Solid Waste Generation in the Agricultural Communities of New Corella, Davao del Norte, Philippines

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ABSTRACT

Solid waste management is a neglected practice in rural areas posing environmental threats. In this study, solid waste generation in the agricultural communities of New Corella, Davao del Norte, was assessed. Materials were collected, sorted, weighed, and classified into compostable, recyclable, residual, and special wastes. A total of 830.3 kg ± 0.100 mg of garbage was collected and characterized as recyclable (25.95%), residual (68.42%), and unique (5.62%). Results revealed that Site 2 showed the highest recyclable waste (31.33%), Site 5 (84.03%) had the most increased residual waste, and Site 2 (13.93%) had a proportion of particular waste. The highest composition of solid waste is non-recyclable from the cellophane category (42%). The findings indicate the need for solid waste management re-orientation of RA 9003 at a barangay level.

Keywords: *solid waste management, RA 9003, agricultural communities, New Corella.*

INTRODUCTION

Waste is a necessary and residual outcome of human activities (Cheremisinoff, 2003; Michael-Agwuoke, 2012) and is categorized into three categories based on their physical states: solid, liquid, and gas, although certain features already exist in other nations (White et al., 1993). Solid wastes include municipal waste, biological waste, electronic trash, and hazardous garbage, both decomposable and non-putrescible materials (Basu, 2010; Kaseva & Gupta, 1996). Agricultural wastes are generated by animal raising, plant seeding, and milk production (Tchobanoglous, 1993), including animal feces and various crop remnants (Williams, 2005).

Since then, waste has been a global problem due to a significant rise in migration from rural to urban regions, hence a considerable increase in the garbage (Williams, 2005; Gutberlet, 2017). Due to an increased population, many countries have increased waste generation over time, such as the United States producing around 12% of worldwide municipal solid waste (Tiseo, 2021), and China has increased garbage rapidly to approximately 54 million tons of hazardous trash expected to be disposed of by 2021 (Liu et al., 2019). Japan produces about 42.7 million metric tons of garbage (Klein, 2021). Roughly 60 million tons of municipal solid trash are created, equating to more than 400 kg of refuse per citizen in Russia (IFC-World Bank, 2019), while Australia has a higher garbage generation rate than the average Western economy (Tomaras, 2020). India has increased waste generation due to urbanization, industrialization, and economic development, endangering the environment and public health (Kumar et al., 2017; Singh, 2020). Indonesia is projected to produce 150,000 tons daily by 2025 (World Bank, 2020).

UNEP reported that the Philippines is the fourth largest emitter of solid waste, creating 14.66 million tons of refuse each year (Bagayas, 2020), and was labeled as one of the globe's major marine plastic pollutants, following Indonesia and China. The country generates an astounding 2.7 million tons of plastic garbage yearly, with an estimated 20% directed into the ocean (World Bank, 2021). It is expected to expand by 65% by 2025, to 77,776 tons per day, from the current level of 29,315 tons, as a byproduct of a projected 47.3 % increase in the urban population (Ng, 2012).

Despite the mandate of Republic Act 9003, statistics showed that 39.39% did not conform to solid waste management, 27.53% did not meet the standard for isolation, 44.38% did not have a material recovery facility, and 10.11% disapproved of disposal facilities (Tantuco, 2018). With this scenario, the country faces serious problems. Locally, there is an observable waste problem in New Corella, Davao del Norte. Since solid waste management is crucial to preventing risks and health hazards, this paper intends to investigate the solid waste generation of the agricultural communities in New Corella, Davao del Norte, which aims to characterize solid waste generation, analyze the composition of solid waste, and compare the composition of solid waste generation. This paper would serve as a baseline for the intervention plan of the local government units to improve solid waste management in agricultural communities.

METHOD

The researchers employed descriptive research with a quantitative analysis approach (Madrigal, 2018) focused on waste generation of five endemic areas: Site 1 (Del Pilar), Site 2 (Poblacion), Site 3 (New Cortez), Site 4 (Carter), and Site 5

(Santa Cruz) in New Corella, Davao del Norte. Protocols were secured following the maximum guidelines set by the Inter-Agency Task Force for the Management of Emerging Infectious Diseases (IATF-EID) during sampling. Entry protocols were processed with the respective government units of each study area (LGU, MENRO) during data collection.

