SOLID WASTES GENERATED FROM SELECTED SECONDARY SCHOOLS IN CLAVERIA, MISAMIS ORIENTAL, PHILIPPINES

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ABSTRACT. *Amidst the strong enforcement of Republic Act 9003, otherwise known as the "Ecological Solid Waste Management Act of 2000", many secondary schools still struggle to address issues on solid waste management because they lack facilities and have implemented waste management practices but no data as to the composition and quantification of solid wastes it produced. Waste composition studies were only carried out in tertiary schools in the municipality of Claveria but none in the secondary schools. This study characterized and quantified the solid waste from selected secondary schools in Claveria, Misamis Oriental. The researcher employed purposive sampling to select Dr. Gerardo Sabal Memorial National High School (DGSMNHS) and Mat-I National High School (MNHS) as the sampling schools. A 7-day waste analysis and characterization study (WACS) was conducted to determine the solid waste composition and generation rate from the sampling schools. The study revealed that among the solid waste categories from the sampling schools, recyclable outweighs (42.08%) which was composed of paper, plastics (PET, Styrofoam), and metal followed by residuals with potential for recycling (30%) which was composed of flexible plastics and rubber. Biodegradable (20.8%) which was composed of food/ kitchen waste and garden/park waste, residuals for disposal (7.11%) which was composed of sanitary composite and soiled papers, and special wastes (0.01%) which was composed of paint container. The weekly per capita generation rate of solid wastes from the sampling schools, DGSMNHS (0.0411 kg/capita-week), and Mat-I NHS (0.0366 kg/capita-week) were found extremely below the reported average generation rate for a household. These results can be used in crafting solid waste management programs to address the problem of waste disposal in schools and for the succeeding waste characterization studies to assess the changes and determine trends in the solid waste generation data for the participating schools.*

Keywords: Solid wastes; secondary school; waste characterization; residuals; generation rate

1. INTRODUCTION

Schools are one of the largest yet frequently overlooked sources of significant solid waste generation worldwide. Schools generate a large amount of waste, including paper, cartons, cans, broken bottles, and polymers that could be recycled but are discarded instead [12]. According to [5], over 70% of school waste consists of food, paper, and cardboard. Of this, 80% is recyclable, unfortunately, only 20% gets recycled. In the Philippines, despite the strong enforcement of the Republic Act No. 9003 otherwise known as the "Ecological Solid Waste Management Act of 2000", many schools still struggle to think of imaginative ways to implement effective waste management and to have an effective and efficient waste management program [29].

In 2008, Republic Act No. 9512, otherwise known as the "Environmental Awareness Education Act of 2008," was enacted to mandate public or private schools at all levels to integrate environmental education into the curricula. This initiative aims to enhance awareness within the education community regarding effective waste management practices, fostering a positive change from existing unsustainable behaviors and practices [25]. In line with this, the Department of Education then released [10] to intensify learners' awareness of solid waste management. However, [28] found that students still have low knowledge of the different laws relevant to solid waste management. Additionally, others reveal in their study that though students are given education on solid waste management such as recycling and proper segregation, the issue of SWM remains unsolved because schools implement generic waste management strategies that are not tailored to the specific types of waste produced in the schools. The same study then adds that schools still lack efficient waste sorting facilities and working recycling programs [29].

The participating schools in this study have comparable issues with solid waste management. Every school has a Material Recovery Facility (MRF) however it only serves as a temporary storage area. When the barangay delays solid waste collection, there are times that the amount of waste to be disposed of sometimes surpasses the holding capacity of the school's MRF. This produces mixed waste streams, which can lead to contamination, making it difficult to recycle items properly.

