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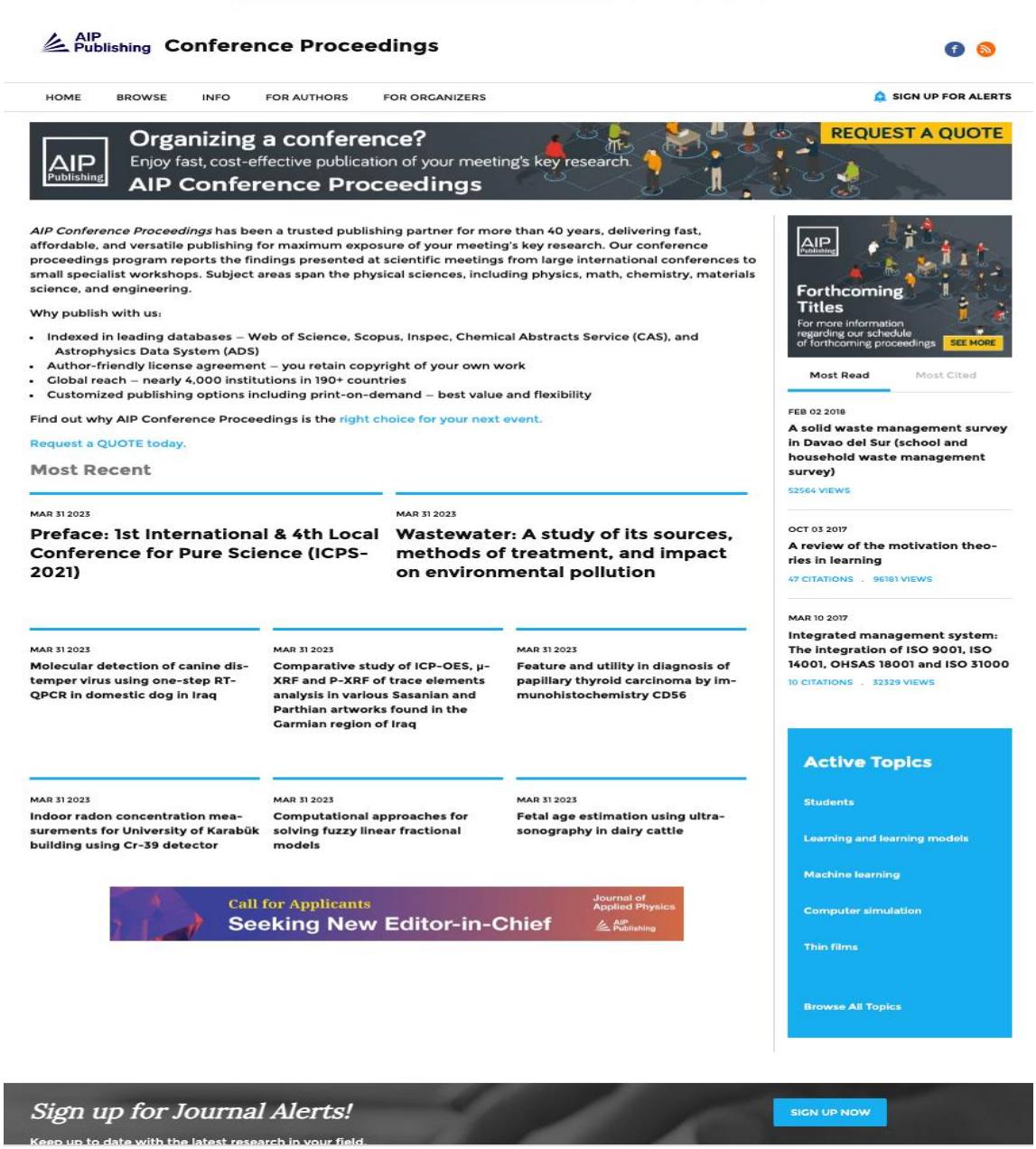