In each endemic area, waste material was collected based on scheduled submission through the material recovery facility (MRF). The specimen was classified and sorted according to the classifications under RA 9003: compostable, recyclable, residual, and particular waste (Aquino et al., 2013; NSWMC, 2016). Each classified material was weighed, recorded, and analyzed using the equation below (Tassakka et al., 2020) where:

$$PC = \left(\frac{PL}{PT}\right) * 100$$

P.C. refers to the percentage of each group, P.L. is the weight of classified waste, and P.T. is the total waste. Per capita waste generation was calculated using the formula below.

$$per\ capita\ waste = \frac{waste\ generated\ (kg)}{population}$$

RESULTS AND DISCUSSION

Waste Characterization among Agricultural Communities

It is crucial to identify and characterize the waste generated in an area to have appropriate waste management policies. In this study, only the classification of wastes submitted at the

MRF was physically surveyed. The submitted wastes in the facility include a listing of newspaper/corrugated cardboard/ office paper, cellophane/candy wrappers/ sachets, sanitary napkins/ disposable diapers, ferrous scrap metal, household batteries, worn-out rugs, glass bottles, plastic bottles, face masks, tin cans, T.V. sets, and tires (Table 1).

A total of 830.3 kg ± 0.100 mg wastes was collected and segregated from the five (5) endemic areas. For all the endemic areas surveyed in New Corella, Davao del Norte, MSW generation ranges from

Table 1
Solid Waste Generated in the Agricultural Communities of New Corella, Davao del Norte in 2022

Endemic Areas	Pop as per the 2015 census	Waste generated (kg)	Waste sub-classification			Waste generated (kg/capita)	Waste Categories												Total
			Recyclable in kg(%)	Residual in kg(%)	Special in kg(%)		Newspaper/ Corrugated cardboard/ Office Paper	Cellophanes/ Candy wrappers/ Sachets	Sanitary Napkins/ Disposable Diapers	Ferrous Scrap Metal	H.H. Battery	Worn-out rugs	Glass Bottles	Plastic Bottles	Face Mask	Tin Cans	T.V. Sets	Tires	Weight (kg)
Site 1	5,028	255.8	69.3 (27.09)	178.5 (69.78)	8 (3.13)	0.0509	13.9 (5.4%)	103.6 (40.5%)	21.2 (8.3%)	6.4 (2.5%)	0	3.0 (1.2 %)	16.0 (6.6%)	48.2 (18.8%)	2.5 (1%)	33.0 (12.9%)	0	8.0 (3.1 %)	255.8
Site 2	10,247	258.5	81 (31.33)	141.5 (54.74)	36 (13.93)	0.0252	11.0 (4.3%)	105.7 (40.9%)	11.5 (4.45%)	0	0	0	43.0 (16.6%)	21.3 (8.2%)	3.0 (1.2 %)	27.0 (10.4%)	36.0 (13.9 %)	0	258.5
Site 3	2,982	106.5	29.9 (28.08)	76.6 (71.92)	0	0.0357	7.1 (6.7%)	41.1 (38.6%)	13.0 (12.2%)	0	0	11.0 (10.3 %)	9.8 (9.2%)	9.8 (9.2%)	1.7 (1.6 %)	13.0 (12.2%)	0	0	106.6
Site 4	1,657	108.7	21.9 (20.15)	86.8 (79.85)	0	0.0656	12.4 (11.4%)	44.9 (41.3%)	15.2 (14.0%)	0	0	3.0 (2.8 %)	3.5 (3.2%)	20.7 (19.0%)	3.0 (2.8 %)	6.0 (5.5%)	0	0	108.7
Site 5	1,511	100.8	13.4 (13.2)	84.7 (84.03)	2.7 (2.68)	0.0667	6.2 (6.2%)	53.8 (53.4%)	7.1 (7.0%)	0	0.6 (0.6%)	6.0 (6.0 %)	1.2 (1.2%)	16.9 (16.8%)	0.9 (0.9 %)	6.0 (6.0%)	2.1 (2.1 %)	0	100.8
						Total	50.6 (6.1%)	349.1 (42.0%)	68.0 (8.2%)	6.4 (0.8%)	0.6 (0.07%)	23.0 (2.8 %)	73.5 (8.9%)	116.9 (14.1%)	11.1 (1.3 %)	85.0 (10.2%)	38.1 (4.6 %)	8.0 (1.0 %)	830.3

Note: C*odes: 1 = Del Pilar, 2 = Poblacion, 3 = New Cortez, 4 = Carter, 5 = Sta. Cruz*

0.02 kg/capita to 0.062 kg/capita. The per capita waste generation in five endemic areas is summarized in Table 1.