These problems will be resolved if schools have reliable waste management data. According to [36] as cited by [2], using data such as the composition, weight, and volume of waste generated from a school, the largest issue of developing comprehensive solid waste management (SWM) programs will be given direction, which will help achieve institutional sustainability. Some [27], also state that having accurate waste management data is crucial for thoroughly and informatively assessing various waste management options in all programs. [2] then supports that to manage waste effectively on a school campus, it's important to understand the different types of waste and their generation rates. This knowledge contributes to the appropriate management, treatment, and disposal of waste. However, [2] emphasizes that some, if not many, schools take for granted waste characterization studies on their respective campuses. The researcher discovered that no studies on solid waste analysis and characterization have been conducted in public secondary schools in the municipality of Claveria. Most studies on the composition of solid wastes have only been done in tertiary schools.

Therefore, this research attempts to address this gap in knowledge by determining the composition, weight, and volume of waste generated by the participating secondary schools. These schools have been chosen for this study since aside from its population size, the waste generation rate and

their corresponding composition have not been reported despite the municipality's strong implementation of RA 9003.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Claveria is a non-coastal municipality in the province of Misamis Oriental composed of 24 barangays. It has ten (10) duly recognized public secondary schools. The study was conducted in the two (2) largest secondary schools in the municipality, the Dr. Gerardo Sabal Memorial National High School (DGSMNHS) and Mat-I National High School (MNHS).

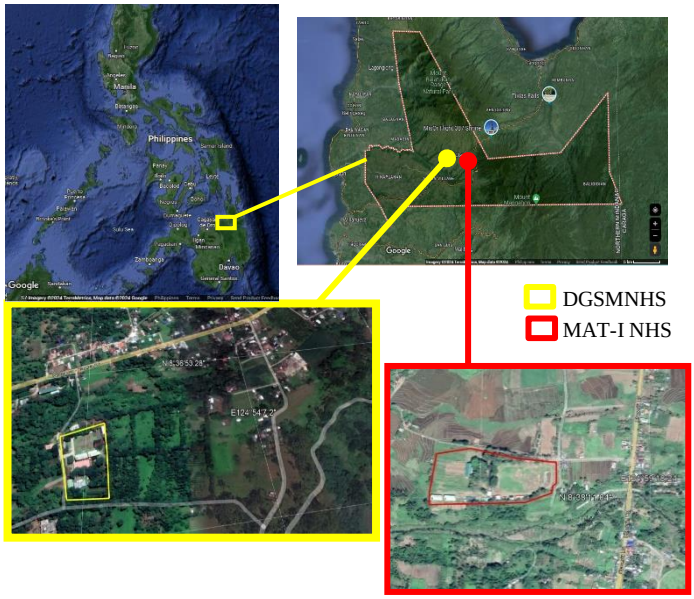

Figure 1. Map of the Philippines highlighting Claveria, Dr. Gerardo Sabal Memorial National High School, and Mat-I National High School (sampling schools)

Source: Google Maps; Google Earth

DGSMNHS is located in Claveria Central District in Barangay Poblacion (see Fig.1). The school has fourteen (14) buildings, but only 3 buildings are 2-story and 7 buildings are 1-story used for instructional purposes and offices. It has approximately 1843 individuals including learners, faculty, and other school personnel from both junior and senior high schools. On the other hand, Mat-I NHS is located in Claveria Northeast District in Barangay Mat-i (see Fig. 1). The school has fifteen (15) buildings, but only 3 buildings 2-story and 7 buildings 1-story used for instructional purposes, and 3 buildings used as offices. The school has approximately 700 individuals including learners, faculty, and other personnel from both junior and senior high schools.

The researcher selected sampling sites from the sampling schools which include the school canteen, buildings where grade-level learners from Grade 7 to Grade 12 are situated, and the offices.

2.2 Data- Gathering Procedure

Before data collection procedures, the researcher asks permission from the concerned authorities and secures necessary endorsements before conducting the study. A letter of Permission to Conduct the Study was given to the Schools Division Superintendent of the Division of Misamis Oriental requesting permission to allow the researcher to conduct the study in the two (2) largest secondary schools in the Municipality of Claveria. Upon approval, copies of the approved letter were given to the assigned District Supervisors and the School Principals. A courtesy call to the Municipal Mayor, the Barangay Officials, and training of the Technical Working Group (TWG), Waste Analysis and Characterization Study, and data evaluation and analysis.

