Comparative Waste Analysis and Characterization Study (WACS) among the Selected Rural Areas in the Northern Part of Mindanao, Philippines

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1. Introduction

In recent years, Municipal Solid Waste Management (MSWM) has become one of the most serious environmental and public health issues confronting local governments in developing countries. Inefficient waste collection and the lack of disposal facilities are identified as the common problems (Michida, 2011). The Philippines is no exception with rapid urbanization, economic growth, changes in lifestyles and consumption patterns resulted in a remarkable increase in both the volume and diversity of waste during past decades (Oliveira et al., 2013; Premakumara et al., 2014).These issues led to the passage of the Republic Act (RA) 9003 or the Ecological Solid Waste Management Act of 2000 as landmark environmental legislation in the Philippines (Festejo et al., 2013). RA 9003 declares the policy of the state in adopting a systematic, comprehensive and ecological solid waste management program that ensures the protection of public health and the environment and the proper segregation, collection, transport, storage, treatment and disposal of solid waste through the formulation and adoption of best environmental practices. It is necessary therefore to characterize waste in order to accurately make waste management decision and evaluate environmental risk (Briones, 2011).

The pressing concern on the increasing volume of wastes produced is undeniable impact on climate change, and the relatively unsustainable Solid Waste Management interventions among LGUs are some of the reasons why the Government should push for the adoption of the appropriate measures (Tiblani, 2014). Since the Ecological Solid Waste Management Act (R.A. 9003) was enacted, several activities were initiated by the government in empowering waste management in every municipality. Waste Analysis and Characterization Study (WACS) was mentioned in RA 9003 and is vital activities that determine the amount of wastes generated in municipality or in any institution (Bautista and Tansengco, 2017). Waste characterizations studies are conducted to profile the waste material types and quantities of waste being generated and/or disposed in certain locality. Commonly, the findings are expected to provide basis for assessing how effective current solid waste management systems are, especially in terms of waste diversion programs, and developing plans for waste reduction and recovery of materials (UNEP, 2009).

The ongoing uncontrolled dumping and open burning of waste in many rural areas in the Philippines poses various environmental risks and causes a loss of valuable resources, whereas waste generation increases steadily due to urbanization and population growth (Paul and Lange, 2011). The biggest challenge to growing LGUs is to come up with solid waste and pollution control strategies that would effectively reduce the rubbish released to the environment. Unfortunately, this challenge cannot be effectively addressed by each LGU alone (Torres, 2009). Contributory factors to this challenge includes inadequate regulatory framework that has manifested in lack of interest in private sector investment in service delivery (infrastructure); uncoordinated institutional functions; low political will, low capacity to discharge duties; poor data of information for planning, insufficient documentation of the volume and characterization of solid waste generation and wrong attitude of waste generator amongst others (Olukanni et al., 2014).

The Philippines government has tried to address problem of waste management by enacting various policies. Policies were implemented as early as 1938, which prohibited dumping of refuse or substances of any kind into the rivers. In later policies, proper collection and disposal of waste and the provision of penalties for non-compliance were emphasized. In this regard, the local government units (LGUs) were highlighted to make effective implementation of solid waste management (SWM) programs. But the problem of solid waste continued to be like before (Atienza, 2011). The situation happened in one of the rural areas in the northern part of Mindanao, Philippines where some of these rural areas have bagged the record as the cleanest areas in the province. However, due to some reasons and unavailability of time to maintain its practices, the areas experienced problems on solid waste management.

It is within the context that the researchers conducted the comparative waste analysis and characterization study (WACS) of the selected rural areas in the northern part of Mindanao. The vitality of this study identified and compared in narrative or empirical way the generated waste of the two selected rural areas. The study also identified waste management practices and determined appropriate measures to be implemented in maintaining the cleanliness of the area.

2. Methodology

Research Design

This study employed a descriptive and comparative method of research using a survey instrument and informal interviews with some of the community respondents in order to describe the present situation. This design describes the current level of the waste generated within one hundred-

sixty eight (168) hours by the different household-participants.

