ISSN No:-2456-2165

Municipal Solid Waste Characterization and Quantification of Waste as a Measure towards Effective Waste Management System of Magsaysay Misamis Oriental, Philippines

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Abstract:- Waste was never a good part of the Environment, but sometimes useful when it is recyclable. It degrades our environment, modifies our climate and creates unsuitable situation. Also, the availability of reliable data on waste generation and composition that serves as the basis for effective planning on waste management in the local government unit of Magsaysay Misamis Oriental Philippines was absent. To help obtain this data on a local basis, selected barangays of the municipality were recruited on the rate of waste generation, the composition of waste by sector, sorting and separation efficiency and per capita of waste. Results show that the municipal generation rate from the present population of 37, 098, was 7,790.58 kg/day with generated waste per capita of 0.21 kg/capita/day. Also, from the classification of the different sectors, residential has 74.92% waste generation followed by the commercial 15.87%, institutional 8.42 %, market 0.68 % and from hospital 0.13%. From the combined percentage of the different sectors, biodegradable has the highest percentage with 68.64% followed by the recyclable 16.78%, residual 13.21% and special waste 1.37%. Through obtaining this data sources the LGU of Magsaysay has planned, integrate and implemented an effective solid waste management strategies which comprises to source reduction, collection, composting facilities, special waste management, marketing development, alternative technologies for residual and recyclable waste and designing landfill for final disposal through 10 years plan projection. The success of this planning strategy would be a marked up to communities to be more responsible in the solid waste management system.

Keywords:- *Municipal Solid Waste, Waste Management, Waste Classification.*

I. INTRODUCTION

Nowadays, the problem of solid waste management is one of the biggest challenges to the authorities of both small and large cities' in developing countries (Abdel-shafy and Mansour 2018). This is mainly due to the increasing population in cities and communities that gave rise to indiscriminate littering and open dumps which leads to the increase of solid waste generation. These dumps, in turn, formed breeding grounds for rats and other vermin, posing significant risks to public health (Amasuomo and Baird 2016) and the burden posed on the municipal budget (Abdel-shafy and Mansour 2018).

Hence, their management has proved to be a rather challenging issue in the 21st century and a lot of research is being conducted in this field (George and Natalia 2016).

As the population grows in Magsaysay, the volume of solid waste generated also increases. Along with this waste generated from different sources other than households, restaurants, market and various business establishments. Mismanagement of solid wastes creates adverse effects on the social and economic well-being of the populace. The efficiency of the SWM greatly relies on the proper segregation and diversion of solid waste. Proper segregation relies on the knowledge and participation of the people. And the participation of the people relies on the political will of the government to implement its policies and to educate its people.

This is why it all boils down to the integrity and willingness of the government to make a difference. Some of the key issues that the community is facing today are the following; the absence of regular solid waste collection in each barangay, no proper segregation of waste in their respective MRF, lack of awareness and information of solid waste management in the Locality, not all barangays covered by the collection of garbage, additional garbage truck in order not to delay the collection schedule, poor community response for the implementation of solid waste management program, no junk shop in each Barangay, no available equipment for processing recyclables and residual, few households practice waste segregation, lack of equipment for special waste treatment before disposal.

Hence, reliable waste management data is needed to provides an all-inclusive resource for a comprehensive, critical and informative evaluation of waste management options in all waste management programs (Miezah et al. 2015). Thus, this study aimed to generate comprehensive data at the regional and national levels for use in the

ISSN No:-2456-2165

planning and implementation of relevant waste management activities in Magsaysay Misamis Oriental.

II. MATERIALS AND METHODS

A pilot source sorting and separation was conducted at the household level in selected barangays of Magsaysay in July 28-30, 2018 for collection of data on the composition, generation rate and compliance level of separation of the waste.

A. Study Area

➢ *Location*

Magsaysay is located in the northern part of Mindanao, Philippines. It is 152 kilometers from Cagayan de Oro City, 44 kilometers from Butuan City, and 30.96 kilometers from Gingoog City. The Municipality is located within the geographic coordinates of 9º North Latitude and 125º 15' East Longitude. It is bounded by Agusan del Norte in the East, Gingoog Bay in the west, Gingoog Bay in the north and Gingoog City in the South (see fig.1).

