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Solid waste characterization, knowledge, practices and attitudes of selected Barangay 22 households in Cagayan de Oro City

Gina C. Lacang*, Remedios T. Tamang[1], Sansen A. Handag Jr., Florianne Consolacion

Department of Environmental Science and Technology, University of Science and Technology of Southern Philippines, Cagayan de Oro, Philippines

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Abstract

The study is conducted generally to assess the solid waste characterization of brgy. 22, Cagayan de Oro City, to investigate the effectiveness of the mandate of the Ecological Solid Waste Management Program (RA 9003). Specifically, it sought to determine the (a) composition of the LGU's overall waste generation, (b) weight and volume of wastes generated by the residents of brgy.22 per income level, per capita/day, (c) amount of waste that will be generated in the next ten (10) years and (d) assess the knowledge, practices and attitudes of selected households. The solid wastes characterization activities involved the courtesy call to the barangay officials, training of the Technical Working Group (TWG), household survey, a one-day pre-sampling workshop, seven – day solid wastes characterization, and data evaluation and analysis. Results of the study showed the overall waste generation of brgy. 22 is composed of 75.41% biodegradables, 24.03% non-biodegradables, and 0.56% special wastes. Non-biodegradables are mostly recyclables and residuals. The composition of wastes varies from plastics, cellophane, cans, papers, glass bottles, vegetables and fruit peelings, electronic waste and textile wastes. Result of the study also showed that low income level household has the highest solid waste generation followed by high income and middle income households. Based on the projections generated by the team, the projected waste will range from 242, 697kg in 2016 to 302, 585kg in 2026. There will be an increase of 24.68% of waste generation within 10 years for Barangay 22. The residents' knowledge and attitude showed favorable response but their practices contradict to what the survey result indicates.

***Corresponding Author:** Gina C. Lacang ✉ ginacaminerolacang@gmail.com

Introduction

Solid wastes management is a multi-dimensional challenge in every urban community especially in developing country (Sujauddin *et al.,* 2008)**.** Due to the growing problem of solid waste in the country, a framework for solid waste management was needed to address it. Hence in the year 2000, Republic Act 9003 or the Ecological Solid Waste Management Act of 2000 was ratified. Moreover, the Act gives prime importance to the roles of Local Government Units (LGUs) in managing their respective solid wastes which was inscribe in Section 20 of the Act, it states that: Each LGU plan shall include an implementation schedule which shows that within five (5) years after the effectivity of this Act; the LGU shall divert at least 25% of all solid waste from waste disposal facilities through re-use, recycling and composting activities and other resource recovery activities: Provided, That the waste diversion goals shall be increased every three (3) years thereafter: Provided, further, That nothing in this Section prohibits a local government unit from implementing re-use, recycling, and composting activities designed to exceed the goal (Bernardo, 2008) & (Peralta & Fontanos, 2006).

Despite the mandate of the act, fewer LGUs were practicing diversion of wastes which only result to increase waste generation and accumulation of large amounts of waste in dump sites. And still at present many LGU's in our country still fail to follow the mandate of closing open dumpsites and shifting from open dumping to controlled dumping and to sanitary land filling. As the population of the Barangay increases it is expected that there will be an increase of waste production. Solid waste management is one of the problems of the barangay for proper disposal of garbage (Manaf *et al.,* 2009). There were garbage trucks that roam around the city however due to road inaccessibility in some slum areas of the barangay they are not included in the collection of garbage. With these, the residents opted to dump their waste in open areas or in Bitan-ag Creek which caused clogging of drainage which eventually leads to surface flooding in the streets (Kabingue *et al.,* 2014) Barangay 22 faces this problem every time strong rain comes.

With this known problem, the need for determining the amount of waste generated and its composition is very essential. The data generated from this study will play a critical role in solid waste system planning and design. Resulting data from waste composition studies can be used in several ways including determining the quantity of material available for recovery (Troschinetz & Mihelcic, 2009), the methods of waste diversion to be used, measuring the effectiveness of existing recycling programs and right-sizing solid waste and recycling facilities. Thus characterizing solid waste is important in formulating a Solid Waste Management Plan (Zurbrugg, 2002).

Thus, the researchers decided to conduct a solid waste characterization study in Barangay 22 to help and guide the barangay in their proper handling of solid wastes. Specifically, the study aimed to: (a) determine the composition of the brgy.22 overall waste generation, (b) determine the weight and volume of wastes generated by the residents of brgy.22 per income level, per capita/day, (c) calculate the amount of waste that will be generated in the next ten (10) years, and (d) assess the knowledge, practices and attitudes of the residents in brgy.22 with regards to solid wastes handling and disposal.

Materials and methods

A. Description of the Study Area

The study area is located at Barangay 22, Cagayan de Oro City (Fig. 1), in the province of Misamis Oriental, Northern Mindanao. The team selected 4 sampling sites represented by the 4 zones of the barangay as shown in Fig. 1. Barangay 22 has a total land area of 217, 600 square meters.

It is bounded on the South by Capitol University, Gaabucayan extension on the North, Old Bitan-ag on the East and Corrales Extension on the West. Fifty percent (50%) of the land area is residential and the other fifty percent (50%) is commercial. In the year 2015, the total population of the barangay was 2,392 with a total number of 530 households in four (4) zones (Zone 1: 88, Zone 2: 236, Zone 3: 103 & Zone4: 103).

Fig. 1.a.) Map of Cagayan de Oro City located in the Northern part of Mindanao b.) Boundary map of Barangay 22 with the other barangays of Cagayan de Oro City c.) Map of the four (4) sampling sites represented by Zones 1-4 of the barangay.

B. Major Activities

The activities conducted during the study includes the courtesy call to the Barangay Captain, Training of the Technical Working Group (TWG), household Survey, a one day pre-sampling Workshop, seven-day Solid Waste Characterization and lastly the Data Evaluation and Analysis. Fig. 2 shows the schematic diagram of the solid waste characterization study.