Participants of the Study

The study focused on the waste analysis and characterization, specifically on the level of waste generated by the different household-participants from the two (2) selected rural areas in the northern part of Mindanao. The areas were chosen based on its population, the type of households and locations. There were only two selected areas coded as (1) Rural Area A which is closely situated to industries and (2) Rural Area B which is situated away from industries. Only those households from each area with multiple-family ranging from 6 and more members were considered. Using the Sloven Formula, the researchers randomly sampled a total of two hundred seventy-seven (277) respondents in rural area A and ninety-eight (98) respondents in rural area B with the total of three hundred seventy-five (375) respondents. Only those with willingness to answer were surveyed and considered as they need to assess if they perform their roles in segregating their waste in order to minimize pollution within the area.

Table 1: Participants of the Study

Rural Areas	Population	No. of Respondents
Rural Area A	898	277
Rural Area B	129	98
Total	1027	375

Margin of error of 0.05

Data Gathering Procedures

Waste Analysis and Characterization

Occupants of households chosen for the waste analysis and characterization survey were not part of the three hundred seventy-five (375) respondents who were surveyed. These households were not also informed about the survey so that any bias that may be created by a temporary change in habits can be eliminated. Each household-participant was provided by five (5) sacks where their wastes generated within one hundred-sixty eight (168) hours are deposited. Waste composition data sheet provided by the Department of Environment and Natural Resources (DENR) is one of the instruments used for recording the weight and bulk density of waste per cubic meter. Weighing scale and volume scale were used to determine how heavy and how much the waste collected from the two selected rural areas weights.

Direct sampling was used on a small scale for obtaining information about waste composition. The direct sampling method involves physically sampling and sorting waste at the source of generation. Although waste can be extremely heterogeneous, direct sampling is one of the more accurate characterization methods. In order to make accurate judgments as to composition, sorting and analysis was conducted in several randomly selected locations within the areas. Waste sampling from multi-family homes created local variations. After gathering the wastes generated by the household-participants in one hundred-sixty eight (168) hours, this was brought to the dumpsite areas for sorting and weighing of wastes. The wastes were characterized and recorded in the waste composition data sheet.

Waste Management Practices

Approval and authorization to gather data before the actual conduct of the study were accomplished from different authorities. The researchers, with the assistance of Local Government Officials (LGU) visited the individual homes of the three hundred seventy-five (375) selected participants to collect the basic information needed. Only those participants with willingness to answer the survey are considered. Respondents were given ample time to answer the questionnaire.

Statistical Tools

Weighted mean was used to determining the waste practices of household-participants from the selected rural areas. K-S Kolmogorov-Smirnov Test Goodness of Fit Test as a non-parametric test of equality of continuous was used to check if the data is normally distributed and to test the Null Hypothesis in the study. Mann-Whitney U Test was used to compare the difference between the two independent samples from the selected rural areas that are not normally distributed.

3. Results and Discussion

Waste Management Practices

Table 2 reflects the waste management practice of the selected rural areas of the northern part of Mindanao, Philippines.

Table 2: Waste Management Practices of the Selected Rural Areas

Rural Areas	Waste Management Practices					
	Segregate	Mixed	Composting	3R's	Burning	Total
Rural Area A	79	101	47	0	50	277
%	29%	36%	17%	0%	18%	100%
Rural Area B	27	28	17	0	26	98
%	28%	29%	17%	0%	27%	100%

As shown in table 2, the waste management practices in selected rural areas are characterized by segregation, mixed-method of waste disposal, composting and burning. It can be gleaned from the table that most of the household participants have practiced the mixed-method of waste disposal or commonly known as non-segregation practice with the highest figures of 36% from rural area A and 29% from rural area B. It is common among household-participants in rural area B to burn their wastes as it is easier for them to reduce the quantity of waste whenever garbage collection service from the LGU is unavailable. The table further shows that there were 29% from rural area A who were practicing waste segregation and 28% from rural area B who practiced both waste segregation and burning. None of the respondents in both areas practice 3R's (Reduce, Reuse and Recycle).

Mixed-method or Non-segregation is widely practiced by the households from both areas due to lack of support, encouragement, and cooperation and monitoring of proper waste management by the authority. The areas also practice other methods which include burning and composting along the road-side or any open site. Most respondents complained of irregular patterns in waste collection service forcing the

others to burn their wastes instead of waiting for unsure service. While majority of rural residents resort to open dumping (traditional method) method for their disposal (Seth, et.al., 2014; Amfo-Out, et.al., 2012).This situation creates a suitable environment for breeding of disease vectors, such as mosquitoes and cockroaches, and the proliferation of rodents, such as rats and mice, which pose threats to public health (Kelly, 1983). Yoada, et.al (2014) supports the claim that households were not satisfied with the solid waste management services in the community. The study findings further agree with the study of Mutungwe, et. al (2014), that the majority of people in the rural community did not take solid waste disposal as their responsibility but that of the municipality. Hence, they were not doing much to help the situation. Some communities had a negative attitude towards the whole concept while a few were very supportive and willing to engage in activities that promote behavior change on solid waste disposal.