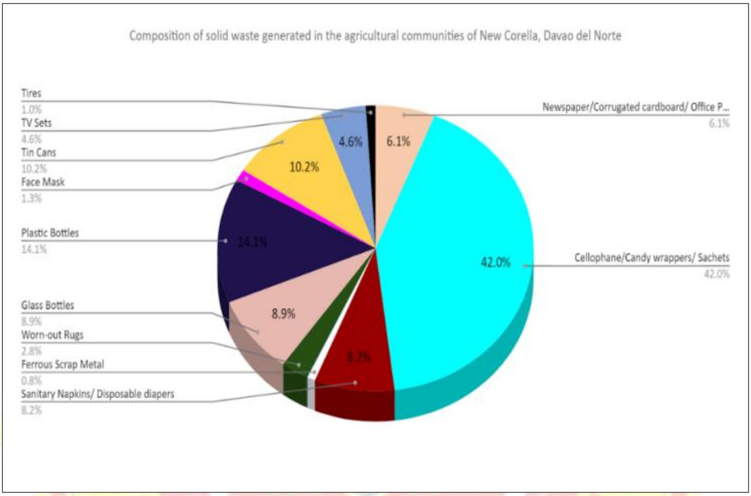
By calculation, the waste generation per capita in all areas is low. Based on the total waste collected, it can be seen that the actual data is lower than expected. During the sampling period in all endemic areas, it was observed that there were some issues in the process of waste submission, collection, sorting, maintenance, and, most importantly, the implementation of the policy. It could be attributed to the submission of households to the facility in each endemic area. This finding is similar to the study in Lahug, Cebu (Salvador & Abocejo, 2015), where household respondents followed proper segregation is significantly lower even though 90% are aware of SWM.

The waste collected was classified into three categories: recyclable, residual, and unique. The sub-classification of wastes (Table 1) revealed a proportion of 25.95% recyclable (43.1 kg ± 0.100 mg), 68.42% residual (115.62 kg ± 0.100 mg), and 5.62% special wastes (9.34 kg ± 0.100 mg). It was observed that the waste collection lacks data on compostable waste. This is noteworthy that this type of waste was not submitted for collection. Instead, these wastes were placed as compost in the respective areas of every household. JICA (2021) emphasized that composting is an approach, especially during the pandemic in 2019, to sustainable, organic farming, directing new opportunities in agriculture. Because composting effectively converts biodegradable trash into organic fertilizer. Food and garden wastes may be composted and converted into organic fertilizer through a regulated biological decomposition process (Lapid, 2004).

Composition of Solid Wastes among Agricultural Communities

Based on the findings presented in Figure 1, it is clear that the most significant proportion of the waste generated among the agricultural communities is from the category of cellophane, along with candy wrappers and sachets, representing the more considerable percentage (42%) that, are non-recyclable and does not have a recycling market in the locality. GAIA (2020) emphasized that the use of cellophane allows low-income earners to manage product consumption effectively. Due to their compact and sturdy packaging, sachets are viewed as affordable and convenient but non-recyclable and non-reusable. On this ground, it is essential to note that cellophane may be used effectively by every household as a container for food, a container for processed products like processed meats and natural products, and food-related packaging, candy, and plastic cellophane. However, because it is non-reusable, these items are thrown away easily as waste, as indicated in the proportion of waste in this survey.

Figure 1
Composition of Solid Waste Generated in the Agricultural Communities via Material Recovery Facility (MRF)



On a similar note, Sha'Ato et al. (2006) showed that commercial buildings were the heavy contributors to cellophane waste, with an average of 10.2%, compared to other waste generators, with an average of less than 10%. Bernado (2008) has shown that plastics and cellophane generation constitute only 2% of the total household waste, significantly lower than the 25% of municipal solid waste. This can be understood because municipal solid waste generally contains a larger volume of cellophane waste from the market, private institutions, and commercial premises.

The second largest proportion of the waste generated is plastic bottles (14%), constituted by soda containers, beverage containers from known brands (Pepsi, Coca-Cola, Refresh Fruit

Drinks), soy sauce containers, cup noodles containers, mineral bottles, etc. This could be understood because every household in the area has daily uses for cooking packed in plastic bottles and beverages. Gambino et al. (2020) reported that in Salento, Southern Italy, about 90% of consumers consumed water, accounting for 200 million bottles per year. On a national basis, WWF Philippines reported that only 9% of plastic garbage is recycled. In comparison, 40% of packaging waste was collected as waste, emphasizing that most local governments still need to formalize recycling procedures at the grassroots level (Gozum, 2020). The Philippines, according to the World Bank (2021), produces a remarkable 2.7 million tons of plastic garbage annually, of which 20% is thought to wind up in the ocean. Portugal (2021) confirmed that the Philippines generates a third of 80% of ocean plastic from Asian rivers.