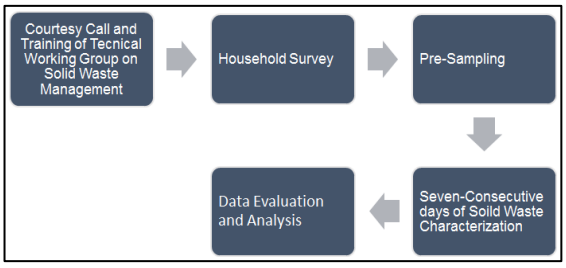

Fig. 2. Schematic diagram of the solid waste characterization study.

Courtesy Call and Training of TWG on SWC

The researchers of this study conducted a courtesy call to the Barangay Captain, Hon. Eldo G. Casino, asking for permission to conduct a solid waste characterization study. After the Barangay Chairman's approval, a meeting and training was conducted at the Barangay Hall as shown in Annex H with the selected key informants, particularly the Zone Leaders and some of the Barangay officials as members of the Technical Working Group (TWG). The Zone Leaders were then asked by the team to select respondents of each Zone that would represent the "high", "middle" and "low" class in the study.

Household Survey & Pre-Sampling

The Zone Leaders selected fifteen (15) households as participants in the one day pre- sampling activity. A survey questionnaire was distributed in each household to obtain information regarding the socio-demographic background of the respondents, the knowledge, attitude and practices of the respondents towards solid waste management, the types of wastes being disposed, and how they managed their waste.

The survey questionnaire was translated to Cebuano for ease in understanding. After the household survey, the pre-sampling activity was immediately performed. The activity started last November 14, 2016 where six (six) CVO's were trained in preparation for the one-week characterization study.

Seven-day Solid Waste Characterization

The result of the pre-sampling activity was used to determine the representative sample size for the seven-day Solid Waste Characterization Activity.

Specification of the sampling frame

The target population of the study was randomly drawn from the 530 households comprising four (4) Zones. Income classification of each household was determined by the Barangay officer obtained from the available data in the Barangay. The three classification of income categories were the following; Low Income Level (earning monthly income below P10, 000), Middle Income Level (monthly income between P 10,000 – 20,000) and High Income Level (monthly income above P 20,000). Pre-Sampling was conducted to calculate the sample size to be adopted for the actual characterization study.

Identification of sampling methods for sampling units

The respondents for the actual seven-day characterization study were selected based on stratified random sampling technique. The sampling area covering 4 Zones were divided into three income levels; Low, Middle and High. This classification was used to identify distribution of classes among zones and was used as basis for the stratified random sampling (Dangi *et al.,* 2008) Respondents were selected from each income level at random. Each member of the survey population had an equal chance of being selected.

Development of a sampling plan

Considering the important elements of a sampling plan, which includes, the mode of collection, techniques of estimation used, and the measures or precision desired, these were carefully treated to provide closed estimates of the data that will be gathered (Paul *et al.,* 2012). Last November 14, 2016, one day before the seven-day characterization study was conducted; a one-day pre-sampling activity was done. A day after, the seven-day characterization study was immediately performed dated November 15- November 21, 2016.

Mode of Collection

The collection of the household waste was done in the morning. This was done daily for 7 consecutive days. The wastes were then weighed, segregated to basic components and weighed again. To establish data for the moisture content of the wastes, the samples were taken to a vacant lot in each zone where segregation and weighing of samples were performed. During the pre-sampling activity, the housewives were the direct respondents. They were interviewed using the survey questionnaire in Annex A and were given proper instructions to get their views and their solid waste management practices. The objective of the project was also mentioned to properly guide them as they contribute to the success of the project.

Estimation Techniques

Projection of the waste generated by Barangay 22 was established using the sample statistics by using per unit value or the per capita generation per day which was calculated to estimated totals.

Measure of Precision

It is recognized that there is a level of uncertainty in measuring samples or a portion of population and use this to project to the whole population. The amount of variation that exists among the estimates from the different possible samples is what is called the sampling error (Abbu Qdais *et al.,* 1997). Sampling error is the difference between the sample mean and the population mean.

Establishing acceptable levels of uncertainty should be addressed in calculating sample size (Hsieh *et al.,* 1998). This uncertainty basically comes from, sampling error, sample size which is relative to the large population, estimation method and materials used in measurement and many other which put to risks the reliability and degree of accuracy of the results (Dietrich, 2017).

Using the pre-sampling data, standard deviation was calculated and was used in the computation of the standard error. Standard deviation is a measure of spread or dispersion around the mean of the data set. Although the standard deviation was sensitive to

outliers still, outliers were included in the calculation of the final descriptive statistics and estimates of weights and volumes but it was evaluated using the scatter plot diagram.

Results and discussion

Data Evaluation and Analysis

Descriptive statistics was used to analyze the distribution and spread of the numerical data on the solid waste's weights and volumes. The mean and median were included to measure the central tendency of the data, also the variance and standard deviation which measures the distribution or spread of the data, and the confidence interval.

Estimates of total solid waste generation for the whole Barangay was calculated using *per unit* and *per capita* values. Result of the household survey regarding solid waste management practices of the respondents was established in reference to the calculated data.

Sample Size Calculation

The sample size was calculated using the data generated from the one-day pre-sampling activity conducted last November 14, 2016. At 95% confidence level, the resulting sample size was 18. However, for increased precision and certainty, it was increased to 24 sampling units.

The fifteen (15) sampling units who were the respondents during the pre-sampling activity were automatically included for the seven-day characterization study. The remaining nine (9) sampling units were added and these households were the respondents of the survey. The details of the pre-sampling data and sample size calculation are in Annex B.

Geographic Location of Sampling Units

The 24 sampling units were proportionately distributed according to strata that are by income levels. The study team made sure that at least each of the four (4) zones have been represented although some were favorably chosen for accessibility purpose during the collection of the waste. Table 1 shows the distribution of the 24 samples based on pre-determined proportions of the income level of the households.

Tests for Outliers

Scatter Plots was used to identify the outliers of the study (Var, 1998). Outliers were identified as the points above 2.5 standard deviations from the mean of the total sample population. Based on the observed pattern in the scatter plot, no outliers were identified.

