or dump trucks and directly hauled to TPA. Limited solid waste sorting was done in integrated temporary solid waste collection site (TPST) Cibodas, while composting of organic waste were done only in TPST Cibodas and TPS Bagusantri.

4. Results and Discussions

4.1 Solid waste generation and composition

Table 1. Solid waste generation from different sources in the City of Banjar 2017-2018 [6]

| Sources            | Solid Waste Generation (tons/day) | (%)  |
|--------------------|-----------------------------------|------|
| Households         | 14.43                             | 33.96|
| Office Building    | 0.28                              | 0.66 |
| Traditional Market | 15.25                             | 35.89|
| Business Center    | 9.25                              | 21.77|
| Public Facilities  | 2.91                              | 6.85 |
| Street Waste       | 0.38                              | 0.89 |
| **Total**          | **42.49**                         | **100.00** |

Table 2. Solid waste composition in the City of Banjar 2017 – 2018 [6]

| Type of Solid Waste | %  |
|---------------------|----|
| Organic waste       | 58.80 |
| Papers              | 10.20 |
| Plastics            | 17.06 |
| Metals              | 1.02  |
| Textile             | 2.06  |
| Leather             | 0.14  |
| Glass               | 2.81  |
| Others              | 7.89  |
| **Total**           | **100.00** |
Table 1 presents solid waste generation from different sources in the City of Banjar. Up to now, Department of Environment of the city has the capacity to handle solid waste of 42.49 tons/day, or 1,275 ton/month. The three main sources of the solid waste come from households (33.96%), traditional market (35.89%), and business center (21.77%). As a small city, economic activities in the City of Banjar are concentrated in traditional market and business center which become the dominant sources of solid waste. Solid waste collection from households, even though become the second dominant source, actually it is still limited, because the area of the city is in transition from rural to urban condition, where most people are still handling their own waste, such as burying in their land.

Table 2 presents solid waste composition of the city. It is realized that the dominant waste of the City of Banjar is organic waste (58.80%), while contribution of papers and plastics are 10.20% and 17.06%, respectively. The large amount of organic waste indicates that composting would be the best approach to reduce the amount of waste hauled to final disposal site, while papers and plastics are very potential for solid waste sorting and recycling. These activities, as an implementation of the concept of 3Rs in the municipal solid waste management, will reduce the amount of waste to be hauled to TPA, and has a potential extra income to municipal government in handling the waste.

4.2 Service coverage

Figure 3 demonstrates monthly service coverage during the period of 2017 – 2018. The monthly solid waste collected data was provided by the Department of Environment of the City of Banjar. The service coverage was calculated by comparing the monthly solid waste collected and the potential solid waste generation from the number of populations with an average of solid waste production for small cities are 0.625 – 0.700 kg/person/day, based on the SNI S-01–1993-03 [7]. This figure shows that monthly solid waste collected are fluctuating between 600 to 1,100 ton/month, while the service coverage is fluctuating between 16 – 30%.

![Figure 3. Service coverage of the solid waste management in the City of Banjar 2017-2018](image-url)
4.3 Solid waste sorting
Figure 4 indicates level of solid waste sorting in the City of Banjar during the period 2017-2018. The weight of solid waste sorting was calculated from the difference between the weight of solid waste collected from the sources and the weight of solid waste hauled to final disposal site. The percentage is then calculated from the above number divided by the weight of the solid waste collected. The above figure shows that the level of solid waste sorting in the City of Banjar is still very limited between 1.5% to less than 5% of the solid waste collected. It can be said that during the two years period, the average of solid waste sorted has dropped from 3.1% in 2017 to 1.8% in 2018.

![Figure 4. Level of solid waste sorting in City of Banjar, 2017-2018](image)

4.4 Organic waste composting
Figure 5 shows the amount of organic waste composted, which is also still very low. In the year 2017, in the average almost 2% of the organic waste was composted, but in the year 2018 it was declining to 0.6%. Limited use of the produced compost become a constraint in organic waste composting.

![Figure 5. Level of composting of the organic waste in the City of Banjar 2020-2030](image)
4.5 Population growth and solid waste generation

Figure 6 shows projection of the population growth and solid waste generation for the City of Banjar 2020 – 2030. With a population growth rate of 2.94% per year, number of population of the City of Banjar will grow from 209,000 in 2020 to 240,000 in 2030. Solid waste generation is estimated around 4,000 ton/month in the year 2020 is expected to grow to 4,500 ton/month in the year 2030. From figure 3 and 4, it should be noted that the monthly solid waste collected during the period 2017 – 2018 was fluctuating between 600 – 1,100 ton/month, which means that the service coverage is still lower than 30%.

Figure 6. Population growth and solid waste generation for the City of Banjar 2020- 2030

4.6 Strategy to improve effectiveness

From the above analysis, it is realized that effectiveness of the municipal solid waste management in the City of Banjar is still very low. To improve the effectiveness, it is proposed three main strategies: (1) Solid waste sorting at the sources, (2) Organic waste composting in TPS-3R, and (3) Increasing service coverage. These three strategies were based on the fact that municipal solid waste management in the City of Banjar actually has been designed to implement the 3R concept. It means that the three strategies are intended to strengthen the capacity of the Department of Environment in managing solid waste by involving communities.