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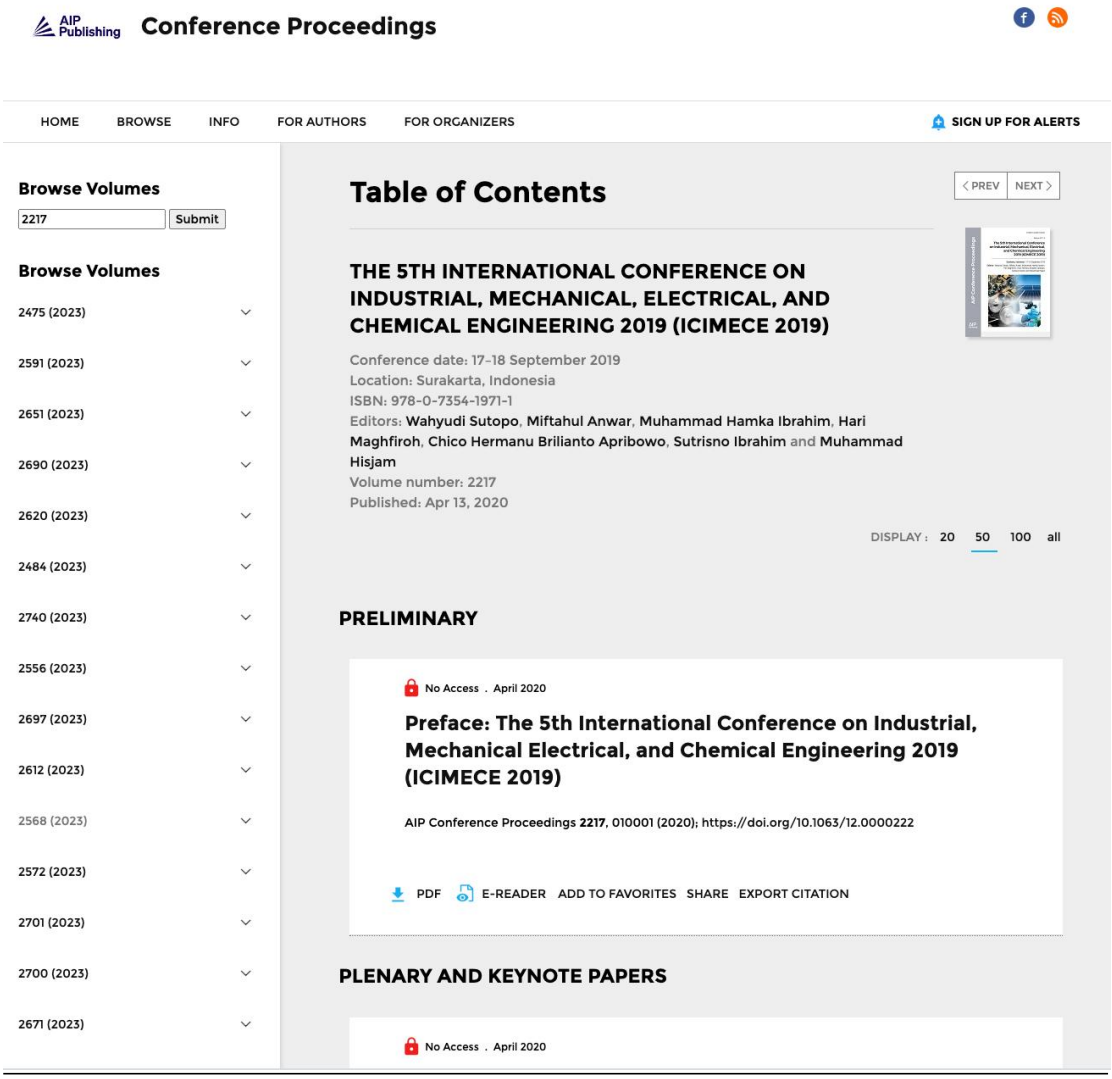

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Municipal solid waste logistics management: A study on reverse logistics

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ABSTRACT

Municipal solid waste problem is a complicated problem, due to its impacts in economic, social and environmental aspects. Municipal solid waste increases not only in weight and volume, but also in the composition, which influences degradation in the quality of air, water, the environment and public health, affecting climate change, and even cause of disasters such as floods and fires. Municipal solid waste problem is a multi-discipline problem which involves many stakeholders that needs to be considered simultaneously. Many analytical approaches have been done since the collecting method, separating method, transportation, disposal and/or 3 R (reduce, reuse, recycle) and other related operations. This paper also compares the implementation of the municipal waste management that has been conducted in some developing countries with different characteristics and focuses on using the reverse logistics approach to solve municipal solid waste problems. The alternative that can be done is to use the concept of a sustainable closed loop system integrated solid waste management paradigm that also applies shared responsibility.