➢ *Land Area & Classification*

The total land area of the municipality is 15,159 hectares, which is classified into Alienable, and Disposable Land (A&D) covering 9,168.76 hectares or 60.48 percent while Timberland/Forestland covered 5,990.24 hectares or 39.52 percent.

Alienable & Disposable Land reclassified into Agricultural Land comprises the biggest area with 5,362.19 hectares or 89.52 percent of the total land area. Next is the Public Land and Built-up Areas with 628.88 hectares or 8.46 percent and 134.95 hectares or 1.68 percent respectively.

The built-up area comprises the institutional sector of 144.61 hectares. The following are residential areas with 57.37 hectares; open space with 2.51 hectares and industrial area with 1.67 hectares. The least area is commercial with only 1.33 hectares.

Land Classification	Land Area (ha.)	Percentage (%) Total
A & D	5,990.24	39.5
Forestland	9,168.76	60.4
Grand Total	15,159	100

Table 1: Land Classification – (***Alienable & Disposable and Forestland***)

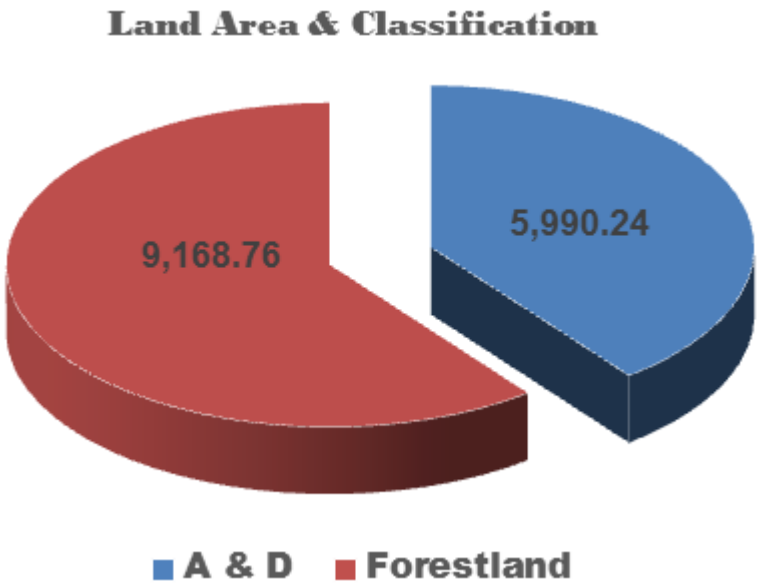

Fig 2:- Land Area and Classification

B. Sampling technique and determination of sample size of waste

Waste Analysis Characterization Study (WACS) was conducted to gather information about waste data in determining the weight and volume of different composition of waste generated from different sources of the community. There are seven barangays covered by the collection system were included in this study.

➢ *Weighing of sorted waste*

The sorted waste was collected using either a truck, a pick-up or a bicycle from the household to the main sorting center. The sorted wastes were weighed using mechanical weighing scale (10 kg and 50 kg), (Labotrix Group Limited, China). Plastic sheets were placed on the floor to ease sorting, segregation, and weighing.

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$$\textbf{\textit{Per Capita Generation}} = Average\ Waste\ Generated\ Per\ Household \div Household\ Size \quad (1)$$

$$\textbf{\textit{Municipal Waste Generation Rate}} = Total\ Number\ of\ Population \times Per\ Capita\ Generation \quad (2)$$

➢ *Level of compliance in the separation*

Source sorting and separation of waste by households require the input of the generators. The ability of household participants to sort and separate their waste well serves as a yardstick for authorities to consider introducing source sorting and separation of household waste.

III. RESULT AND DISCUSSION

A. Waste Generation Rate

As tabulated in the table below, the community of Magsaysay has a population of 37,098 (PSA Survey 2018) with a per capita generation of 0.21 kg/day, the Municipality will generate waste of 7,790.58 kg/day. The result shows that the municipality lacks equipment/technology for the reduction of waste volume.