Annex C shows the relative pattern of the samples that were grouped into the three categories – Low, Middle and High Income Households. Table 2 shows the waste generation of each household sample in kilograms per day during the seven-day waste characterization.

The sampling units of the study were grouped according to income category. Table 3 shows the average weights of the wastes generated for the seven-day characterization study of the respondents. The average weight of waste generated during day 1 was considerably low due to much earlier collection of wastes by the city's garbage collectors in the sampling households. Moreover, the household sampling respondents weren't aware that they need to keep their wastes intended for the technical working team to characterize.

Table 1. Sample Size Distribution

Income Level	Proportion, %	Sample Distribution
Low	29.17%	7
Middle	50%	12
High	20.83%	5
TOTAL	100%	24

Moisture Content of Solid Waste

The collected solid waste samples were sun dried for at least 4 hours after the fresh weights were recorded. Results showed that a typical household waste of Barangay 22 have a moisture content of 9.60% based on the 24 samples. High moisture content value was obtained due to high temperature of the area and also some of the fresh wastes collected are wet. Refer to Annex D for the calculations.

Table 2. Solid Waste Raw Data in kg/household/day.

Sample No	Name of Sample (Household)	Purok No	Sub-category	Total Weight Day1	Total Weight Day2	Total Weight Day3	Total Weight Day4	Total Weight Day5	Total Weight Day6	Total Weight Day7
16	Maculob	3	High	0.0135	2.8	0.8	1.2	0.4	3.66	0.8
17	Janio	3	High	0.0243	0.9	0.75	1.6	0.8	3.4	1
18	Lagsa	3	High	0.0209	0.9	1.75	0.7	1.6	1.5	1.6
19	Abueva E.	3	High	0.007	1.5	1.9	2.2	1.5	0.7	1.1
21	Cabucos	4	High	0.0087	1.75	0.35	0.55	0.4	0.2	0.4
3	Salvacion A.	1	Medium	0.0087	0.702	2	1	1.5	3.4	3.2
5	Dulos E.	1	Medium	0.013	1.65	0.45	1.8	1.1	0.5	1.1
9	Oporto	1	Medium	0.0071	3.204	0.85	1.7	2.7	1.3	3.2
10	Tormis	2	Medium	0.0072	1.35	2	0.85	1.3	0.95	1.7
11	Dacut	2	Medium	0.0008	1.45	0.75	0.8	0.15	0.2	0.2
20	Bigcas	2	Medium	1.25	0.57	0.5	1.95	2.1	0.6	3.2
23	Tagalog	2	Medium	0.0023	0.2	0.99	0.2	0.7	0.6	0.35
1	Salise R.	2	Medium	0.0008	0.95	0.6	1.55	0.49	0.8	1.4
2	Bonjan E.	2	Medium	0.0008	0.1	0.31	0	0.06	0.25	0.7
4	Quiber V.	3	Medium	0.024	1.65	1	0.4	0.35	1.45	1.6
6	Sarmiento	4	Medium	0.0087	0.23	0.95	0.75	0.55	0.35	1.85
7	Rosal	4	Medium	0.0087	0.7	0.65	0.2	0.65	0.5	0.2
8	Dacup	1	Low	0.0083	0.802	2.45	2.9	1.7	3.1	3.2
12	Cabactulan	1	Low	0.0072	2.2	0	0.4	1.7	0.6	1.7
13	Besere	2	Low	0.04	3.6	0.6	2.05	3	3.1	3.2
14	Gulle	2	Low	0.0225	3	0.4	3.25	3	2.45	3.45
15	Abueva A.	2	Low	0.0243	2.5	0.75	0.65	1.55	2.3	3.2
22	Ejercito	4	Low	0.064	1.15	0.9	2.35	0.45	0.4	0.35
24	Tagaan	4	Low	0.0208	1.5	0.4	1.6	0.8	0.9	0.2

Table 3. Sampling Units Grouped per Category (Total Average, kg/household/day).

Sample No	Name of Sample (Household)	Purok No	Sub-category	Average Daily Generation (a)
Maculob	16	3	High	1.373357
Janio	17	3	High	1.210614
Lagsa	18	3	High	1.152986
Abueva E.	19	3	High	1.272429
Cabucos	21	4	High	0.522671
Salvacion A.	3	1	Medium	1.687243
Dulos E.	5	1	Medium	0.944714
Oporto	9	1	Medium	1.851586
Tormis	10	2	Medium	1.165314
Dacup	11	2	Medium	0.507257
Bigcas	20	2	Medium	1.452857
Tagalog	23	2	Medium	0.434614
Salise R.	1	2	Medium	0.827257
Bonjan E.	2	2	Medium	0.202971
Quiber V.	4	3	Medium	0.924857
Sarmiento	6	4	Medium	0.669814
Rosal	7	4	Medium	0.415529
Dacut	8	1	Low	2.0229
Cabactulan	12	1	Low	0.943886
Besere	13	2	Low	2.255714
Gulle	14	2	Low	2.224643
Abueva A.	15	2	Low	1.567757
Ejercito	22	4	Low	0.809143
Tagaan	24	4	Low	0.7744

Solid Waste Generation

Table 4 shows the summary of descriptive statistics calculated for the 24 sampling units in Barangay 22.The mean solid waste generation across all income levels is 1.18kg/ household/day and the median is 1.03kg/ household/day. The data calculated regarding measures of central tendency were quite close to each other. Estimating the confidence interval at 95% is important since it tells how confident the range captures the true population parameter (Nakagawa & Cuthill, 2007) given the distribution of 24 sampling units. The calculated average household solid waste generation rate in Barangay 22 lies between 1.09 and 1.27kg/ household/day. The average solid waste generation per income level clearly does not conform to common trends where the high income level households generates more waste and then followed by middle income and low income households. This might be due to the proximity of the area to commercial establishments like malls and restaurants where high income and middle income families may choose to eat at any given time. The lifestyle of households in an urban setting greatly varies from that of a rural household and can considerably alter the volume and weight of their waste generation (Eberhardt and Pamuk, 2004). Annex E shows the detailed calculation for this confidence interval. The average per capita solid waste generation was calculated to be 0.25 kg/person/day. This information was supported by dividing the average waste generation per household per day (1.18) by the average no. of members per household across all income levels (4.82). Table 5 shows the different averages of no. of household members and its average

waste generation per household per day in different income levels. With 530 households or an estimated population of 2, 392 in the areas covering 4 Purok, the present waste generation based on 0.25kg per capita/day is 598 kg/day or 0.60 tons/day. The volume of household wastes generated is 0.44096 cum/household/day as shown in Annex F. Density household solid waste was calculated at 7.34 tons/ m^3 as shown in Annex G.