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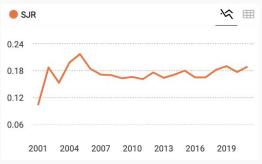

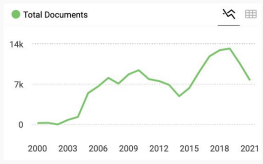

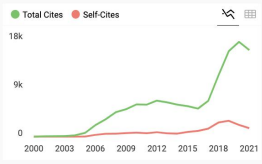

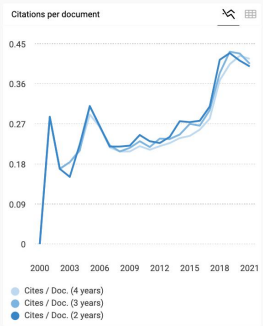

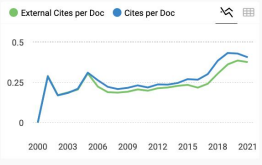

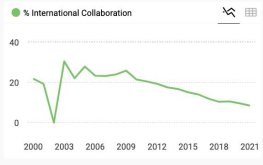

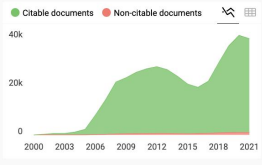

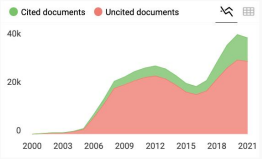

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Annie Purwani, Muhammad Hisjam, and Wahyudi Sutopo

Municipal Solid Waste Logistics Management: a Study on Reverse Logistics

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Abstract. Municipal solid waste problem is a complicated problem, due to its impacts in economic, social and environmental aspects. Municipal solid waste increases not only in weight and volume, but also in the composition, which influences degradation in the quality of air, water, the environment and public health, affecting climate change, and even cause of disasters such as floods and fires. Municipal solid waste problem is a multi-discipline problem which involves many stakeholders that needs to be considered simultaneously. Many analytical approaches have been done since the collecting method, separating method, transportation, disposal and/or 3 R (reduce, reuse, recycle) and other related operations. This paper also compares the implementation of the municipal waste management that has been conducted in some developing countries with different characteristics and focuses on using the reverse logistics approach to solve municipal solid waste problems. The alternative that can be done is to use the concept of a sustainable closed loop system integrated solid waste management paradigm that also applies shared responsibility.

INTRODUCTION

Municipal solid waste is a problem that faced by every country, whether it is a poor country, a developing country or even a developed country. Data from World Bank's Urban Development and Local Government [1] there is an increase in the average solid waste in the world produced by everyone. In 2002, the solid waste produced by each person was around 0.64 kg/capita/day, whereas in 2012 the solid waste generated was 1.2 kg/capita/day and it is estimated that in 2025 it will be 1.42 kg/capita/day. This is also reinforced by the United Nations Environment Program that the annual increase in global solid waste reaches 2 million tons. Besides the explosive growth in the weight and volume, the composition of the municipal solid waste is becoming more and more complex [2]. That is why municipal solid waste becomes very important to be discussed, explored and researched.

Poor management of municipal solid waste will result in unsettled solid waste. Municipal solid waste have induced severe degradation of air quality, water quality, and public health such as respiratory diseases, diarrhea and dengue fever, and also have contributed to climate change (for example, the release of methane gas). To avoid these things it is necessary to find the best solution. Many researchers have conducted municipal solid waste studies. The best solution is a solution that suits the existing environmental conditions. The search for solutions begins with gathering recommendations from researchers to then be selected in accordance with the existing environmental conditions to be implemented and ultimately evaluated for their ongoing achievements.