Interestingly, this waste material has a recycling potential and has a recycling market in the locality, such as junk shops and refuse collector shops. The Plastic Industry Association (2022) lists recycling prices for plastic bottles ranging from Php 5.00 to Php 20.00 per kilo, depending on the type of plastic classification. Regarding recycling, Khurram (2015) highlighted that plastics could be reused as containers, such as gardening tools, an alternative container type in production nurseries. This may be a cost-effective strategy for adopting initiatives like reforestation and restoration. To date, Portugal (2021) mentioned many attempts to reduce plastic waste and the crisis in the Philippines by converting bottles, single-use sachets, and snack food wrappers that jam waterways and ruin beaches into building materials.

Tin cans (10.2%) rank third on the list among the total waste generated, primarily samples of the sardines container, processed food containers (meatloaf, corn beef, milk container, processed fruit, fruit juice cans), as well as canned soft beverages. Mainly, these sampled wastes are household cooking materials. Although tin cans containers are durable, they can severely affect the environment. Onstad (2019) reported that it could produce twice as much carbon dioxide per can, releasing a higher carbon footprint. This might be due to the smelting process during the manufacturing process; aluminum can production also accounts for 2% of the total greenhouse emission in the world (Huesden et al., 2020). The US EPA emphasized that it may adversely affect the bodies of water. They claim that the primary source of aluminum in the waste stream is aluminum cans. In 2008, the U.S. produced about two million tons of aluminum packaging, of which 2.7 million tons were dumped into the waste stream and bodies of water illegally (Turley, 2017).

Tin cans have the potential to be recyclable; hence, they can be sold to junk shops and factories with estimated pricing of Php 3.00-Php 9.00 per kilogram (NSWMC-EMB, 2016). Ramadan (2017) illustrated that recycled cans save up to 70%. Similarly, Inocencio et al. (2020), recycled tin cans can be used for other purposes and play an important role in cost management to reduce the waste generated by transforming them into new usable products. Collected glass bottles (8.9%) include wine, liquor, and soda. In the locality, these materials have a recycling market which costs ranging from Php 0.25-5.00 (NSWMC-EMB, 2016). These materials are commonly used in beverages, liquor, and food condiments with 100% capacity to be recycled. In the U.K., the glass recycling rate is 67.7%. However, it was found unsustainable (Williams & Brook, 2020). In 2018, 3.1 million tons of glass containers were recycled in the U.S., representing a 31.3 percent recycling rate of the total glass waste in the U.S. (EPA, 2021). With the current trend of waste production, specifically in glass waste, one of the largest beverage companies (Coca-Cola) is moving to a new approach and planning to make beverage bottle production 100% recyclable in 2025 (De Vera & Noriega, 2019). These initiatives are part of the company's commitment and response to the commitment to sustainable development goals (Food Engineering, 2022).

Waste classified under residual includes diapers and sanitary napkins (8.2%), which cannot be reused or recycled, and were deposited directly in the municipal landfill. By observation, this type of waste was not adequately segregated and sorted according to its level of biological hazard. Diapers contain many chemicals, such as tributyltin, dioxins, sodium polyacrylate, and volatile organic compounds that harm infants (Karpisz, 2020). These wastes pose a health risk when not properly sorted and separated due to blood or feces (Sukumaran, 2021). An average of 23 sanitary pads and nine tampon applicators were discovered per square kilometer of beachfront in the U.K. (Tribe, 2019). In Central Visayas, Philippines, BFAR reported offshore waste accounting for 772 kg of face masks, medical gloves, diapers, tin cans, and polystyrene objects from coastal cleanup activity (Newman, 2021).

Newspaper, corrugated cardboard, and office paper (6.1%) have a recycling market. It is reported that metropolitan areas in the country exhibit the highest density of paper usage (Parayno & Busmente, 2011). In Europe, about 72% in 2012 (with an increase of 20% from 2000), paper product recycling rates continue to rise. Thus, this paper recycling benefits economic and environmental initiatives (Pivnenko, 2015). Locally, It can be sold in shops with a price ranging from Php 1.50- Php 9.00 per kilogram (NSWMC-EMB, 2016). Cardboard and paper are biodegradable but release methane as it decomposes, contributing to global warming (Plank, 2020). In the country, the paper industry remains primarily a net importer of wastepaper products as its primary raw material despite the country's high levels of waste paper production (Parayno & Busmente, 2011).