Table 4. Descriptive Statistics (Unit in kg/ Household/ day).

Statistics	ORIGINAL VALUES			
	Income Level			Average/ Total
	Low	Middle	High	
Mean	1.51406	0.92367	1.10641	1.18138
Median	1.5	0.7	0.9	1.03333
Standard Deviation	0.66906	0.5263	0.33638	0.57977
Minimum	0.845	0.39737	0.77003	0.6708
Maximum	2.18313	1.44996	1.44279	1.69196

Table 5. Household Size.

Income Category	Average No. of Members Per Household	Average Waste Generation kg/household/day
Low	6.95	1.51
Middle	4.65	0.92
High	2.85	1.11
AVERAGE	4.82	1.18

Solid Waste Composition

Solid wastes generated from the household of the respondents made up primarily of 75.36% by weight of biodegradables, 24.05% by weight of non-biodegradable and the remaining 0.56% by weight for special wastes. The non-biodegradables which composed of two sub-categories, the highest percent composition of waste was the recyclables (21.41%) followed by the residuals (2.80%). Of the total volume obviously, biodegradables (54.44%) comprised the highest volume of waste as shown in Table 6. In Table 7, it shows the composition of recyclables generated from the seven-day characterization study. Of the total recyclables, plastics rank the highest with a percent weight to recyclable waste of 51.41%, this was followed by dry paper (18.17%), metals (8.86 %). glasses/bottles (8.63%), leather and textiles (7.55%) and others (5.38%). The compositions of biodegradables generated by the constituents were mostly composed of garden wastes like dried leaves and kitchen left-overs.

These were basically thrown since there were no available areas to raise animals in the area such as pig and chicken. Most of the residuals were sanitary napkins, liners and diapers. Special wastes were mostly composed of batteries, fluorescent lamps and perfume and air spray containers.

Table 6. Solid Waste Characterization.

Materials	Average Composition by weight	Average Composition by volume
Total Bio-degradable	75.41%	54.44%
Non Bio-degradable	24.03%	43.28%
a. Recyclable	21.41%	
b. Residuals	2.80%	
Special Wastes	0.56%	2.28%
Total Waste	100%	100%

Table 7. Recyclables Composition (kg/day).

COMPOSITION	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	TOTAL kg/day	% Weight to Recyclables	% Weight To Total Waste
Plastic	8.83	7.44	2.50	10.17	7.24	9.80	12.98	58.96	51.41%	21.91%
Dry Paper	2.60	1.16	9.32	3.50	2.16	2.10	0.00	20.84	18.17%	7.74%
Metals	0.702	1.775	2.33	2.45	0.85	1.3	0.75	10.16	8.86%	3.77%
Glass/Bottles	2.850	2.650	0.600	0.750	0.250	1.350	1.450	9.90	8.63%	3.68%
Leather and Textile	2.35	1.81	1.95	0.25	0.2	2.1	0	8.66	7.55%	3.22%
Others	2.126	0.8	0	0.6	0.6	1.85	0.2	6.18	5.38%	5.38%
Total Recyclable Waste								114.69	100.00%	42.61%
Total Waste								269.16		100.00%

The biodegradable wastes (75.37%) generated by the respondents in the study which are mainly composed of food-left overs and garden wastes should be diverted into usable materials. Barangay 22 is situated in highly urbanized area characterized by many industrial and commercial establishments thus solid waste management programs such as composting would not be feasible hence the area lack space for the facility to be constructed. Pursuing the plan for composting and diversion of recyclables via the MRF, the barangay has to consider partnership with other barangays for the facilities' realization and incorporating all logistical requirements to transport this much of waste daily.

Solid Waste Management Survey Results

The result of the survey describes the knowledge, attitudes and practices of the respondents on the solid waste management.

Solid Waste Disposal

Fig. 3 shows that 16 households or 55% of the respondent's waste were collected by garbage collectors every day, 17% or 5 households reported that their wastes were collected weekly and the other remaining 28% of the respondents or 8 households said that their wastes were not collected at all. The main cause for this was that the barangay are only dependent on the collection schedule of the garbage collectors provided by the city. Those houses that are located near the roads will be collected but those in slum areas will not be included due to road inaccessibility. Usually residents which were not reached by garbage collectors will dispose their solid waste in an open area or in the creek (Al-khatib *et al.,* 2010). The types of solid waste generated by the respondents in the seven-day solid waste characterization study are shown in Fig. 4. Most of the wastes generated by the respondents are cellophanes - all of the households generate this type of waste - followed by the cans and papers, vegetables and fruit peelings, plastics, bottles, e-waste and lastly textiles. This shows that the barangay should implement an ordinance minimizing the use of cellophanes which is commonly the cause of the clogging (Bernardo, 2008) of the waterways (canals and drains) causing overflow of water (floods) and even damaging road infrastructures (Babayemi & Dauda, 2009) and bringing problem to many people.