Solid waste sorting at the sources will reduce the amount of solid waste collected by the municipal solid waste management. Every types of sources, either they are households, traditional markets, schools, offices, or business centers are expected to do solid waste sorting, to get valuable resources such as plastics and papers, and reduce the amount of waste up to 27.26% that should be collected to TPS-3R. To encourage people in doing solid waste sorting, the concept of Recycle Bank (Bank Sampah) should be introduced. Through the development of Recycle Bank, papers and plastics are collected to the TPS-3R who acts as the recycle bank.

If papers and plastics have been sorted at the sources, the residual waste which mostly consists of organic waste (58.8%) are then collected by the community based solid waste management to TPS-3R. It is suggested that TPS-3R become the centers for organic waste composting, since they have been designed to implement this task. City government of Banjar is expected to support community based solid waste management by facilitating them with tricycle motors or handcarts. Organic waste composting in TPS-3Rs will significantly reduce the amount of garbage that should be hauled to final disposal site (TPA). Concentrating organic waste composting in TPS-3Rs will provide at least three
advantages, i.e. (i) the operation will be more efficient, (ii) it will open more jobs, and (iii) the quality of the compost can be well maintained.

Strengthening the role of TPS-3Rs as the Recycle Bank and center for organic waste composting will increase the income of the City Government which can be used to increase service coverage. The increasing available budget can be used to support community based waste management by facilitating them with tricycle motors for collecting organic waste to TPS-3R. This facility can also be used to collect sorted materials from the communities, such as plastics and papers. To separate sorted materials from other waste, it should be done in different schedule, say once a week on Saturdays. Strengthening collaboration between the Department of Environment who is responsible for solid waste management in the city level with communities based solid waste management in each sub-districts level, will increasing service coverage from current level which is still less than 30% of the waste generated.

4.7 Target of composting
Figure 7 presents the target of composting for the City of Banjar during the period 2020 – 2030. The present level of composting which is only 3% of the organic waste is gradually increased to 90% in the year 2030. Combined with the increasing service coverage, the monthly production of compost from the City of Banjar will exponentially increase from 35 ton/month in 2020 to 1,905 ton/month in 2030. This increment of compost production should be followed by marketing strategy to utilized the compost, either to local farmers, plantation, as well as the city gardens and urban farming activities. Collaboration with fertilizer manufacture should be developed to improve the quality of the compost, and its distribution.

![Figure 7. Target of organic waste composting for the City of Banjar, 2020 – 2030](image)

4.8 Target of solid waste sorting
Figure 8 presents the target of solid waste sorting for the City of Banjar for the period 2020 – 2030. The present level of solid waste sorting which is only 3% of the collected waste is gradually increasing to 70% in the year 2030. Combined with the increasing service coverage, the weight of solid waste sorted should be gradually increased from 16 ton/month up to almost 700 ton/month in the year 2030. Increasing capacity of the Department of Environment in handling this recycle program will also be followed with increasing income. Solid waste sorting in sources combined with their collection by officers from TPS-3R will motivate people to get some financial benefits.
4.9 Residual solid waste hauled to final disposal site

Figure 9 demonstrates the results of comprehensive efforts to improve effectiveness of solid waste management in the City of Banjar for the period of 2020 to 2030. Enlarging service coverage up to 80%, combined with increasing solid waste sorting up to 70% and organic waste composting up to 90% will result the decrease on the amount of residual solid waste that should be hauled to final disposal site. The weight of residual solid waste hauled to FDS will increase from 1,129 ton/month in 2020 to 1,440 ton/month in 2026, but then decrease to 1,008 ton/month, due to the increase amount of solid waste sorting in the sources and organic waste composting in TPS-3R. It should also be noted that solid waste sorting will provide financial benefit to people, while solid waste composting and the development of Recycle Bank will increase the income of the Department of Environment who is responsible for the solid waste management in the City of Banjar.

5. Conclusions

From the above analysis, it can be concluded that MSWM in the City of Banjar has been designed to implement to concept of 3R, however it has not been completely implemented. Service coverage of the MSWM in 2018 is estimated 30%, solid waste sorting 3%, while solid waste composting 3% of the
organic waste. It means that effectiveness of the MSWM in the City of Banjar is still very low. To improve effectiveness, three strategies should be implemented, solid waste sorting at sources, organic waste composting in TPS-3Rs, and increasing service coverage. Setting the target in 2030 for service coverage (80%) will increase the capacity of MSWM to 3,600 tons/month. Combined with solid waste sorting (70%) and organic waste composting (90%) will significantly decrease residual waste hauled to final disposal site up to 1,008 tons/month in 2030. In summary, improving effectiveness will result in sustainable solid waste management in the City of Banjar.

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