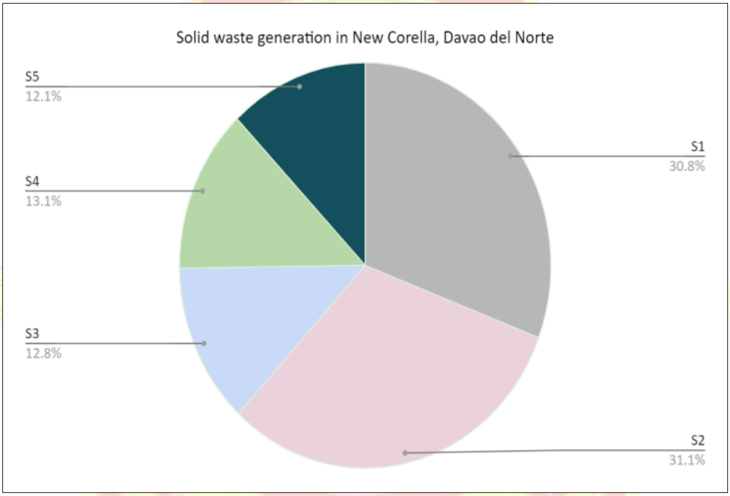
While T.V. sets as electronic waste (4.6%) and worn-out rugs (2.8%) account for the lowest materials inventoried. E-waste refuse contains potentially dangerous components that could contaminate the air, water, and soil. In 2016, the country produced 290 million kg of e-waste, estimated at kilograms per person (Mateo, 2019). Hence, DENR has now placed strict compliance measures under R.A. 6969 to control the generation of e-waste (DENR, 2020). According to Yoon (2017), used clothing and rugs degrade slowly and produce methane emissions. In Europe, it was reported that there are at most 59 identified chemicals released during clothing and carpet production. This is a significant problem, especially concerning endocrine disruption, carcinogenicity, mutagenicity, and reproductive toxicity (Onyshko & Hewlett, 2018). A current trend, an emerging problem in the country, is face mask waste generation. Limon et al. (2022) reported that disposable masks are improperly discarded and suggested that a decisive intervention on disposal of these materials should be placed forward because it poses a severe health risk when left inappropriately discarded.

Comparative Analysis of
Solid Waste Generation

Results of the solid wastes collected from the five (5) endemic areas over the sampling period are presented in Figure 2. Site 2 showed the highest (31.1%) waste generation during the survey period, followed by Site 1, accounting for 30.8% of waste generation. There is only a slight difference between Sites 1 and 2. This finding implies that members of these communities are aware of proper waste disposal and willing to participate in waste submission. This can be attributed to the larger population and households in Sites 1 and 2 compared to the other sites. According to Przydatek and Ciągło (2020), the population is an element that impacts the quantity of garbage accumulation.

Figure 2

Percentage of Solid Waste Generation in New Corella, Davao del Norte in 2022



Tatlonghari and Jamias (2010) contend that media must be explored as a strategy to sustain SWM campaigns. Desa et al. (2015) argue that solid waste management should be encouraged through education to promote attitude change. Babaei et al. (2015) assert that the public must be provided with essential programs to promote awareness and implementation of solid waste management. On this note, attention must be encouraged in the municipality of New Corella and a sustainable approach and practices to sustain the performance of RA 9003.

Among the minor areas with low waste generation are Site 4 (13.1%), Site 3 (12.8%), and Site 5 (12.1%), respectively. This finding could be pointed out that the population of households in Site 3, 4, and 5 are lower than in Site 1 and 2. Also, these sites have lower economic activity since these areas are agricultural lands, thus the low refuse count. US EPA (2022) highlighted that economic activity, consumerism, and population increase all impact the quantity of garbage created. It can also be argued that households may still need to render the submission of waste at the facility center for weekly recording. This implies a weak implementation of local policies on SWM.

It can be observed that some households have made a compost pit, and it is essential to note that these areas are agricultural. In an environmental sense, composting plays a significant role in greenhouse gas emissions reduction, preventing about 2.5 mt of CO_2 annually (Fry, 2008). Sherman (2020) reported that backyard composting initiatives diverted 14%, or more than 1,145 tons annually, of the yard waste produced, reduced collection expenses to $23 per ton, and decreased disposal costs to $32 per ton. Additionally, most households prefer using biodegradable materials for feeding animals. This accounts for low reports of solid waste in the facility. According to Truong et al. (2019), food waste, which occurs across the whole food supply chain, can partially replace maize and soy in broiler diets. Food waste also can help farmers increase their income by minimizing the fertilizer used and instead using compost soil which contains more nutrients and organic compounds (JICA, 2021). Hence, food waste is utilized as an alternative feed (Alpert et al., 2014; JICA, 2021).