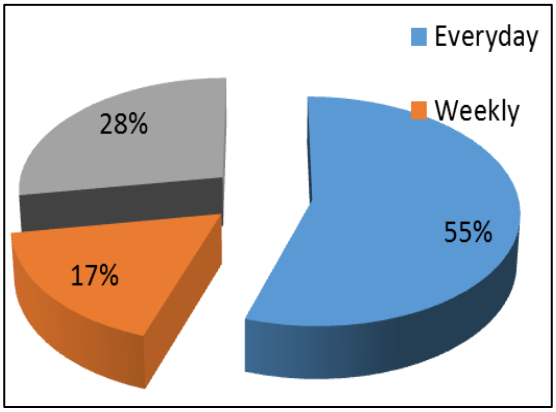

Fig. 3. Percentage of households catered by the City's garbage collectors in Brgy.

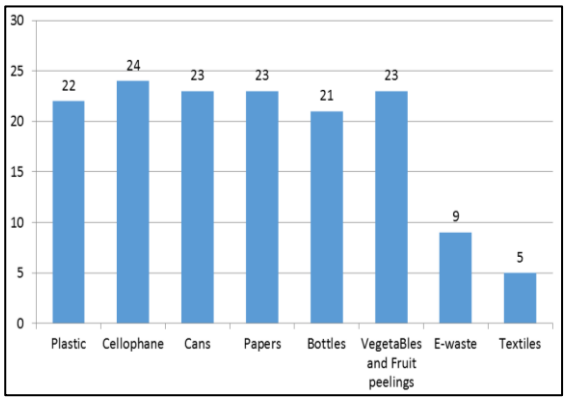

Fig. 4. Types of solid wastes generated in Barangay 22.

On the survey regarding waste segregation, Fig. 5 shows that 75% of the respondents do not practice segregation at source because according to them they only have one container for their waste and also it's useless to segregate their waste since during collection, garbage collectors will just mix all the wastes inside the truck. The remaining 25% of the respondents practice segregation and have their own set of receptacles for biodegradable & non-biodegradable waste. Hence, the practices towards waste segregation of the households were affected by the availability of waste containers and the way of waste collection where all the generated wastes were mixed together neglecting the essence of segregation done by the households.

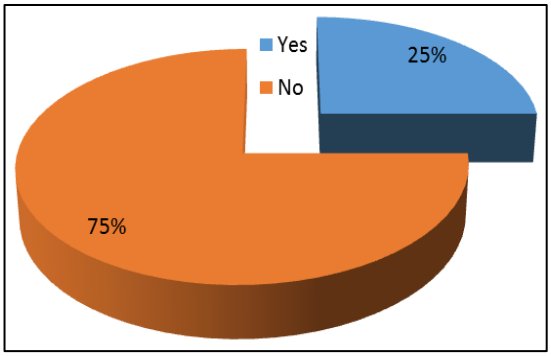

Fig. 5. Respondents who practice waste segregation in Brgy. 22.

Knowledge, Attitudes and Practices of the Respondents on solid waste management.

Table 8 indicates that most of the respondents know the importance of solid waste management and the hazards brought by these waste to their health and environment. Respondents were aware that there are ordinances implemented in their barangay regarding the proper disposal of solid waste and most of them know about waste segregation and had an idea on the4 R's (Refuse, Reuse, Reduce, and Recycle) of waste reduction. In the attitude section,

Table 9 indicates that respondents had a favorable attitude towards solid waste hazards. Respondents also show an active response on waste reduction through recycling and reusing of waste materials.

Table 8. Knowledge on Solid Wastes.

	Questions	Yes (Frequency)	No (Frequency)
1	Do you know what waste is?	24	0
2	Do you know about segregation of waste?	22	2
3	Do you have any idea about the 4 R's (Refuse, Reuse, Reduce, and Recycle)?	22	2
4	Are you aware that the waste you generated contains chemicals that contaminate our water?	22	2
5	Do you know that burning of waste is not an effective way of waste reduction?	21	3
6	Do you know that dumping of waste near your house may cause adverse effects in your health and environment?	24	0
7	Are you aware that plastics and bottles do not easily degrade?	22	2
8	Do you know that dumping your garbage everywhere is the reason why there's clogging of drainage and flooding?	24	0
9	Do you know what Biodegradable and Non-Biodegradable means?	21	3
10	Do you know the different ordinances implemented in your barangay regarding waste disposal?	22	2

Table 9. Attitudes towards solid waste hazards.

Questions		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
		(Frequency)				
1	Do you agree that you should avoid handling solid waste that contains toxic chemicals such as broken bulbs, batteries and thermometer?	17	7	0	0	0
2	Do you agree that you should cover your nose whenever you smell burnt wastes?	23	1	0	0	0
3	Do you agree that reusing or recycling used plastics reduces waste production?	23	1	0	0	0
4	Do you agree that it is all right to re-use old plastic bottles?	21	3	0	0	0
5	Do you agree that everyone should follow the laws, policies and ordinances implemented in your barangay regarding solid waste?	20	4	0	0	0

The respondent's knowledge and attitude shows favorable response but their practices contradict to what the result indicates (Table 10). Some of the respondents still dump their waste in open areas and creek even though they were aware that there are policies that prohibit dumping of garbage in particular areas particularly in open areas and creek. The respondents know about waste segregation but failed to segregate their waste before handling it to the garbage collectors. This indicates that the respondents had poor practices in terms of managing their waste (Babaei *et al.,* 2015). The reason behind of this is the weak implementation of the ordinances, poor collection facilities (Banga, 2011) and lack of waste receptacles.

Table 10. Practices towards Solid waste hazards.

	Questions	Always	Sometimes	Never
		(Frequency)		
1	Do you throw your garbage properly?	7	15	2
2	Do you make sure that your waste receptacles are always closed?	10	9	5
3	Do you segregate first your waste before you throw it or handle it to the waste collectors?	6	7	11
4	Do you sell your recyclable wastes?	7	6	9
5	Do you educate your household members on the proper handling of waste?	13	11	0
6	Do you dispose your waste in an open area or in the creek if the garbage collectors failed to collect the waste on that day?	2	17	5
7	Dou you follow the policies, laws and ordinances regarding solid waste?	11	12	1

Solving Waste Problems

In response to the problems that occurred in the community, the Barangay has its own community cleaning locally known as "*pahina*" which is represented by each member of every household. Signages regarding prohibition of throwing of garbage in particular areas were also posted. But the problem lies with the willingness of the residents to properly manage their waste. Sanitation problem is common particularly in the urban areas for the residents are uncooperative and act irresponsibly on their wastes (Desa *et al.,* 2011). The collection of waste always failed and has long time interval for the next collection. The bottom line of this is that, solid waste management should be funded appropriately particularly its collection facilities to be able to cater all the constituents in the Barangay (Lebersorger & Beigl, 2011) & (Guerrero *et al.,* 2013). Waste segregation at source will be properly implemented if the policy on "No segregation, No collection." will be strictly enforce (Matter *et al.,* 2013). and also, the time of collection of waste should be set to prepare the constituents when to bring their wastes outside their homes to avoid scavenging by stray animals.

