Economic Valuation of Externalities on Organic Waste Processing in Makassar City, Indonesia by Regarding Applicable Scenarios

Irwan Ridwan RAHIM[1], Hirofumi NAKAYAMA[2] and Takayuki SHIMAOKA[2]

[1]Faculty of Engineering, Hasanuddin University
A visiting researcher on Faculty of Engineering Kyushu University
(744 Motooka Nishi-ku, Fukuoka City, Japan, 819-0395)
[2]Faculty of Engineering, Kyushu University
(744 Motooka Nishi-ku, Fukuoka City, Japan, 819-0395)
Corresponding author: irwan@doc.kyushu-u.ac.jp

Municipal solid waste in developing countries of south east asia is composed of 50-90% organic waste. In Makassar city, Indonesia, food waste is the primary component in organic waste, amounting until 80%. Waste management by open dumping has resulted in a variety of prejudice effects on the environment, human health and economics.

The purpose of this study is to investigate external (negative and benefit) cost for processing organic waste separately, including existing open dumping, composting, biogasification, and energy recovery as part to determining short, medium and long-term sustainable strategy municipal solid waste management in Makassar city.

After analyzing the external costs of impact solid waste processing activity on community health, environment, and benefits by simplified life cycle assessment and replacement or substitute cost method.

Existing open dumping activity released highest external negative cost with US$ 183/ton solid waste. In contrast, biogasification released the least external negative followed by energy recovery and composting, from emission to water and soil points of fiew the biogasification still the external cost and composting has the greatest benefits compared to other scenarios.

These result revealed that amongst the waste management scenario studied, biogasification was the best scenario for medium-term strategy plan, for a short-term converting existing open dumping to a semi aerobic landfill will be the best scenario and recovery energy from landfill by incineration can be the best scenario for long-term strategy caused reduction of greenhouse gas emission and lowest negative externalities.

Key Words : economic valuation, organic waste processing, Makassar city

1. INTRODUCTION

Municipal solid waste in developing countries of Southeast Asia is composed of 50%-90% biogenic waste (Inanc B., Idris A. et al., 2004) In Makassar , Indonesia, food waste is the primary component in biogenic waste. Waste management by open dumping, which is a common practice in developing countries of Southeast Asia, no exception in Makassar, although provision has been made in the soil layer of waste disposed but not consistently has resulted in variety of adverse effects on the environment and human health which will lead to economic and welfare issues.

There are some impacts that occur as: bad odour, flies breeding, rodents pests, leachate infiltration into the soil body and the most important impact, greenhouse gas (GHG) emission from the decomposition of biogenic waste, is associated with climate change. Several methods have been applied for reducing GHG emissions, which is used as an example by many developing countries is Japan's 'Reduce, Reuse, Recycle' policy also known as the '3Rs', is an integral part of the country's management system. specialized in several major cities that had established economic, advanced waste incineration technology has been developed with the aim of energy recovery, and organic waste reduction technology is the predominant choice of most agencies (Sakai S., Yoshida H. et al., 2001)

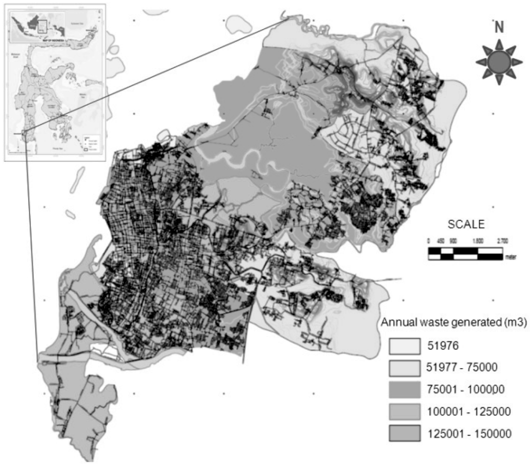


Fig.1 Makassar City Map and annual waste generated

In Singapore 90% of wastes incinerated at 4 incineration plants so only 10% of wastes disposed of at the off-shore Semakau sanitary landfill.

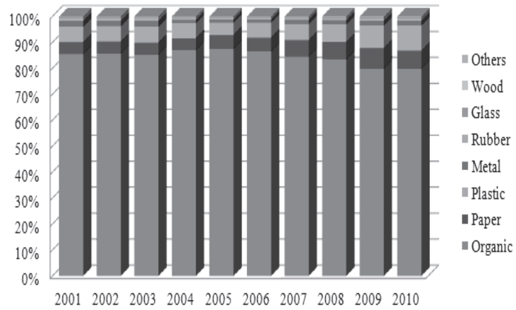
In addition to the negative impact and costs that must be spent to manage the municipal solid waste (MSW), behind it turns out there are benefit to be gained from an appropriate management strategies, can directly benefit from sales and use compost from MSW or indirect benefit which is the replacement or substitution benefit of the strategy is better than ever.