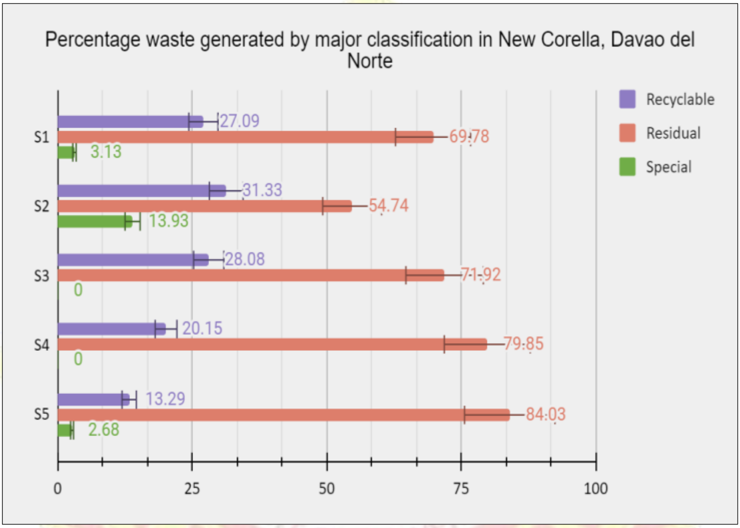
Figure 3 shows the percentage of waste generation by classification as recyclable, residual, and special wastes.

Among the surveyed areas, Site 2 (31.33%) has the highest recyclable waste, followed by Site 3 (28.08%), Site 1 (27.09%), Site 4 (20.15%), and Site 5 (13.29%). Economic activity, including restaurants, coffee, and milk tea shops, are numerous in these areas, which are also considered heavy contributors to coffee, soft drinks, and bottled water. It is also supported by the study by FAO that 12.5 million tonnes of plastic were used globally for food production in 2019 (UN-FAO, 2021). Among the surveyed areas, Site 5 (84.03%) has the highest residual waste, followed by Site 4 (79.85%), Site 3 (71.92%), and Site 1 (69.78%). Sites 1, 3, and 4 are areas near tourist spots, which could influence a high proportion of residual waste due to tourism activity. This finding can be supported by Martins & Cro (2021). McDowell (2016) reported 4.8 mt of waste generated annually of all solid waste. Locally, much solid waste was collected on Samal Island during a coastal cleanup activity (Rocamora, 2021). The area with the least residual waste is Site 2 (54.74%). These findings can be attributed to a low population, hence less economic activity. This could influence the low contribution to particular waste, which makes its residual waste low.

Site 2 (13.93%) has a relatively high proportion of particular waste, while the rest have a relatively low to none. Most households in these communities use electronic gadgets and electronic devices, including T.V. sets, cell phones, and others. E-waste also contributes significantly to particular waste, particularly industrialization and technological development. The DENR (2020), through the research by EMB, states that the Philippines produced 32,664.41 metric tons of WEEE overall in 2019. According to Alam (2016), only a relatively small portion of consumers actively recycle their stuff. Sixty-nine percent of the respondents stated that they were worried about how incorrect e-waste disposal might affect the environment and human health. All interviewees acknowledged that they were unaware of what would become of the old technological devices.

Figure 3

Percentage of Solid Waste Generation by Primary Classification in New Corella, Davao del Norte in 2022

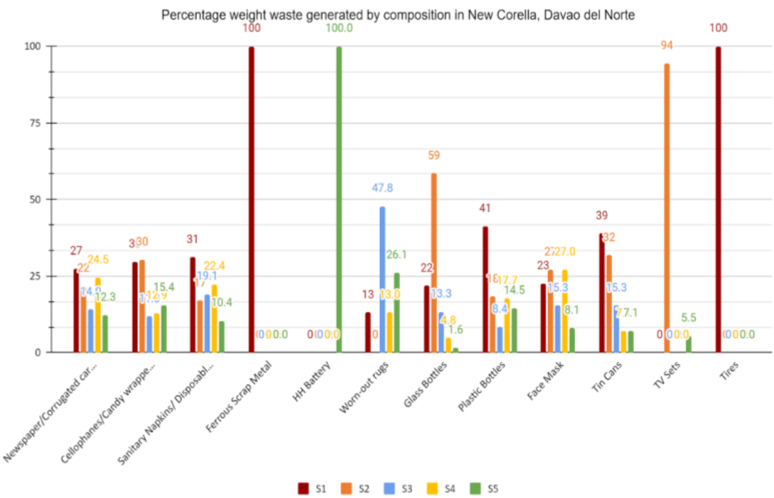


Presented in Figure 4 is the profile of solid waste generation by composition. Results showed relatively high amounts of newspaper/corrugated cardboard/office paper materials in Site 1 (27%), while the lowest was in Site 5 (12.3%). Materials like paper and cardboard are being produced significantly due to the rising global demand for usage (Simao et al., 2018). According to Parayno and Busmente (2011), nineteen percent (19%) of the total municipal solid waste produced in the Philippines comprises wastepaper.