Conclusion and recommendations

Barangay 22 has a total estimated population of 2,660 and is projected to increase by 3,316 after 10 years given that the annual growth of population is still similar to Cagayan de Oro's rate of growth at 2.23% between 2010 to 2015 (Annex I).The average waste generation of Barangay 22 is 1.18kg/ household/day which is equivalent to 0.044cum/ household/day. Households from high income category generate an average of 1.11 kg/household/day while households from middle income category generate an average of 0.9kg/ household/day and low income category households generate 1.5kg/ household/day.

The per capita calculation is 0.25kg/ day/capita which did not conform to the expected waste generation of 0.5kg/ day/capita in urban barangays. This might be attributed to the high percentage (55%) of household samples catered by the city's garbage collectors daily. Nevertheless results show low level of awareness among barangay citizens on proper practice of segregation which hinders recycling and failed to reduce wastes. This is shown by the high percentage (75%) of respondents who does not practice solid waste segregation.

Residents have thorough knowledge on the possible problems that may occur as consequences of unmanaged garbage disposals especially health problems despite of the inadequate support from the municipal LGU. Others were partly aware of the long term effects of burning the solid waste including plastics and other biodegradables to the environment and dumping to open areas will contaminate groundwater supply but some do not have any idea about it. Respondents said they do not have other options since garbage collectors will not be there to collect waste, everybody is doing it and not disposing them immediately will create direct problems and annoyance due to its foul odor that will affect their health. Barangay 22 obviously does not have their own garbage collectors and rely upon the city garbage service collection. Another problem is that, the Barangay lack space for solid waste management programs to be realized, for example establishing composting facilities. In order to address this problem, the Barangay should partner with adjacent barangays to divert the bulk of biodegradable waste and divide the expense of the service.

The solid waste characterization study is essential for a long term projection on the planning for solid waste management in the framework of 10-year plan as mandated by RA 9003. Based on the projections generated by the team, the projected waste will range from 242, 697kgs in 2016 to 302, 585kgs in 2026. There will be an increase of 24.68% of waste generation within 10 years for Barangay 22. Composting facility, controlled dumpsite or sanitary landfill and regular schedule of waste collection needs to be implemented to address properly not only the problem of wastes in the Barangay but also of the city itself. These programs should be incorporated in Barangay Plan to address the need and to prepare the growing population of the area.

With the completion of the solid waste characterization study, it is recommended that the Barangay should have its own Solid Waste Management Plan and organize a Solid Waste Management Committee that will oversee and focus the development of the plan. As it is the responsibility of the LGU to divert the 25% of its locally generated wastes, the committee can provide appropriate programs that will address this issue. Establishing markets for recyclables needs to be supported also to ensure the complete diversion of recyclables and Information Education Campaign activities should be done in all Purok.

In order to achieve the goal in Solid Waste Management, policy support components should be strengthened and implemented accordingly. Strict implementation of Barangay ordinance is highly recommended. In this regard, the barangay can comply with RA 9003 and its' IRR which integrates good governance practices of transparency, accountability and participation.

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Annexes

Annex A

Survey Questionnaire

A. Socio-Demographic Profile

Name:_____ Age: _____ Gender: Male ( ) Female ( ) Civil Status: _____ Religion : _____ No. of Household members: _____ Monthly Income: 10,000 below ( ) 10,000 – 20,000 ( ) 20,000 up ( )

Educational Attainment: Elementary Level ( ) High School Level ( ) Elementary Graduate ( ) High School Graduate ( ) College Level ( ) College Graduate ( ) Employment Status: Employed ( ) Unemployed ( )

B. Types of Waste generated

1. What type of wastes you usually produced?

Cellophane ( ) Papers ( ) food waste ( ) Cans ( ) Bottles ( ) e-waste ( ) Vegetables and Fruit peelings ( ) Plastics ( ) others:_____

2. How often is solid waste collected in your barangay?

Every day ( ) Weekly ( ) Monthly ( ) others: _____

3. Do you segregate your waste into biodegradable and non-biodegradable? Yes ( ) No ( )

C. Knowledge towards Solid Waste.

	Questions	Yes (Frequency)	No (Frequency)
1	Do you know what waste is?		
2	Do you know about segregation of waste?		
3	Do you have any idea about the 4 R's (Refuse, Reuse, Reduce, and Recycle)?		
4	Are you aware that the waste you generated contains chemicals that contaminate our water?		
5	Do you know that burning of waste is not an effective way of waste reduction?		
6	Do you know that dumping of waste near your house may cause adverse effects in your health and environment?		
7	Are you aware that plastics and bottles do not easily degrade?		
8	Do you know that dumping your garbage everywhere is the reason why there's clogging of drainage and flooding?		
9	Do you know what Biodegradable and Non-Biodegradable means?		
10	Do you know the different ordinances implemented in your barangay regarding waste disposal?		

D. Attitude towards Solid waste hazards

	Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Do you agree that you should avoid handling solid waste that contains toxic chemicals such as broken bulbs, batteries and thermometer?					
2	Do you agree that you should cover your nose whenever you smell burnt wastes?					
3	Do you agree that reusing or recycling used plastics reduces waste production?					
4	Do you agree that it is all right to re-use old plastic bottles?					
5	Do you agree that everyone should follow the laws, policies and ordinances implemented in your barangay regarding solid waste?					

