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MANG-KALAKAL: A Prototype Promoting Waste Management and Segregation in Local Government Unit

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Abstract: Waste management has evolved into a global issue with far-reaching impacts, and significantly reduces waste production through prevention, reduction, recycling, and reuse, which is a primary focus of the United Nations Sustainable Development Goals (SDGs) objectives designed to reduce communities' negative per capita environmental impact (Berger, 2018). Given this, it is evident that solid waste management is a critical problem that impacts everyone on the planet. With over 90% of waste in underdeveloped countries being publicly tossed or burned, the poorest and most vulnerable suffer disproportionately (The World Bank, 2021). This being the case, this quantitative correlational study aims to determine the waste management practices and attitude towards recycling among selected barangays in the National Capital Region (NCR). Using cluster sampling, the researchers gathered 214 respondents from the NCR. Data gathered from the adapted survey-questionnaire of the Commission on Audit (2013) and Larsen (1995) was treated using ANOVA, Chi-Square, and Pearson Correlation. Their waste management practices are slightly effective (61.7%). Their attitude towards recycling is extremely negative (45.8%). The two variables show a significant relationship (.000) and have a significant moderate positive correlation (0.01 level of significance, $r=.484^{***}$). This proves that as their waste management practices reach their ineffectivity, their attitude towards recycling also becomes negative. However, with the MANG-KALAKAL prototype recommended and designed by the researchers, there is hoped to effectively implement waste management practices and improve the respondents' attitude towards recycling.

Key Words: Barangay Officials; Waste Management; Recycling; Prototype; Innovation



1. INTRODUCTION

The Philippines is known to have numerous urban centers, and one such example is the capital of the country, Manila. According to the Asian Development Bank's (2004) "Garbage Book," Metro Manila alone is expected to generate more than seventy million tons of solid trash over the next thirty years.

One of the study's main objectives is to cultivate an innovation that deals with waste management and segregation, which falls under the 9th SDG known as "Industry, Innovation, and Infrastructure." In line with the long-term vision and aspirations of Ambisyon Natin 2040, the study centers on ensuring ecological integrity and a clean and healthy environment through the researchers' advocacies, which are mainly promoting waste management and segregation.

On January 26, 2001, the Ecological Solid Waste Management Act of 2000 (RA 9003) was passed and went into effect on February 16, 2001. Alongside this policy, the reduction, reuse, and recycling systems, as well as their final disposal in landfills, are ineffective and inefficient in achieving a clean environment and reducing the country's greenhouse gas emissions, as well as their effects on local and global climate change (Castillo & Otoma, 2013).

The study aims to focus on innovating a prototype that can benefit specific communities that deal with critical waste issues. The study also advocates for communities' sustainability to meet basic human needs, particularly in this time of the COVID-19 pandemic. Thus, the study seeks to promote the right of the people to have a sustainable community to live in.

As waste management was defined as a complex concern that necessitates the collaboration of technologies, economics, sociocultural, and governmental actions, it was used in the study as the primary advocacy of the researchers' proposed prototype that is programmed to promote waste management and segregation. The MANG-KALAKAL prototype is also considered to be an innovation wherein it is a model having segregation, alarm, and weighing functions integrated into one creation.

In aligned with the study, the researchers chose barangay officials, for they are the ones who generally initiates the plans and policies in their barangays. These authorities also have a remarkable role in governance as they are under the LGUs. The

study aims to identify the barangay officials' waste management practices in their community and their approach to recycling.

2. METHODOLOGY

2.1 Research Design

The study used a quantitative correlational research design to investigate the relationship between barangay leaders' assessments of waste management practices in the community and their attitude towards recycling (Muijs, 2011).

2.2 Research Locale

The researchers chose the selected barangays in the National Capital Region (NCR) as the locale of the study. The NCR, often known as Metro Manila, is the country's political, economic, and educational center.