2.3 The conduct of seven (7) -day WACS

The steps followed in this study are adopted from the study of [13] and [30].

- ***Collection of Sample***
  The samples were selected from twenty percent (20%) of the total receptacle bins present in the target area. The collection of waste started at 4:00 pm. Unsorted wastes were taken from each selected sampling site. Wastes from each receptacle bin were collected using trash bags and brought to the sorting station. The initial weight and volume of the entire sample were recorded before sorting it.
- **Waste Characterization**
  Black bags were provided for the proper segregation of the collected waste samples. The solid waste samples were sorted according to their composition whether biodegradable, recyclable, residual with potential for recycling, residual for disposal, and special waste.
- **Determination of Weight and Volume before Air Dry**
  A calibrated empty container was used to measure the volume of the collected waste samples while a 40-kg weighing scale was used to measure the weight of the sample.
- **Air Drying Process**
  After proper segregation, the segregated wastes were subjected to air drying for 2 hours. Its purpose is to reduce the water content in the collected waste.
- **Determination of Weight and Volume after Air Dry**
  After air drying, the wastes were measured again to determine their final weight and volume.
- **Determination of Percent Mass Composition**
  The percent Mass Composition of each waste classification was determined using Equation 1[2];

$$Wt\%\ of\ material = \frac{mass\ of\ material}{the\ total\ mass\ of\ waste} \times 100 \quad Eq.\ 1$$

- **Determination of Waste Generation Rate**
  The waste generation rate per kg/capita-week was determined using equation 2 [2];

$$GenRate\ by\ Capita = \frac{mass\ of\ wastes}{\#\ of\ waste\ generators} \quad Eq.\ 2$$

On each sampling day, the researcher counted the number of waste generators from each source, including students, faculty, and staff whose waste contributed to the school's waste stream for the School Year 2023-2024. This inclusion was essential to quantify the waste generated when they were present on-site.

2.4 Statistical Analyses

The data were processed, analyzed, and interpreted using waste compositional analysis.2.3 The Conduct of seven (7)-day WACS.

3. RESULTS AND DISCUSSION

Table 1. Composition of solid wastes from the sampling schools

Waste Categories	Waste Composition	Percentage of Waste Composition of the Sampling Schools (7 days sampling period)			
		Weight (kg)	Weight (%)	Volume (L)	Volume (%)
Biodegradable	Food Waste	8.87	8.75	28.90	1.33
	Garden Waste	12.22	12.05	149	6.85
Recyclable	Paper	31.02	30.60	527.35	24.26
	Plastics (PET,styro)	9.88	9.75	261.03	12.01
	Glass	1.25	1.23	2	0.09
	Metals	0.51	0.50	3	0.14
Residuals with recycling potentials	Flexible Plastics	30.12	29.71	1154.4	53.10
	Rubber	0.296	0.29	1.25	0.06
	Sanitary Composites	2.51	2.48	11	0.51
Residuals for disposal	Soiled Paper	4.69	4.63	35.70	1.64
Special	Paint Container	0.01	0.01	0.25	0.01
	TOTAL	101.376	100	2173.88	100

Table 1 presents the percentage of solid waste composition from the sampling schools, covering both weight and volume over a 7-day sampling period.