Cellophane, sachets, and candy wrappers were relatively high in Sites 1 and 2 (30%) and relatively lower in Site 3

(11.8%). This waste is commonly generated because it is used in several packaging and containers for human needs, including food, cosmetics, and physical products, at a cheaper cost.

Figure 4
Solid Waste Generation by Composition in New Corella, Davao del Norte



Sanitary napkins and diapers were relatively high in Site 1 (31%) but low in Site 5 (10.4%). Ferrous scrap was generated only in Site 1 (100%), and household batteries and other types of batteries were only found in Site 5 (100%). The disposal of batteries and scrap metals is essential because it poses a health risk when stored at home (Jaishanmar, 2014). Worn-out rugs, clothes, and carpet is significantly high in site 3 (47.8%) and lowest in site 1 and 4. Glass bottles were high in site 2 (59%) and relatively lower in Site 5 (1.6%). Plastic bottles are relatively high in Site 1 (41%) but lower in Site 3 (8.4%). Due to the observable and identifiable rise of plastics, the House of Representatives passed House Bill No. 9147, or the Single-Use Plastic Products Regulation Act, to stop the production of this plastic (Ibañez, 2021). Face masks were found high in site two and aite (27%) and lowest in site 5 (8.1%), while tin cans are relatively high in site 1 (39%) and site 2 (32%) and lower in site 4 (7.1%) and site 5 (7.1%) T.V. sets are relatively high in Site 2 (94%) but no collected samples in Site 1, Site 3, and Site 4. Tires were only collected at site 2 (100%), and the rest of the site had no data recorded.

Developing nations like the Philippines have aggressively pursued economic growth, which has led to the production of waste and the manufacturing, distribution, and use of goods that worsen the environment and alter the planet's climate pattern (Castillo & Otoma, 2013). Despite many environmental laws in the country (R.A. 10068, R.A. 6969, RA 9003), the country is experiencing an increasing waste problem.

It is common knowledge that burning and incineration waste is prohibited because it releases toxic fumes which add pollutants to the air and GHG emission as specified under the Philippine Clean Air Act of 1999 (Republic Act No. 8749). However, due to unawareness or neglect, these problems continue to persist. Poor governance on the ground, lack of commitment among stakeholders, poor monitoring, and policy enforcement, as well as the neglect of the social dimension's participation in the policymaking and feedbacking, are the primary causes of the low success rate of its waste policy (Wee et al., 2017). Hence, national policies will only be successful once supported by a robust local government supporting the institutional framework (Premakumara et al., 2013).

As evident in the graph in Figure 4, some areas may have contributed greatly to waste, but most sites are significantly low to no records. This indicates a need for solid waste management re-orientation of the rules and regulations of RA 9003 at a barangay level.

Intervention Plan for Solid Waste Management

Despite the DENR-EMB efforts and initiatives to manage waste, it remains a severe problem in the country. Manning (2019) discussed the environmental rights of every citizen, emphasizing those affected by acts of environmental degradation. Unfortunately, Castillo and Otomo (2013) reiterated that the Philippine system of the 3R waste principle and its disposal facilities might still need to be more effective and efficient. Adejumo and Adebuyi (2020) pointed out that every stakeholder in agricultural operations, including middlemen and women, farmers, and consumers, should be adequately informed about the negative impacts of careless disposal of agricultural solid wastes and the positive advantages of the management of such wastes.

Hence, an intervention in solid waste management should provide solutions to the identified problems. This involved identifying the problem, planning, intervening, implementing, evaluating, and adapting. Most of the problems encountered among surveyed areas are the lack of awareness and willingness to practice waste segregation. In this study, it is proposed for every endemic area to (a) conduct a monthly orientation and monitoring under RA 9003; (b) install material recovery facility units; (c) conduct training and workshops on 5S, 3R, and composting; (d) link with partners that promote the recycling market; and (e) improve communication strategies to facilitate the solid waste management.