2.3 Sampling Design

The method used in the study is probability-cluster sampling. As per SAGE (n.d.), probability sampling is a kind of sampling procedure in which each unit in a population has a preset chance of being picked from the population.

2.4 Instrumentation

The questionnaires were constructed by the researchers using MS Forms, which were validated by experts. It is composed of 40 total items, and they are all on the Likert scale. The first section of the questionnaire is about the respondents' demographic information. The second section is composed of 20 statements that address the waste management practices of the barangay officials in their community, adapted from the Commission on Audit (2013). The third section is also composed of 20 statements that discuss the barangay officials' attitude towards recycling, adapted from Larsen (1995).

2.5 Data Gathering Procedure

The researchers reached out to barangay officials from selected barangays located in NCR

through the publication of "Call for Respondents" public materials on social media platforms. The researchers also joined pages and groups associated with local government units (LGUs). Moreover, the researchers visited barangays located in NCR for face-to-face data collection.

2.6 Statistical Treatment

The researchers used the Pearson R-Moment Correlation as their statistical treatment. According to SAGE (n.d.), it is used to determine the correlation or significant relationship between two continuous variables.

2.7 MANG-KALAKAL Prototype Recommendation

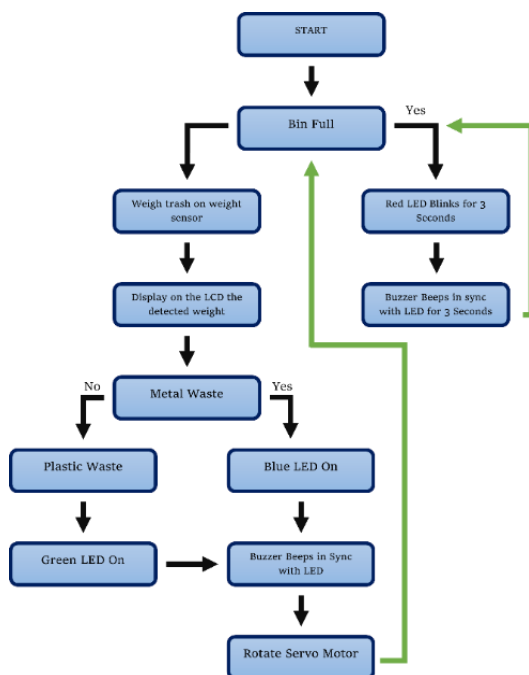


Fig.1. MANG-KALAKAL Flowchart

The prototype comprises several sensors for it to execute its intended function. The **Arduino UNO Microcontroller** serves as the brain of the prototype since this is where the software will be executed. Since its purpose is to detect and segregate metal and plastic materials, a **Metal Detector Module** and an **Infrared (IR) Sensor** will be utilized. As stated, there will be an exchange of goods for those who participate in

segregating. The **Weight Sensor** will determine the amount of goods received by the user. The **RGB LED** and **16x2 LCD I2C Module** will serve as a visual indicator in which the LED will light up depending on the detected material, while the LCD will print the current situation on its screen. This includes the material and weight detected, and the capacity of the trash bin. The **Buzzer** will serve as an audio indicator that will ring whenever it detects a material. The MG996R Servo Motor will mainly execute the segregating since it will tilt the plate connected to the motor according to its designated trash bin. Lastly, the **Power Supply** will serve as the heart of the prototype since the whole system will not work without its power source.