E. Practices towards Solid Wastes Hazards

	Questions	Always	Sometimes	Never
1	Do you throw your garbage properly?			
2	Do you make sure that your waste receptacles are always closed?			
3	Do you segregate first your waste before you throw it or handle it to the waste collectors?			
4	Do you sell your recyclable wastes?			
5	Do you educate your household members on the proper handling of waste?			
6	Do you dispose your waste in an open area or in the creek if the garbage collectors failed to collect the waste on that day?			
7	Dou you follow the policies, laws and ordinances regarding solid waste?			

F. Health Issues/problems

1. Have you suffered any illness or health problems caused by garbage piles in your barangay? Yes ( ) No ( )
2. If yes, what are those particular illnesses? Cholera ( ) Skin disease ( ) Amoeba ( ) Stomach disorders ( ) Others:

Annex B

Sample Size Calculation

What is the total number of pre-sample?		=	15
What is the mean of the pre-sample?		=	2.4046
What is the standard deviation of the pre-sample (**s**)		=	2.02797601
What degree of confidence was used?		=	95%
What is the tolerable error			
Small Sample Properties (E)		=	1
Large Sample Properties (E)		=	1
Critical Value			
Small Sample	$t_{\alpha/2}$	=	2.14479
Large Sample	$z_{\alpha/2}$	=	1.645

What is the sample size?