Average Waste Generated (HH)	1.26 kg/day
Average HH Size	6
Number of HH Sample	30
Total Number of HHs	7,400
Total Number of Population	37,098

Table 2:- Generated Waste Per Capita

Sector	biodegradable	recyclable	residual	special	total
high income	471.2	206.15	200.26	5.89	883.50
middle	1350	486	522	18	2,376.00
low	3658.03	751.65	250.55	100.22	4,760.45
commercial	1386.9	100.5	201	10.05	1,698.45
market	47	10	15	0.3	72.30
institutional	430.5	241.5	218.4	10.5	900.90
hospital/others	4	1	7	1.5	13.50
	7,347.63	1,796.80	1,414.21	146.46	10,705.10
% Composition	**68.64%**	**16.78%**	**13.21%**	**1.37%**	**100.00%**

Table 3:- Waste generation Rate

As presented in the table below, from the data gathered from 3 days of WACS, it was observed that greater volume of waste generated was household which has 75%, followed by the commercial has the total volume of waste generated of 15.9%, next is from institutional has 8.4%, 0.7 from market and 0.1% from Rural Health Unit and Magsaysay Provincial Hospital.

B. Disposed Waste (End of Pipe)

Disposed wastes considered in this study included material waste from different establishments and waste collected from the regular route of the collection which composed of waste generated from households and non-households. This is the end-of-pipe waste collected (EOP). LGU collects mixed wastes during the study; all waste types are included in the sample. The team disallowed the recovery of recyclable waste by collectors to provide information as to the total volume of waste.

Tabulated data below shows the disposed waste composition from the end-of-pipe (EOP) source. It is indicated that the volume of wastes coming from the market generated a total rate of 1.7% while a greater volume of waste from other sources registered at 98.3%. The smaller amount of waste was generated by the market because there are only a few vendors available.

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Source	Types, kg/day				Total, kg/day	Total Percentage (%)
	Bio	**Recyclable**	**Residual**	**Special**		
Market	47	10	15	0.30	72.30	1.7
Other Sources (Regular Route)	3,478.5	461	209.5	41.95	4,190.95	98.3
Total	**3,525.5**	**471**	**224.5**	**42.25**	**4,263.25**	**100**
TOTAL (%)	**82.7**	**11.04**	**5.26**	**1**	**100**	

Table 4:- Disposed Waste Composition from End of Pipe

C. Waste Composition by Sector

The total waste composition by sector was shown in the figure below. The highest generated waste was coming from residential with 74.92% followed by the commercial with 15.87%, institutional with 8.42 %, market with 0.68 % and from hospital with 0.13%.

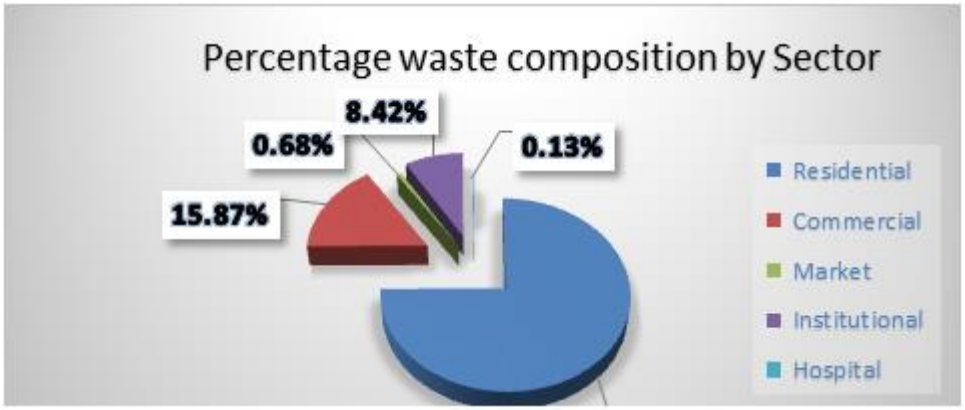

Fig 3:- Percentage Waste Composition by Sector

D. Waste projection

The waste projection in the municipality of Magsaysay is presented in the table above using the projected population growth for the year 2018 and with the generation rate per capita of 0.21 kg/capita/day. It shows that in the year 2018 the total population has a 37,098 will be generated of waste 10,705.10 kgs/day. The projection population increase the more waste generated will be an increased every day.