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LOGISTICS MANAGEMENT

Logistics processes are in general defined as the flow of information and materials [3]. Flow information from customer to plan and from plan to supplier. Material flow from supplier to plan and from plan to customer. When logistics process is added with purchasing, procurement, capacity planning, supply planning then it is referred as supply chain process. The most important activity in the supply chain is how to balance supply and demand. On the other hand, environmental legislation requires companies to be responsible for their waste, while the cost of waste disposal is increasing. When forward logistics processes are expanded by adding reverse logistics processes, so they become new models that related to closed loop supply chain [3].

The Brazilian government requires each company to be responsible for managing the products it has produced (reverse logistics). The company is asked to take responsibility from the product design, processing the residue including e-waste, and determining who will be involved in the turned supply chain. The management of actors is carried out through constitutional sectoral [4]. Reverse logistics includes several logistics activities from managing used products that are no longer needed by the user to products that can be used again or can be re-marketed [5]. Another thing to consider in reverse logistics is related to the physical transportation needed to bring used products from the end user back to the manufacturer. So, aspects of distribution planning become very necessary to consider. Before the next will go through a transformation process to process so that the used product can be reused and has a sale value.

Reverse logistics has not only expressed the company's global concern for sustainable development, but has also influenced the stated organization at a strategic level to reduce negative environmental impacts. Such impacts exist throughout the supply chain: from logistics management of raw materials to the final product to be used by customers. Therefore, the supply chain must ensure the reduction of waste in the production process of their goods by designing environmentally friendly production systems, managing secondary markets, and meeting environmental standards. Likewise, management of materials or products returning to the supply chain also involves environmental impacts, which is their own challenge. To meet this challenge, reverse logistics (RL) has become a strategy that consists of a series of operations regarding the proper assessment and allocation of solid waste (SW), after the product completes its life cycle [6].

MUNICIPAL SOLID WASTE MANAGEMENT

Solid waste management (SWM) has become an issue of increasing global concern as urban populations continue to rise and consumption patterns change [7]. Population increases occur throughout the world, not only in developing countries, but also in developed countries. It's just that the increase in the population of developed countries is not as high as developing countries. But, progress will affect lifestyle patterns which of course will affect the amount of consumption. Increased consumption will increase solid waste. As stated by Lino that increase in world population, technological innovation, and profound changes in lifestyle habits and patterns in recent decades have stimulated consumption with strong reflexes to increase solid waste [8].

Solid waste based on the definition of the Republic of Indonesia Law on waste management is the remnants of daily human activities and or solid natural processes [9]. The definition of the US EPA (United States Environmental Protection Agency) waste, food waste, institutional waste, commercial waste, industrial waste, construction waste and sanitation waste [10]. This solid waste needs to be managed so as not to cause problems. Given this importance, some countries include urban solid waste management as a national regulation. Urban solid waste management based on RI Law is a systematic, comprehensive and sustainable activity that includes the reduction and handling of waste. Meanwhile, according to the US EPA is a complete system for the reduction of waste, collection, composting, recycling, and disposal required [11].

Increasing urban solid waste is an interesting topic to discuss because it will involve many scientific disciplines and from many aspects of the approach. The approach from the management side, both the government and the private sector, from the type of solid waste, as well as from the collection process. More discussion was approached in terms of management in general with limited scope in cities and countries [6], [7], [9]–[15]. Another approach in terms of types of solid waste, such as plastic [12]–[16], glass [17], electronic equipment [4], as well as desktops / laptops [18]. While in terms of solid waste collection from routing [19]–[21], location determination and number of locations [22], [20], [23], [24].

Several papers on urban solid waste management view the management system as a problem related to the environment [4], [8], [11], [18], [19], [21]. Reference [8] views municipal solid waste as not only considering the

environment, but also considering economic aspects. Meanwhile, [4], [11], [19] in their research added consideration of social aspects, so that the management system will be seen from environmental, economic and social aspects. It is also different from [13] and [10] which describe municipal solid waste with operational and tactical approaches.