Small Sample Formula

$$n = \left(\frac{t_{\alpha/2} * s}{E} \right)^2 =$$ 18.9188693

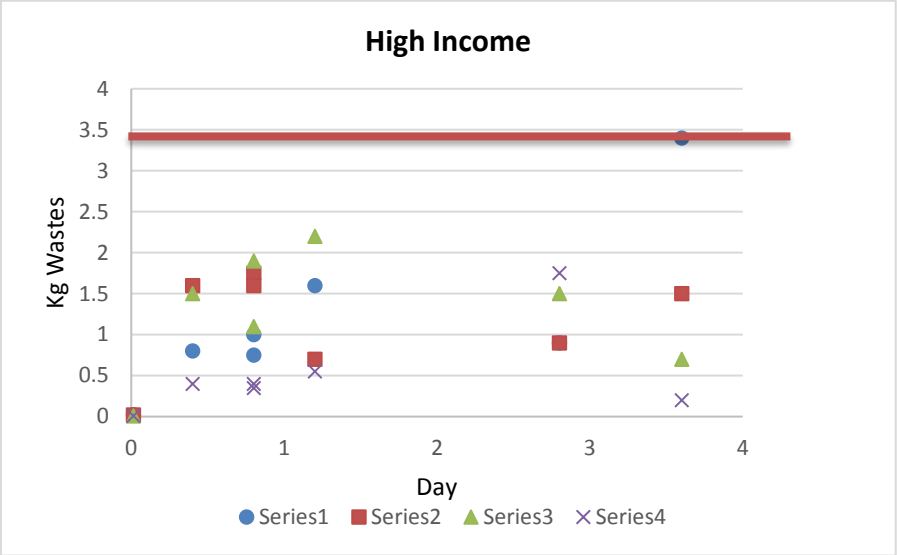
Large Sample Formula

$$n = \left(\frac{z_{\alpha/2} * s}{E} \right)^2 =$$ 11.12903

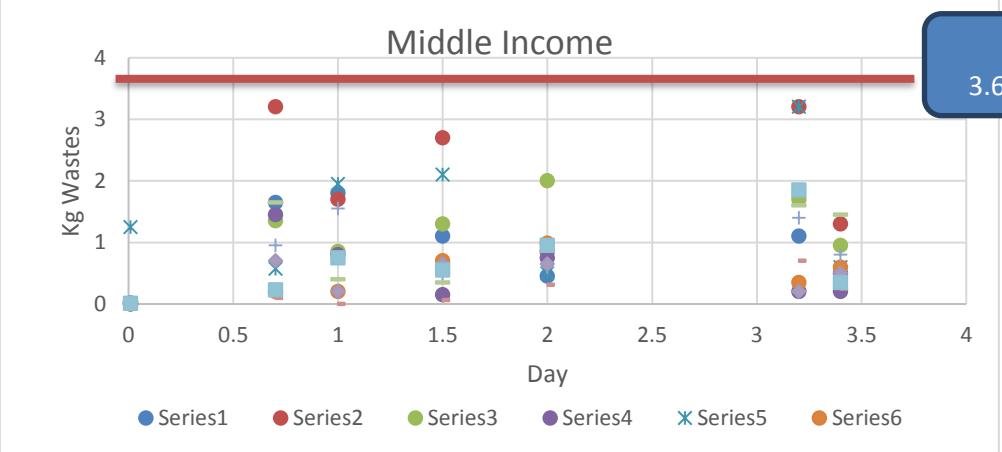
Annex C

Scatter Diagram

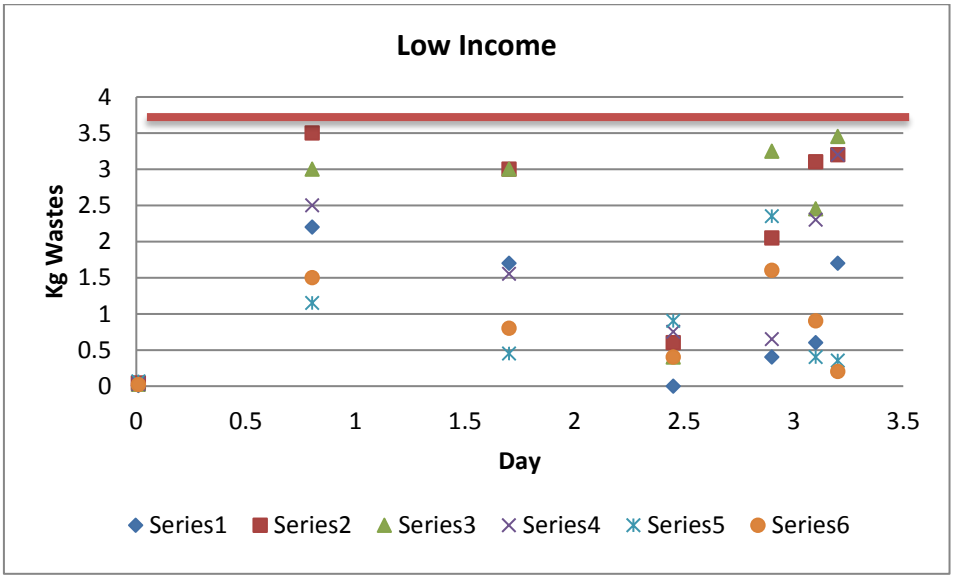
High Income



Middle Income



Low Income



Annex D

Moisture Content

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total
Fresh Weight	50.303	35.558	0.22414	30.65	28.55	33.15	38.9	217.3351
Dry Weight	46.354	33.0122	0.22414	28.61	26.75	32.845	30.499	198.2943
Moisture	3.949	2.5458	0	2.04	1.8	0.305	8.401	19.0408
Percent Moisture	8.52%	7.71%	0.00%	7.13%	6.73%	0.93%	27.55%	**9.60%**

Formula

$$\%MC = \left(\frac{Wwet - Wdry}{Wdry}\right) \times 100$$

$$\%MC = \left(\frac{217.33351 - 198.2943}{198.2943}\right) \times 100 = \mathbf{9.60\%}$$

Where: MC = moisture content

W_{wet} = fresh weight in kg

W_{dry} = weight after drying

Annex E

Estimating the Confidence Interval

With the assumption that sampling error E = 1, the confidence interval for small size population, such as this with N=24, is given by this equation:

$$\bar{x} \pm t_{\alpha/2}\, \sigma / \sqrt{n}$$

Where: the t-statistic at 95% confidence level is equal to 2.06866. By substitution using standard deviation of 0.58 and N = 168, we obtain the following confidence interval: $1.18 \pm \frac{2.06866*(0.58)}{\sqrt{168}}$

Minimum Value	Mean	Maximum Value
1.09	1.18 kg/household/day	1.27

ANNEX F

Solid Waste Characterization

1. Weight Basis

What is the total weight of waste generated per day from the sample? Kg

Source	*Day 1*	*Day 2*	*Day 3*	*Day 4*	*Day 5*	*Day 6*	*Day 7*	*Total*	*Average*	*Weight per unit*	*Per day/unit*
Low Income	0.1871	14.952	5.5	13.2	12.2	12.85	15.3	74.1891	10.59844286	8.243233333	1.177605
Middle Income	1.3321	12.756	11.05	11.2	11.65	10.9	18.7	77.5881	11.08401429	19.397025	2.771004
High Income	0.0744	0.0506	0.0096	0.0371	0.22712	0.0346	0.0219	0.45532	0.065045714	0.22766	0.032523
Total	1.5936	27.7586	16.5596	24.4371	24.07712	23.7846	34.0219	152.23252		Average	1.327044

What is the composition of materials from total solid waste from the sample? Kg

Materials	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	TOTAL kg/day	Average Composition by weight
Total Bio-degradable	50.30	20.42	5.40	14.65	16.25	17.85	16.00	400.94	75.37%
Non Bio-degradable	30.35	16.14	16.70	17.70	11.30	18.30	17.48	127.97	24.05%
a. Recyclable	19.355	14.688	16.70	17.70	11.30	16.06	17.48	113.28	21.29%
b. Residuals	3.350	1.800	1.65	1.60	1.60	2.85	2.84	15.69	2.95%
Special Wastes	2.126	0	0.00	0.00	1.00	0.00	0.00	3.13	0.59%
Total Waste								532.03	100%

2. Volume Basis

What is the total volume of waste generated per day from the sample in cubic meter?

Source	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total	Average	Weight per unit	Per day/unit
Low Income	1.3471	0.0799	0.0233	0.0811	0.0556	0.0659	0.0508	1.7037	0.243385714	0.1893	0.027043
Middle Income	0.2022	0.31617	0.22987	0.3201	0.19372	0.33188	0.23157	1.82551	0.260787143	0.4563775	0.065197
High Income	0.0443	0.0712	0.0609	0.0969	0.11067	0.1163	0.0604	0.56067	0.080095714	0.280335	0.040048
Total	1.5936	0.46727	0.31407	0.4981	0.35999	0.51408	0.34277	4.08988		Average	0.044096

What is the composition of materials from total solid waste from sample by volume in m3?

Materials	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	TOTAL cum/ day	Average Composition by volume
Total Bio-degradable	0.16	0.45	0.22	0.13	0.09	0.15	0.09	1.29	54.44%
Non Bio-degradable	0.1851	0.13347	0.04967	0.2003	0.10731	0.21198	0.13867	1.03	43.28%
a. Recyclable	0.1851	0.13347	0.2003	0.0203	0.10731	0.21198	0.13867	1.00	
b. Residuals	0.000	0.000	0.034	0.000	0.000	0.000	0.000	0.03	
Special Wastes	0	0	0	0.027	0.027	0	0	0.05	2.28%
Total Waste	0.35	0.58	0.27	0.36	0.22	0.36	0.23	2.37	100%

Annex G

Solid Waste Density Calculation

Unit	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total
Total Weight (kg)	50.303	35.558	0.22414	30.65	28.55	33.15	38.9	217.3351
Total Volume	0.0015936	0.00046727	0.00031407	0.000498	0.000301	0.000514	0.000343	0.029618

$$Density = \frac{weight\ (tons)}{\text{volume (cum)}}$$

$$0.04188 = \frac{217.3351\ /\ 1000}{0.029618}$$

Density =7.34 tons/ m^3

Annex H

Photo Documentation

Barangay Hall Office of Barangay 22

Weighing Samples during the Pre-sampling Activity

Weighing Samples during the 7-day Characterization

Drying of Waste Samples

Meeting and Orientation with the different Purok leaders and Barangay officials together with the TWG.