The purpose of this study is to investigate external (negative and benefit) cost for processing organic waste separately, including existing open dumping, composting, biogasification, and energy recovery as part to determining short, medium and long-term sustainable strategy municipal solid waste management in Makassar city

2. MATERIALS AND METHODS

Makassar is a provincial city of south Sulawesi. The city (Kota) has an area of 176 km2 where the population number was 0.95 million (1990) and 1.35 million (2010). The city has been growing at a rate of 1.7 % yearly, and unofficial forecasts suggest, that by 2015 approximately 1.50 million people will live in the city. Similar to big cities in Java and other provincial cities in Indonesia, Makassar faced pressing problems on high quantity of solid waste. In 2010, solid waste is generated approximately 3,900 m^3/day or 871 tonnes/day within the city, and 80 % could be handled by cleaning agency (Dinas Kebersihan and Keindahan). The remaining waste of 12% have been successfully recycled by scavengers and composting efforts then 8% is unsolved which most common

Table 1 Makassar City Solid Waste Characteristic



means of coping with this waste is to burn it or dump it on unused land or in rivers and canals. Even the percentage is small, however, this has serious environmental consequences, such as local air pollution and increased incidence of flooding. Makassar municipal waste characteristics are dominated by organic waste, the analysis of the data shows from 2001 to 2010 are in the range of 80% -87% (Table 1). Under these conditions then drafted a strategy that concentrated on organic waste management by dividing three sustainable strategies, short-term strategy from 2013-2018, the medium strategy until 2004 long term to 2030, subsequently drafted an applicable scenario alternative for organic waste processing that still rely on the only landfill by open dumping (Tamangapa Landfill), based on information obtained from Makassar city sanitation departments the applicable scenarios shown in table 2.

In this study, assessment strategy chosen by the smallest accumulated external cost, are environmental costs, health costs and social costs without taking into account the economic costs (initial, operational and maintenance costs, residual value of asset, as well as closure and post closure cost of landfill).

Table 2 Applicable scenarios on organic solid waste processing

No.	Description	Scenarios
1	Open dumping with no option	BAU
2	1 + Landfill gas collection	1
3	2 + Energy recovery by gas engine	2
4	Semi aerobic digestion	3
5	4 + Landfill gas collection	4
6	5 + Energy recovery by gas engine	5
7	Incineration with no option	6
8	7 + Energy recovery by steam turbin	7
9	5 + Integrated Composting	8

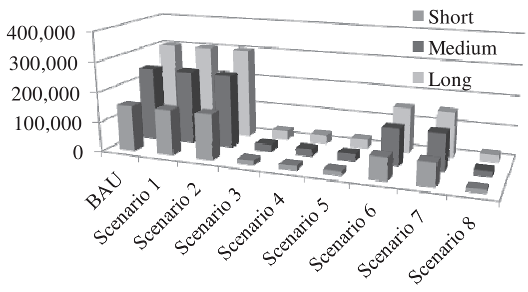


Fig.2 NPV ($, 2013-2030) environmental cost (contaminating of soil and groundwater by leachate)

3.ANALYSIS

Environmental Cost

Cost of contaminating of soil and groundwater due to leakge of leachate is external (environmental) costs in this study generally from landfill disposal or composting facility cause the infiltration of precipitation and surface water into landfills coupled with the biochemical and physical breakdown of waste produce a liquor or leachate with a high organic and inorganic content. The leachate causes various adverse impacts.

So far never been studies contain valuation results for emissions to soil and water in Indonesia particularly so only a small part of these base valuation on a damage cost approach. The large majority of the study results is based on approximate valuation approaches such as control cost and linked environmental values. The results of calculation of external costs for soil and water contamination by leachate in landfills and soil derived from averaging the results of research conducted by DEFRA in 1993 and 1997, is: €0-1.54 per tones waste landfilled and €0-1.09 per tones waste landfilled. Research result from several major cities in the UK are then converted to Indonesia conditions, particuraly of Makassar city by comparing the value of the costumer price index (CPI) between the two countries. Environmental costs by contaminating of soil and groundwater due to leakge of leachate in applicable scenarios can be seen in gigure 2.