Reference [20] based on [10] research gave rise to the concept of integrated solid waste management. Reference [10] uses the solid waste management paradigm to make decisions related to location determination and facility allocation using linear mixed-integer linier programming (MILP). Reference [20] uses MILP to make decisions in a widely paradigm Integrated Solid Waste Management (ISWM). The ISWM paradigm is defined as a complete waste reduction, collection, composting, recycling, and disposal system where an efficient ISWM system considers how to reduce, reuse, recycle, dispose, and manage waste to protect human health and the natural environment.

The ISWM paradigm (see Figure 1) with the addition of the word integrated will have a wider and more complex impact. Based on several previous papers, integrated will involve many parties, many fields and many characteristics. Reference [8] describes ISWM based on the type of waste from the process side from generation, composition, collection, recycling, thermal process, bio digestion and composting. Reference [7] mentioned that ISWM involved three areas of environmental friendliness, social acceptability, and economic reasonability. While reference [18] described ISWM from the parties involved, informal sector, formal sector and policy.

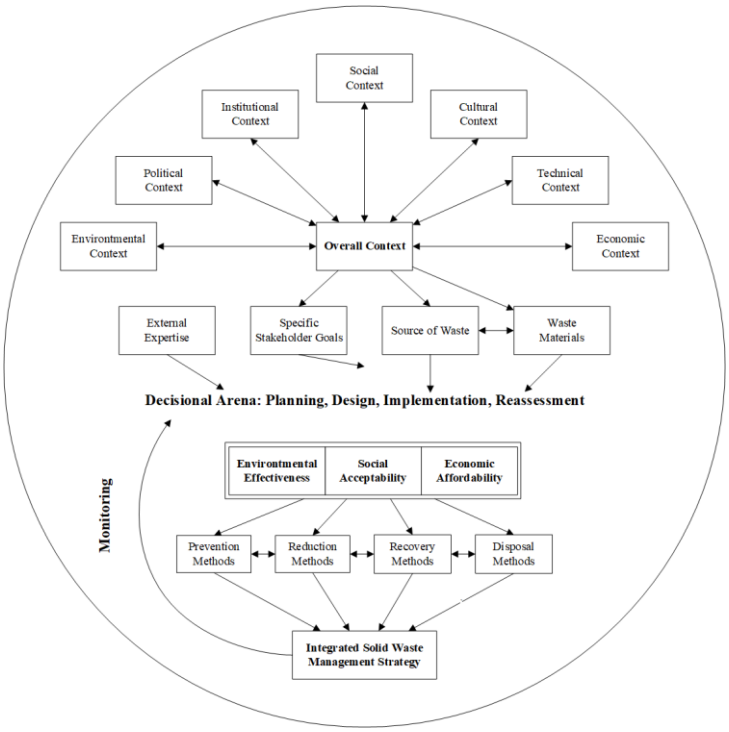

FIGURE 1. Integrated Solid Waste Management Paradigm
Source: Reference [7]

ISWM with a three approach is actually more able to accommodate the involvement of various parties or stakeholder and the management process. ISWM also focuses on the integration of the many interrelated processes and entities that make up a waste management system [4]. Each approach will consider simultaneously to get the optimal method for prevention, reduction, recovery and disposal. To reduce environmental impacts and drive costs down, a system should be integrated (in waste materials, sources of waste, and treatment methods), market oriented (i.e. energy and materials have end uses), and flexible, allowing for continual improvement. ISWM systems are considered simultaneously to specific community goals by incorporating stakeholders' perspectives and needs; the local context (from the technical, such as waste characteristics, to the cultural, political, social, environmental, economic and institutional); and the optimal combination of available, appropriate methods of prevention, reduction, recovery and disposal. So that the output can be obtained by strategic action, environmental action, economic action and social action.

The United Nations Environment Program (UNEP) publishes guidelines for urban or city waste management called the Global Waste Management Outlook (GWMO). GWMO broadly follows the international concept known as 'waste'. The GWMO makes a holistic approach, environmental management will work optimally if the policies and regulatory controls, and the agencies responsible for each, are integrated across pollution control (into air, water and land) and waste management. GWMO views that waste can occur throughout the life cycle of materials and products. This includes mining and extracting (extraction); agriculture and forestry; industry (materials, parts and products); construction and demolition; trade and institutions (distribution and service); and consumption (household). The main analytical tools used in the GWMO, including integrated sustainable waste management [2].