Mean Waste Composition of the Selected Rural Areas

Table 3 reveals the waste composition of the two rural areas in the northern part of Mindanao. The mean compositions of wastes are categorized into biodegradable, recyclable, residual (non-divertible) wastes, residual (divertible) wastes, and special wastes.

Table 3: Mean Waste Composition of the two rural areas

Types of Wastes	Rural Area A						Rural Area B					
	W.t.-g	%	Rank	B.d-cum	%	Rank	W.t.-g	%	Rank	B.d-cum	%	Rank
Biodegradable	10, 250	42.82	1	.051	25.76	2	30, 750	75.46	1	.1065	50.47	1
Recyclable	4, 210	17.59	3	.05	25.25	3	4, 400	10.8	3	.0375	17.77	3
Residual (Non-divertible)	5, 875	24.55	2	.082	41.41	1	5, 050	12.39	2	.062	29.38	2
Residual (Divertible)	500	2.09	5	.006	3.03	5	550	1.35	4	.005	2.37	4
Special	3, 100	12.95	4	.009	4.55	4	0	0	5	0	0	5
Total	23, 935	100		.198	100		40, 750	100		.211	100	

It can be observed from the table that the waste compositions in the two selected rural areas differed on its type. Biodegradable wastes in both areas are high with its weighted gram (Wt.g) of 75.46% in Rural Area B and 42.82% in Rural Area A. These are followed by Residual (non-divertible waste) and recyclable Waste which fell both in second and third ranks in the selected rural areas. In terms of bulk density, residual (non-divertible) wastes which include diaper, sanitary napkins, sludge and others which are not acceptable for recycling and composting, received the highest bulk density in rural area A with 41.41%, while rural area B resulted to be high in Biodegradable wastes when measured in its bulk-density of 50.47%. Residual wastes in rural area A is followed by Biodegradable wastes (25.76%) and Recyclable (25.25%) of bulk density. The results are contradictory to the bulk-density of waste composition in rural area B where residual waste (29.38%) and Recyclable (17.77%) are high. The location of the rural areas have produced various mean waste composition among households. Rural area A that is situated close to the industries have accessed to more residual (non-divertible) wastes due to some commercial activities that usually involve the utilization of glass, plastics sludge and other non-divertible wastes. While rural area B that is situated away from industries generally has organic and natural waste products which give high bulk-density of biodegradable wastes. The results are similar to the study of Seth, et.al., (2014); Oteng-Ababio, (2014); Downmore, et.al., (2011) that wastes generated with regards to the location of the areas may be attributed to the general household consumption pattern in rural areas where fresh food items like fruits, tubers, roots, and vegetables form the bulk of purchases of the average household. The processing and consumption of these food items generate a lot of biodegradable and residual wastes in the home. Moreover, Boateng, et.al., (2016) on their paper claimed that the biodegradable waste was the most prevalent in rural communities, followed by the residual (non-divertible) wastes. The high proportion of biodegradable waste can be explained by the fact that there is a high level of consumption of fresh food products from the rural areas since it has limited access to convenient and synthetic products. Furthermore, most of the staple food products yield a lot of waste during preparation and consumption. Again, those households which yield high in residual (non-divertible) wastes as the most frequently generated waste materials engaged in some kind of home-based commercial activities in which glass, plastic, debris of metals, cottons and others were used as raw materials.

Significant Difference between waste composition in selected rural areas

Table 4 reflects the test of normality on the test of signicance between the waste compositions of the two selected rural areas in the northern part of Mindanao. K-S Kolmogorov-Smirnov and Shapiro-Wilk as non-parametric tests were used to check if the data is normally distributed.