Furthermore environmental cost obtained from a simplified life cycle assessment was conducted to estimate GHG emission and energy from each component of biogenic waste treated with additional scenarios. Net GHG emissions from the treatment of each biogenic waste waste type were estimated on the basis emission-derived waste, electrical and fuel consumption of treatment facilities, and energy recovery from biogas used for electricity production. Net environmental costs in this case is the difference between GHG emissions from each applicable scenario the GHG emissions of the BAU is multiplied by the estimated per tonne CO_2 price in the world market as € 3.90 or $5,00/tones CO_2 eq. Price per ton of CO_2 is assumed as WTP (willingness to pay) value of the world community to the impact of environmental damage that can be caused by CO_2 emissions. Figure 3 shows the result of net GHG emission cost, transforming the opendumping (BAU) into semi-aerobic system was the most less cost impact and could reduce up to 57%, also 10% for soil layering, 28% for gas collection system and 31% for energy recovery shown in figure 3.

Social Cost

In the analysis of social costs based on the cost of disamenity of communities that live around the organic waste treatment facilities, yet the presence of processing facilities in addition to composting and landfill in Indonesia so that there is no data about the cost of any disamenity, this may instantly research data on the social costs of converting from Netherlands condition, social costs for waste incineration or waste to energy (WTE) facility amount to € 97 per tone and € 58 per tonne of landfilled waste (Dijkgraaf and Vollebergh, 2003). Even though the environmental cost of incineration is somewhat lower than that of landfilling and composting, it does not outweigh the much larger private cost difference. In other words, even in a densely populated country such as the Netherlands, incineration seems to be a

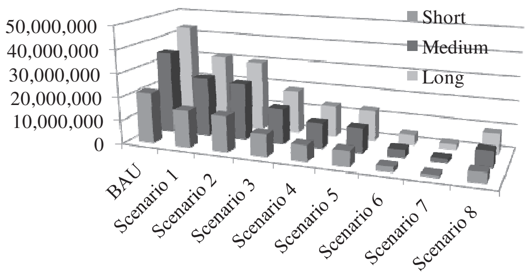


Fig.3 NPV ($, 2013-2030) environmental cost (GHG emission impact)

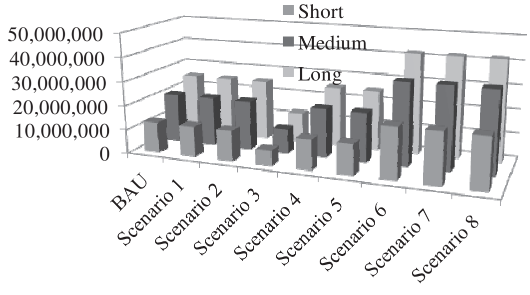


Fig.4 NPV ($, 2013-2030) social cost (disamenity living close to organic waste processing facility

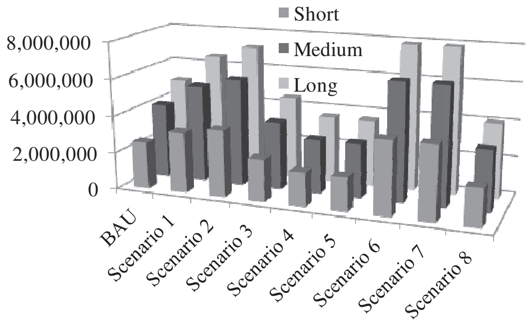


Fig.5 NPV ($, 2013-2030) health cost (6 major disease that plagued scavengers working and society around Tamangapa landfill)

rather expensive option for disposing of waste. This remains true even if one allows for the joint production of energy and materials, so estimate clearly rejects the hypothesis that WTE plants signal lower social cost than landfilling. In other words, the current policy preference for incineration is not supported by social cost data in a country where this support is most likely. This preference for incineration probably originates in the overall environmental cost savings, because incineration without recovery generates much higher environmental costs than the modern landfill. Net savings are far from substantial and only exist for best performing WTE plants that also recover materials on a considerable scale. Traditional incineration plants without energy and materials recovery are strongly outperformed by modern landfills like semi aerobic type.

Health cost

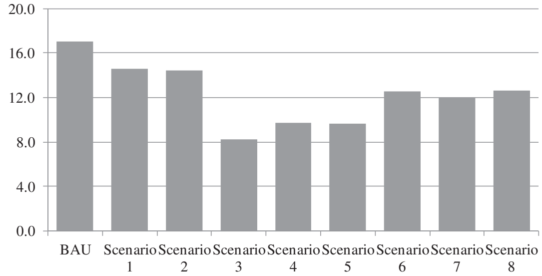
In general, it is easier to value environmental health effects using the cost of illness approach when the illness is relatively short, discrete, and does not have negative long-term impacts (Harrington et al., 1989; Turner et al., 1993). Pollution caused by organic waste can cause disease impact gives rise to short and discrete epidemic diseases, like Upper Breathing System Infection (ISPA), Skin and sub cutan tissue disease, Diarrhea, Skin disease caused by allergic, Digest sore and Scabies) that do not have negative long-term impacts, there are 6 major disease that plagued scavengers working and society around Tamangapa landfill, data obtained from the ERM 2007 and after confirmed by the management of Tamangapa landfill no change parameters and values of the diseases arising from activities landfill Tamangapa. Upper Breathing System Infection (ISPA) disease with 453 case per 1,000 person on first rank and on the last rank was scabies disease with 31 case per 1,000 person. Particularly ISPA disease, based on society information not only impact to the scavenger community that work into landfill but spread to almost all sub distric Tamangapa but the case of other diseases confined to the public or scavengers working in the area landfill. although the cost of a standard treatment in public health care is free, but based on information from the community health center staff (PUSTU) of Tamangapa that the cost of treatment ranges between IDR50,000 to IDR70,0000 depending on the type of illness and the likelihood of a person contracting about 3 times a year.