The GWMO aims to be relevant to all countries wherever they fall on this spectrum of current drivers and regardless of their state of development in terms of waste and resource management. It aims to provide assistance in identifying and implementing the appropriate policies and actions for the next steps in developing their own specific waste and resource management systems.

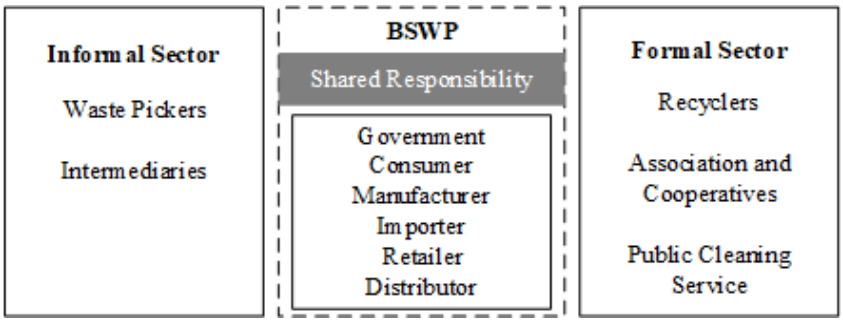

FIGURE 2. Agents of Reverse Logistics Systems According to Brazil Environmental Legislation
Source : Reference [18]

The Brazilian solid waste regulations promote the inclusion of recyclable material pickers by hiring the cooperatives and associations legally constituted to implement reverse logistics and the waste management plan, as shown in Fig. 2. It also shows the involvement of many parties or stakeholder in management Brazil Solid Waste Policy (BSWP). Cooperatives are formed with the aim of formalizing scavengers, so as not to be pressured by intermediaries or used goods traders, who are sometimes very strong or dominant in negotiations or greater bargaining power [18]. All agents play a role and have the responsibility in achieving government objectives.

Active participation from stakeholders or agents called public-private partnerships (PPP) is needed in the implementation of the GWMO. The government regulates incentives for PPP involvement in both the public and private sectors. Benefits for the public sector to adopt PPP include: (1) In the previous period MSW spent a large portion of the city budget, while PPP could offer substantial savings on this expenditure; (2) PPP can help overcome the problem of chronic budget deficits, difficulties in adding labor, and limitations in meeting public demand; and (3) for the public sector the involvement of PPP can prevent corruption and political influence, which hinders the efficient delivery of services [2]

Many analytical approaches [13], [14], [25]–[27] have been done since to collecting method, separating method, transportation, disposal and/or 3R and other related operation. There have been at least three categories of approaches, conceptual framework, statistical analysis and mathematical modelling. Research using frameworks, [15], [20], [22], [28], [29], while research using stati.stical analysis [25],[8], [21], [30], [31] and researchers using mathematical modelling, among others, [22], [27], [29], [32]–[34]. Other approaches used by researchers are based on the type of waste, such as dry waste, wet waste, solid waste ([28], [32], [35]), paper, desktop / laptop ([18]), electronics ([4]), glass ([17]), plastic ([13]–[15], [32]) , industrial hospital etc.

METHOD

The study of municipal solid waste began by collecting references and documents between 1990 and 2019. The collection was carried out using a search engine, to search for papers with the topic of municipal solid waste. References and documents obtained were then reviewed, based on topics, objects, methods, research locations from titles and abstracts. However, if there is not enough information in the title and abstract, a search is carried out to the full text. After the collection is complete, the next step is to arrange all references and documents using the published category year, author, title, abstract, method and results.

RESULT AND DISCUSSION

The integrated solid waste management paradigm with closed loop system becomes a complete paradigm whose hope is to produce an effective and optimal management of solid waste. Table 1 describes the data collection rate and disposal method [1]. Not all data are available. The Urban Development and Local Government Unit of the Sustainable Development Network in a global review of solid waste management explores and researches on urban waste management around the world. This effort is intended to alleviate poverty, foster a deeper understanding of sustainable urban environments and improve the quality of life of the people.