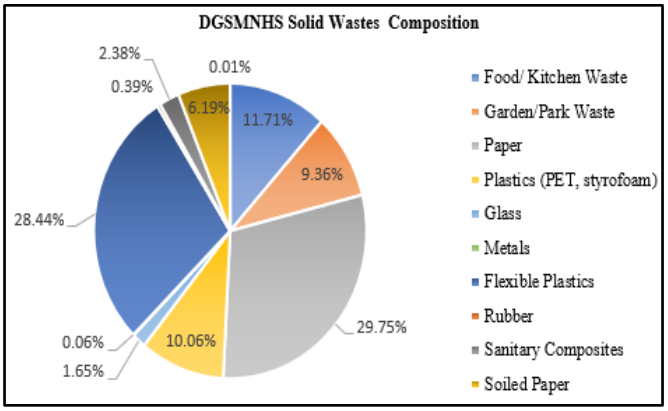

Figure-2. Distribution of solid waste compositions from DGSMNHS (Dry Weight %)

The results showed that recyclable materials made up the highest percentage of solid waste composition at DGSMNHS and Mat-I NHS, comprising 42.08%. It mainly comprises paper, plastics (PET and styrofoam), glass, and metals. It was then followed by residuals with potential for recycling which is 30%. It is mainly composed of flexible plastics and rubber. Biodegradable which is mainly composed of food/kitchen and garden/park waste has 20.8%. Residuals for disposal which is 7.11% composed of sanitary composites and soiled papers and special waste composed of paint containers is 0.01%. The high recyclable waste component of the solid waste generated from the sampling schools indicates a high potential for recycling.

[35] similarly found that aside from organic waste, paper constituted the largest component of solid waste generated in schools, comprising approximately 29.0%, followed by plastics at 18.0%. Additionally, [2,24,38,41] all conducted studies on the composition of solid waste in various educational institutions. [2] found that organic waste was the largest component, while [24] identified plastic and paper as the primary waste materials. [38] study at a university campus revealed a significant portion of recyclable materials, including paper, glass, plastic, and metals. [41] study at the University of Nigeria, Nsukka, also highlighted a high percentage of recyclable waste, with organic and polythene being the most dominant components. These studies collectively underscore the need for effective waste management strategies, particularly in educational institutions, to address the significant presence of recyclable materials.

Paper (29.75%) dominated the solid waste composition of DGSMNHS. This was thoroughly followed by flexible plastics (28.44 %), food/kitchen wastes (11.71%), PET Plastics (10.06%), garden/park wastes (9.36%), soiled paper (6.19%), sanitary composites (2.38%), glass (1.65%), rubber (0.39%), metals (0.06%), and paint container (0.01%), respectively. This finding aligns with the study by [13] on solid waste characterization at the University of Science and Technology of Southern Philippines, Cagayan de Oro Campus, where the paper had the highest percentage by both weight and volume. The main reason for this is that paper and other paper products are the main academic tools for learning and documentation [13]. Aside from paper, flexible plastics comprised the second-highest composition of recyclables. A comparable result was found in [1], indicating that plastic waste, following rubber, was the second-largest component in the waste stream.

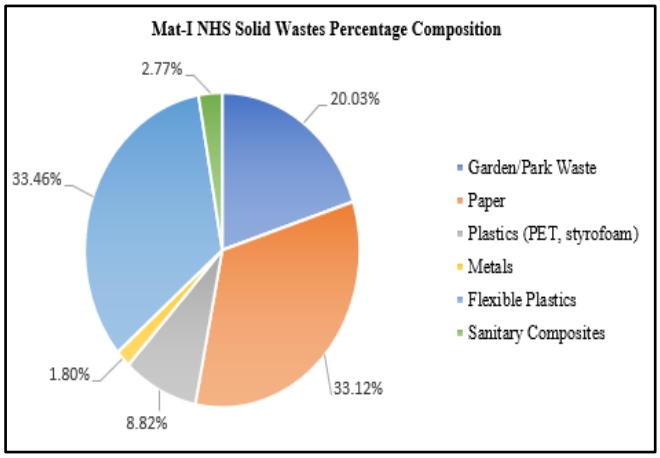

Figure-3 Distribution of waste compositions from Mat-i NHS (DryWeight %)

The highest generation of flexible plastics (33.46%) outweighed the solid waste composition from Mat-I NHS. Results of the study have shown that significant weight of paper (33.12%), garden/park wastes (20.03%), PET bottles (8.82%), sanitary products (2.77%), and metals (1.80%) were evident. A similar finding was obtained in the study of [13] that other plastic products are still in higher percentage compared to other waste compositions since plastic waste is composed mainly of packaging, plastic products, hard and flexible plastic household items, PET bottles, plastic cans, etc. Plastic waste, especially packaging materials, does not decompose or compact easily, significantly impacting transportation costs and landfill longevity [13, 32]. Garden and park waste, which dominate the biodegradable category, are potential materials for composting. Similarly, [2] found that yard and food wastes are suitable for making organic compost.