Benefit

Using replacement or substitute cost method, benefits are calculated based on comparison of each applicable scenario in an effort to replace the electrical energy derived from the burning fossil (fuel or coal). Waste incineration has been a method for dealing with waste sine the 20th century (Denafas and Jager, 2007). While the original motivation for this practice was likely due to the simple fact that combustion reduces the amount of waste one has to deal with, today the energy generated from incineration offers a convincing argument for this type of waste disposal. The energy recovered from incineration in many cases is harvested as steam for heating purposes while many facilities convert it to electricity and sell it to power companies who add it to the grid. Some research has reported from Europe and America show the potential energy recovery from incineration of mixed waste organic in reaching, US$ 6.88–23.60/ton waste (CSERGE et al. 1993), US$ 10.99–15.04/ton waste (Powell and Brisson, 1994), but for Makassar case which have a high water content assumed to be only 40% of what can be obtained from cases in europe and American.

As waste decomposes through anaerobic processes in landfill, methane is one of the main by-products. Methane is also twenty times more effective as a GHG than CO_2, so its impacts on climate change should not be underestimated (Themelis,

Table 3 Net external cost ($/ton waste)



Kim, and Brady, 2002). As a result, capturing methane emitting from landfills and using it for energy not only reduces its contribution to climate change, but also provides an alternative form of energy; methane can be burned as method of heating or electricity generation, where US$ 0.72–3.07/ton waste (CSERGE et al. 1993), US$ 1.29–1.79/ton waste (Powell and Brisson, 1994).

4.RESULTS AND DISCUSSION

1. Cost of contaminating of soil and groundwater due to leakge of leachate is external (environmental) costs in this study the largest cost are BAU conditions, 1st scenarios and 2nd scenarios with net present value (NPV,2013-2030) of $303,181 and the smallest are 3rd, 4th and 6th scenarios of $30,318 because assumed almost all organic waste will be processed at the incineration and leachate generally from landfill disposal or composting facility cause the infiltration of precipitation and surface water into landfills coupled with the biochemical and physical breakdown of waste produce a liquor or leachate with a high organic and inorganic content. Furthermore environmental cost obtained from a simplified life cycle assessment to estimate GHG emission and energy from each component of biogenic waste treated with additional scenarios. The largest cost of BAU conditions with NPV of $43,311,508 and the smallest is incineration with no option + Energy recovery by steam turbin (7th scenario) $2,165,575.
2. In the analysis of social costs based on the cost of disamenity of communities that live around the organic waste treatment facilities, yet the presence of processing facilities in addition to composting and landfill in Indonesia so that there is no data about the cost of any disamenity this may instantly research data on the social costs of converting from Netherlands condition. Scenarios 6th,7th and 8th are the largest cost with NPV of $42,016,163 and the smallest is semi aerobic digestion (4th scenario) $12,560,337.
3. In general, it is easier to value environmental health effects using the cost of illness approach when the illness is relatively short, discrete, and does not have negative long-term impacts. Pollution caused by organic waste can cause disease impact gives rise to short and discrete epidemic diseases, like Upper Breathing System Infection (ISPA), Skin and sub cutan tissue disease, Diarrhea, Skin disease caused by allergic, Digest sore and Scabies) that do not have negative long-term impacts, this study the largest cost are 6th and 7th scenario with NPV of $7,885,622 and the smallest is Semi aerobic digestion with Landfill gas collection and Energy recovery by gas engine (6th scenario) $3.609,439
5. Benefit Using replacement or substitute cost method, benefits are calculated based on comparison of each applicable scenario in an effort to replace the electrical energy derived from the burning fossil (fuel or coal). Comparative benefit of energy recovery strategy by incineration or gasification to methane in landfill gas utilization reached 8 times more high.
6. After analyzing the external costs of impact solid waste processing activity on community health, social, and environmental by simplified life cycle assessment and replacement or substitute cost method. Existing open dumping activity released highest external negative cost with US$ 17.0/ton solid waste. In contrast, biogasification into main selection because released the least external negative US$ 9.6/ton followed by landfill gas collection.

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