According to Jeremias et al. (2020), the lack of relationship between environmental knowledge, awareness, and perception of residents' SWM practices implies that information on SWM that reaches the household needs to be revised. This supports the needs of barangay stakeholders and city governments to increase awareness and knowledge by further organizing or conducting campaigns and seminars among households through capacity-building workshops. Ifegbesan (2010) emphasized the need for behavioral and attitudinal change essential to reduce waste and promote environmentally friendly practices. Even in schools, lectures on solid waste management are conducted for both children and parents to foster an understanding of the importance of solid waste management (Almanzan & Vargas, 2016). Thus, higher awareness of SWM positively affected the reduction of solid waste disposal practices (Barlow, 2016).

Seminars and lectures with the participation of government and non-government organizations may encourage residents to reduce waste generation (Reyes & Furto, 2013). These activities served as a key for people to be involved in the waste management programs of the community for its practical, sustainable implementation (Lalamonan, 2020).

NSWMC Resolution No. 24 Series of 2009, as stated, requires establishing a Material Recovery Facility (MRF) in every barangay or cluster of barangays. This must be done to accommodate the collected biodegradable and recyclable waste collected from residents (Dalugdog, 2021). The primary function of the MRF is to maximize the number of recyclables processed while producing materials that will generate the highest possible revenues in the market. MRFs can also process wastes into feedstock for biological conversion or into a fuel source to produce energy (Zafar, 2022). The utilization of the material recovery facility is expected to optimize solid waste management to maintain the surrounding environment. Therefore, it is necessary to design appropriate MRF-based temporary disposal sites (Citrasari et al., 2019).

Local recycling industries can band together and form a professional association that can dialogue with the government and other stakeholders, educate the public on the benefits of industrial recycling, and pursues programs to promote support for the recycling industry. Also, stimulating demand for recycled products and promoting the benefits of post-consumer recycled products could provide a larger market for recycling businesses and encourage the growth of more eco-entrepreneurs, noting that in the Philippines, as in many other countries, more than 90% of the industry is small and medium in size (Antonio, 2010).

Creating recyclable products in every community and opening markets for recycled products is an effective strategy (Reyes, 2013). According to Pepino (2019), recycling is a commercially attractive waste treatment due to the availability of recyclable materials that can generate income and livelihood opportunities for small communities or informal waste collectors. One strategy is linkage, such as a partnership of PARMS with the local government to launch a residual plastic recycling program turning plastics into eco-bricks or recycled building bricks (Pepino, 2019). Linkages with private groups and civic groups committed to sustainable development objectives are a good strategy to facilitate areas that need improvement, such as waste reduction (Weekes et al., 2021). For example, informational campaigns directly from the waste management organization (European Commission, 2015), local governments and the private sector, or public-private partnerships for environmental advocacy (Asian Development Bank, 2013). Most importantly, to assist with funding, it is necessary to consider raising funding from the LGU, donation drive, and volunteers (Range & Dzwairo, 2021). With these proposed plans and programs, it is anticipated that the endemic areas will have a substantial improvement in terms of solid waste management implementation and adhere to sustainable practices

CONCLUSION AND RECOMMENDATIONS

The waste generated in New Corella, Davao del Norte's agricultural areas was characterized, and a total of 830.3 kg ± 0.100 mg waste was collected and segregated. The majority comprises cellophane/candy wrappers/ sachets, plastic bottles, and tin cans. Among the least are sanitary napkins/ disposable diapers, ferrous scrap metal, household batteries, worn-out rugs, glass bottles, face masks, T.V. sets, and tires. MSW generation ranges from 0.02 kg/capita to 0.062 kg/capita for all the endemic areas surveyed, which is relatively low. Most wastes are residual and recyclable, while only a few are exceptional.

Among the five endemic areas, no sample of compostable waste was collected. Site 2 has the highest percentage of recyclable waste, while Site 5 has the lowest. Site 5 has the highest residual waste on residual wastes, while Site 5 has the lowest proportion. Particular waste only constitutes a small fraction of the overall waste generated. Among areas, Site 2 showed higher waste generated than other sites.

Comparative analysis of solid waste generation showed that cellophane, sachets, and candy wrappers are relatively high in Site 2 and low in Site 3. Newspapers, corrugated cardboard, and office paper were high in Site 1 and low in Site 5. Sanitary napkins and diapers were high in Site 1 and lowest in Site 5. Site 1 was found to have the highest plastic bottle waste and shallow in Site 3. Face masks showed a higher percentage in Sites 2 and 4.

With the results, it is highly suggested that the local community and community members should foster cooperation and practice communication. Several areas need further study to improve and expand this research. It is recommended for future researchers focusing on solid waste management to explore household practices such as recycling and composting techniques, conduct a qualitative analysis of awareness, practices, and attitudes toward solid waste management policies, explore cost-benefit analysis on recyclable materials in the locality, and the promotion of local recycled materials.

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