Table 4: Test of normality on the significant difference among the waste composition

Location		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Weight	Area A	.182	5	.200*	.972	5	.889
	Area B	.395	5	.010	.703	5	.010
Bulk Density	Area A	.230	5	.200*	.897	5	.393
	Area B	.202	5	.200*	.927	5	.573

** This is a lower bound of the true significance*
a. Lilliefors Significance Correction

The results reflect a statistically significant value of p = 0.200 and .889 for rural area A in terms of its weight in grams of its waste composition; and p = .200 and .393 for its waste bulk density. This means that the mean waste composition in rural area A is not normally distributed. It can be observed that rural area B has p-value of 0.010 in terms of its weight in grams of its waste composition, and p value of .200 and .573 for its waste bulk density. Since the p-value is lesser than the p-value required, then it meets the assumption that rural area B has normally distributed mean

waste composition. The distribution of data in rural area A is not normally distributed because it has a large number of households compared in rural area B. Subsequently, the number of households contributes to how they limitlessly disposed their wastes within one hundred-sixty eight (168) hours considering that they were not informed about the survey to avoid bias.

Table 5 offers the actual significant difference between the waste compositions of the selected rural areas. Mann-Whitney U Test was used to compare the difference between the two independent samples by not considering its normal distributions.

Table 5: Mann-Whitney U Test on the significant difference between the waste compositions of the selected rural areas in Northern Part of Mindanao

	Weight	Bulk-density
Mann-Whitney U	12.000	11.000
Wilcoxon W	27.000	26.000
Z	-.104	-.313
Asymp.Sig. (2-tailed)	.917	.754
Exact Sig. [2*(1-tailed Sig.)]	1.000[b]	.841[b]

The Mann-Whitney U test yields a p-value of .917 in weight and .754 in bulk density. Since the p-values are greater than 0.05 level of significant, this means that there is enough evidence to accept the hypothesis. Hence, there is no significant difference between the weight and bulk density of the two (2) selected rural areas in the northern part of Mindanao. The results can be attributed to the densely populated areas, which may set the pace for the generation of more waste in the community. Although the mean waste composition of the rural areas varies on the types of wastes collected, yet in general, the issue of solid waste management is increasingly becoming a problem in the rural areas. The result aligned to the claim of Poor (2009) that the attitudes of the household about waste disposal could result in the whole community practicing similar disposal styles or behaviors. Dense populations and increased consumption have been shown to increase more waste and increase disposal problems. The results can also be linked to the study of Hoornweg and Bhada-Tata (2012) that waste composition is influenced by many factors, such as level of economic development, cultural norms, geographical location, energy sources, and climate. Many factors that jointly account for this include institutional weakness, inadequate financing, poor cost recovery, the lack of clearly defined roles of stakeholders, and the lax attitude of officials and residents (Baabereyir, 2009).

4. Conclusions

The comparative waste analysis and characterization study (WACS) from the selected rural areas in the northern part of Mindanao showed similarities on their waste management practices and disparities among the weight in gram and bulk-density of waste collected. It was found out that even at present, majority of the household-participants are not fully aware yet of RA 9003 or Ecological Solid Waste Management Act of 2000. It was observed that most of the households practiced the mixed-method or non-segregation of waste over Recycling, Reusing and Reducing of wastes. Though common of the households considered wastes as a threat and regard waste as a priority problem, yet they fail to fully practice proper waste management. Most of the household-participants do not mind following the imposed policy due to lack of public support, weak implementation and unavailability of waste collection service from the Local Government Units. The situation remains unresolved resulting to continuous neglect of RA 9003 for a reason that local government officials have poor convincing strategies to maintaining the cleanliness of the area and poor information transformation between the local government and the community.

Results of solid waste composition analysis conducted during the study also revealed that biodegradable waste and residual (non-divertible) wastes are the most prevalent in both rural areas. The high proportion of biodegradable wastes can be explained by the fact that there is a high level of consumption of fresh food products in rural areas. Moreover, some of the households that are situated close to industries generate waste materials that can be characterized to residual (non-divertible) wastes.

Hence, it is recommended that authorities should give their full support on the implementation of RA 9003 by strictly setting incentives to those responsible areas and penalties to violators. Waste management information should be intensified and integrated among the selected rural areas. The government should also exert effort to reach out the areas by sponsoring orientation and awareness regarding environment protection.With consistency, active support, and continuous education to improve people's practices and perceptions regarding waste management, it can eventually lead to minimization of waste generation.

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