Some developed countries that have conducted independent and intensive exploration and research on municipal solid waste have been able to carry out a very effective waste collection process with performance reaching 100%. The process of reducing waste with the concept of reuse, reduce and recycle in several countries such as China, Singapore, the Netherlands and Sweden has also been effective, calculated to have a percentage level above 25%. Israel and Slovakia manage waste more on landfill management and burning, which of course in the long run will affect environmental health.

TABLE 1. Collection Rate and Performance Disposal Method

Country	Waste kg/person/day	Collecting rate %	Recycle %	Landfill %	Dumps %	Compost %
Israel	2.12	-	10	90	-	-
US	2.58	100	24	54	-	8
Estonia	1.47	79	-	-	-	-
German*	2.11	100	-	-	-	-
Slovakia	1.21	93	1	78	-	1
Netherland*	2.12	100	25	2	-	23
Japan*	1.71	100	17	3	-	-
China	1.02	-	45	55	-	-
India	0.34	-	-	-	-	-
Sweden*	1.61	100	34	5	-	10
Singapore	0.49	100	47	15	-	-
Indonesia	0.52	80	-	-	-	-

Source : Refrence [1]

* Countries that has managed municipal solid waste is good

Some developed countries that have conducted independent and intensive exploration and research on municipal solid waste have been able to carry out a very effective waste collection process with performance reaching 100%. The process of reducing waste with the concept of reuse, reduce and recycle in several countries such as China, Singapore, the Netherlands and Sweden has also been effective, calculated to have a percentage level above 25%. Israel and Slovakia manage waste more on landfill management and burning, which of course in the long run will affect environmental health.

The Urban Development and Local Government Unit of Sustainable Development Network [1] in conducting exploration and research divides countries into seven regions, namely: (1) Africa region, (2) East Asia and Pacific

region, (3) Europe and Central Asia region, (4) Latin America and the Caribbean region, (5) Middle East and North Africa region, (6) Organization for Economic Co-operation and Development and (7) South Asia region. The availability of sustainable systems and infrastructure support is the basis for implementing solid waste management integration because it greatly helps the success of developed countries in managing MSW. For this reason Urban Development and Local Government categorizes countries into four classes, (1) Low-income countries, (2) Lower middle-income countries, (3) High-income countries and (4) Upper middle-income countries.

India, with an average waste of 0.34 kg/capita/day already has processing technologies such as composting, bio-methane, recycling, gasification, incineration, pyrolysis, engineering landfills, etc., it still has problems such as process limitations waste collection and land limitations for the landfill process. This limitation is more due to infrastructure limitations in the collection and funding process. That is why the Development and Local Government of India are included in the category of Lower middle-income country.

Israel citizen with the capital Tel-Aviv produces an average of 3.1 kg of waste per day. But in the city of Ashdod the amount of garbage is only 1.4 kg/capita/day. Ashdod is a city that has been successful because it has implemented reuse, reduce and recycle concept.

Although China is also included in the Lower middle-income country, it has managed to manage MSW effectively. China is an effective recycle country, with the highest value of recycled process percentage, which is 45%. The process of sorting until recycle is strengthened by regulations that apply throughout China. The community does the sorting process independently by using an automatic machine that can directly provide cashback.

Municipal solid waste in any country will always be a burden on the government, from the collection, separation, until the delivery and management in landfills. Countries with large populations contribute more burdens to the management of municipal solid waste. Waste management will focus more on the collection process. So that integrated management in other processes is hampered. The concept of shared responsibility needs to be included in the paradigm of integrated solid waste management that is sustainable, so that the burden of the government is helped and there is an educational process for the community as has been implemented in China and Singapore.

CONCLUSION

Reverse logistics has not only expressed the company's global concern for sustainable development, but has also influenced the stated organization at a strategic level to reduce negative environmental impacts. The analysis gives alternatives to solve the problems that can help the stakeholders in improving the performance of managing the municipal solid waste. The alternative that can be chosen is to use the concept of a sustainable closed loop system with integrated solid waste management paradigm that also applies shared responsibility. So that all stakeholders will feel comfortable, have self-belonging, responsible and happy.

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