		kgs/day					
YEAR	POPULATION	**BIO**	**REC**	**RES**	**SPL**	**TOT (kgs/day)**	**TOT (tpy)**
2018	37,098	7,347.63	1,796.80	1,414.21	146.46	10,705.10	3,907.36
2019	37,973	7,520.93	1,839.18	1,447.57	149.91	10,957.59	3,999.52
2020	38,862	7,697.01	1,882.24	1,481.46	153.42	11,214.12	4,093.16
2021	39,775	7,877.84	1,926.46	1,516.26	157.03	11,477.58	4,189.32
2022	40,707	8,062.43	1,971.60	1,551.79	160.71	11,746.52	4,287.48
2023	41,664	8,251.97	2,017.95	1,588.27	164.49	12,022.68	4,388.28
2024	42,643	8,445.87	2,065.37	1,625.59	168.35	12,305.18	4,491.39
2025	43,641	8,643.54	2,113.70	1,663.64	172.29	12,593.17	4,596.51
2026	44,667	8,846.75	2,163.40	1,702.75	176.34	12,889.23	4,704.57
2027	45,716	9,054.51	2,214.20	1,742.74	180.48	13,191.93	4,815.06

Table 5:- Projected Population and waste generation for the 10-year plan

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IV. SOLID WASTE MANAGEMENT SYSTEM

A. Source Reduction

The main purpose of Ecological Solid Waste Management is the waste reduction, hence reduction at source is very important. All waste generators must segregate their wastes into bio-degradable, recyclable, special and hazardous waste.

PPAs	Indicator/Output	Target Sectors	Responsible Person
I. Reduce residual waste generation			
- IEC on Responsible consumerism	- consumers to patronize products that have lesser residual waste - Consumers to use baskets in marketing and ECO Bags	Consumers	MENRO/EMB/DA
- Enactment of Municipal - Ordinance	- Regulate market vendors the use of plastic bags	Market vendors	MESWMB SBO
	- Require all households to re-use residual waste, e.g., pillow-making, decorative, bags, etc.	All households	MESWMB SBO
- Institutionalization of Barangay-Based Institution and Private Organizations	- Institutionalized groups that utilized residual waste as their livelihood activities	Women's Organization, religious sector,	MENRO, Barangay Council
II. Composting			
- IEC on Composting Technology	- Mandatory implementation of backyard composting for households - Establishment of Vermicomposting facilities	Households	MENRO/DA
III. Recycling			
- IEC Activities	- Segregate and recover at least 75% of recyclables at source	Households	MENRO/DA
- Enactment of Municipal Ordinance	- Requiring all households to have composting	Households	MESWMB SBO

Table 6:- Source reduction activities will be implemented in three ways:

B. Collection

The collection of segregated residuals and special waste is the responsibility of the Municipality. As mandated, barangays shall undertake the collection of segregated recyclables and compostable wastes of their respective areas of responsibility. Eighteen barangays covered by the collection namely:

Cabantian, Cabubuhan, Poblacion, Villa Felipa, Damayuhan, Kauswagan and San Isidro every:

- Monday – Residual Waste
- Tuesday – Recyclable Waste

Consuelo, Bonifacio Aquiño, Artadi, Kandiis, Sta. Cruz, Kibungsod and Terminal every:

- Wednesday – Residual Waste
- Thursday – Recyclable Waste

Mindulao, Cabalawan, Tibon-Tibon, San Vicente, Tulang every:

- Friday – Residual
- Saturday – Special Waste

Gumabon, Katipunan, Mahayahay every 1st Saturday of the Month

Pag-asa, Abunda, and Tama Tinaan every 2rd Saturday of the Month:

- Saturday – Residual

C. Collection Equipment and Routes

Magsaysay has an existing one garbage truck for weekly collection. In times when a garbage compactor is not available, the minidump truck is used in the collection. During times when there is a large volume of garbage to be collected like after holidays, the municipal dump truck is used to help in the collection. Additional 1 unit garbage compactor as collection equipment will be purchased in 2022.