Paper and flexible plastics dominated the solid waste composition at both sampling schools. The findings are supported by [24] stating that solid wastes generated by students from the schools were mostly from food packages and school materials such as papers, cardboard, and plastic bags. His study revealed that plastic waste had the highest proportion in Christian (36%) and technical (64%) schools. This finding is similar to the study of [2] on the solid waste management response of selected public secondary school science teachers where the solid waste generated in schools was mainly plastics, papers, food waste, and polyethylene (PET) bottles. Furthermore, the same result was obtained in agreement with waste characterization studies in the Philippines revealing plastics and papers as dominant SW [4, 15, 16, 31, 44].

Thus, converting a high percentage of paper waste into valuable products is economically beneficial as it saves energy and water resources and contributes to forest conservation [35]. However, adopting and implementing a recycling strategy as a sustainable method for treating solid waste depends on the volume of recyclable waste generated [3, 35].

Table 2: Solid Wastes Generation Rate

School	Per Capita Generation Rate
	(kg/capita-week)
DGSMNHS	0.0411
Mat-I NHS	0.0366

Table 2 illustrates the weekly per capita solid waste generation rate of the sampled schools.

The highest per capita generation rate was from DGSMNHS with 0.0411 kg/capita-week while Mat-I NHS generated 0.0366 kg/capita-week. This was computed using the school year 2023-2024 population of the respected sampling schools. Results showed that the generation rates from the sampling schools were found extremely below the reported average weekly household per capita generation rate of 0.171-29.03kg [2]. This finding is similar to the study of [2] on the composition of solid wastes generated from a school campus where classrooms and offices generated wastes were found extremely below the reported average generation rate (0.031 kg/capita-week) and food services were found to have the least generation rate (0.024kg/capita-week).

The findings of [35], indicate that data on per capita waste generation helps in planning and decision-making on the size and number of bins to be used for waste collection including the frequency.

The results of the study imply that sampling schools have practiced solid waste management initiatives. DGSMNHS practices the 'Basura Mo Iuwi Mo' initiative while Mat- I NHS practices segregation at source strategy wherein designated receptacle bins are available in every classroom and the school has a vermicomposting facility.

A critical analysis of the findings above suggests that the characteristics of solid wastes differ from different locations in terms of composition, quantities, and generation rates. [35, 42] confirm this assertion by stating that solid wastes are heterogeneous and have varying features, depending on their origins, and require a different method for their treatment. The waste generation rate depends on factors, such as population density, economic status, level of commercial activity, culture, and city/region [21].

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the study, paper and plastics (PET bottles) dominate the recyclable wastes which have the potential for additional income if sold to junk buyers and can be utilized for new products if recycling facilities are available. Residual wastes with potential for recycling are mainly composed of flexible plastics (juice wrappers, plastic cups, and straws). Biodegradable wastes showed potential generation. Thus, it is recommended that segregation at source must be practiced to increase the recycling potential of the recyclable wastes. The use of tumblers in school and having composting facilities are also encouraged.

The weekly per capita generation rate of solid waste from the sampling schools namely, DGSMNHS (0.0411 kg/capita-week) and Mat-I NHS (0.0366 kg/capita-week) were found extremely below the reported average generation rate for households. However, it is still a contributing factor to solid waste management problems if not sustainably managed. Therefore, it is highly recommended that Information, Education, and Communication programs should be sustainably implemented and policy briefs on solid waste management should also be developed in schools.

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