D. Composting/Management of Biodegradable Waste

Household Level must practice composting on their biodegradable waste. Collected biodegradables from different establishment places will be brought to the MRF composting facility and municipal nursery for composting also require the barangay to have a composting area for biodegradable. At present, the LGU has 1 organic shedder worth Php 270,000.00 and Php 730,000.00 for the construction of vermi bed and other facilities (on the biding process). To sustain this composting program, the MESWMB allocates Php 20,000.00 each year.

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E. Marketing and Market Development

The Municipality through MESWMB facilitates and develops linkages to private business institutions within and outside the locality for the marketing of compost fertilizers produced by the households and ESWM Center and Municipal Nursery, recyclables and recycled materials produced by the barangays and municipal MRF.

Next year, the Municipality will develop marketing strategies within the area for easy market and patronage of own products.

- Strategies for developing and expanding markets for compost, recyclables, recycled and other processed materials

Name of Recovered Materials	Estimated Selling Price (PhP)
▪ **Bottles (whole)**	3.00 per piece
▪ **Plastics (hard)**	11.00 per kg
▪ **Metals**	10.00 per kg
▪ **Tin/cans**	2.00 per kg
▪ **Papers/Cartoons**	7.00 per kg

Table 7:- Estimated Selling Price for Recovered Materials
**Source: Junkshop*

F. Alternative Technologies for Residual and Recyclable Waste

The LGU Magsaysay collects Residual from all sectors, and the MESWMB plan to have 5% of total residual to process into eco-bricks and component to CHB. The shredder machine from EMB will help to shred some residuals to process into eco-bricks and components to CHB. The LGU Magsaysay mandate to establish a Material Recovery Facility and Residual Containment Area in every barangay to cater to the recyclable wastes and residual waste in all sectors. The MRF should have compartments for the segregation of bottles, pet bottles, plastics/cellophane, cartoons other recyclable wastes. Junkshops also contribute to the processing of recyclables where materials that can still be sold are processed here.

G. Disposal

The final disposal of the waste from the community is disposed to Barangay San Isidro. With 4.3 hectares, it can accommodate the total volume of residual waste from 2018 to 2027 in the plan period, the projected amount of waste generation from 2018 is 1,414.21 TOT (tpy) the increase of population the more increase of generated increase in a day.

H. Existing Facilities

The existing Facilities within the SLF Area have an RCA and Centralized Material Recovery Facility at barangay Cabubuhan, with 4 compartments plastics, cans, bottles, and special waste. Good condition of one garbage truck and one dumbstruck.

I. Special Waste

At present, the Special hazardous waste from Magsaysay Rural Health Unit and Cabubuhan Emergency Hospital will be disposed of in a septic vault in their respective area. Special wastes from Household and Commercial collected and properly placed in closed containers such as barrel and closed tanks and place in a storage room located within the Sanitary Landfill Site or in the MRF Building. Special Waste from Residential, Commercial, Institutional, and Market the LGU Magsaysay must coordinate for EMB to develop a Special Waste Management Plan and Program.

V. CONCLUSION

The pilot study was successful because all the needed logistics were provided. It was found that the municipal generation rate was 7,790.58 kg/day from the existing population of 37, 098 with the per capita generate a rate of 0.21 kg/capita/day. Also, the base on the combined percentage from the different sector biodegradable waste has the highest percentage with 68.64% followed by the recycle 16.78%, residual 13.21% and special waste 1.37%. From the present generated waste which is 10,705.10 kg/day it is projected that the waste generation rate in 10 years-time will increase up to 13,191.93 kgs/day. Thus, with the help of the good governance of the LGU of Magsaysay, the simple sorting and separation system could be recommended for communities learning to separate waste which will lead to an efficient and effective solid waste management system practice. There is also the need for regular collection of the sorted waste to avoid a lack of trust from the community. Fee reduction could also be employed as an incentive for those who are effective in sorting and separation. The commitment of the household to the exercise was a major factor that accounted for the sorting and separation efficiency.

ACKNOWLEDGEMENT

The authors wish to express their deep appreciation and gratitude to the Local Government Unit of Magsaysay, Misamis Oriental for their cooperation and financial support.

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