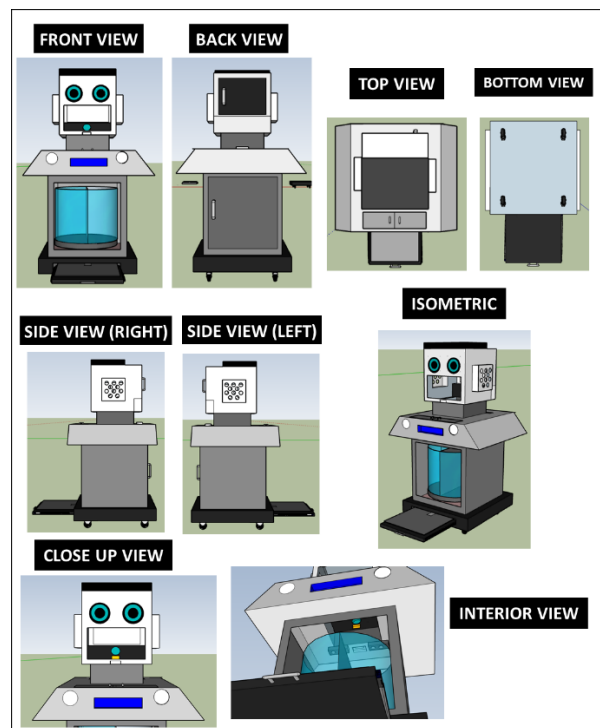


Fig. 2. Proposed Design of MANG-KALAKAL

3. RESULTS AND DISCUSSION

3.1 Demographic Profile

The researchers conducted their survey in 115 barangays in selected areas and collected a total of 214 respondents. Out of all the 214 respondents, there were a total of 137 (64%) male and 77 (36%)



female barangay officials who answered the survey. The leaders ranged from 22 to 77 years old, with most of the respondents being 30 to 59 years old (65.9%) and the least being below 29 years old (7.5%). Most of the respondents are Sangguniang Barangay Members (Kagawad) with a frequency of 125 (58.4%), while only 7 (3.3%) are Sangguniang Kabataan Chairpersons. 138 (64.5%) respondents have lived within the area for 31 to 59 years, and 35 (16.4%) of them have lived within the area for 1 to 30 years. Lastly, most of the leaders who answered were post-graduate, which has a frequency of 99 (46.3%), and 49 (22.9%) of them had non-formal education.

3.2 Waste Management Practices

Table 1. Assessment of Barangay Leaders on Waste Management Practices of the Community

	Statements	Weighted Mean	Verbal Interpretation
1	There is an implementation of the Solid Waste Management Program (SWMP) in my barangay.	1.39	Not at all Effective
2	The implementation of the Solid Waste Management Program (SWMP) is consistent in my barangay.	1.52	Not at all Effective
3	There is an organization/group that advocates for proper waste management and segregation in my barangay.	2.84	Moderately Effective
4	The barangay leaders/representatives are frequently monitoring the Solid Waste Management Program (SWMP) implemented in my barangay.	1.59	Not at all Effective
5	The barangay leaders/representatives often provide information on waste segregation in my barangay.	1.65	Not at all Effective
6	I am aware of how garbage is collected in my barangay.	1.43	Not at all Effective
7	My barangay practices proper waste management and garbage collectors collect garbage with proper segregation.	1.89	Slightly Effective
8	Unsegregated garbage is common in my barangay.***	3.94	Very Effective
9	The garbage collectors collect unsegregated waste in my barangay.***	3.93	Very Effective
10	There is a firm schedule for garbage collection in my barangay.	1.67	Not at all Effective
11	The biodegradable waste is collected based on the schedule implemented in my barangay.	2.50	Slightly Effective
12	The non-biodegradable waste is collected based on the schedule implemented in my barangay.	2.48	Slightly Effective
13	The garbage collectors in my barangay arrive on time.	1.97	Slightly Effective
14	I would say that the garbage collectors in my barangay are strictly following the rules and guidelines in collecting waste.	2.02	Slightly Effective
15	There are alternative methods of collecting biodegradable waste in my barangay.	2.89	Moderately Effective
16	There are street sweepers in my barangay.	1.28	Not at all Effective
17	I am satisfied with how our garbage is being collected in my barangay.	1.83	Slightly Effective
18	I am satisfied with the garbage collection schedule in my barangay.	1.83	Slightly Effective
19	I would say that the surroundings of my barangay are clean.	1.63	Not at all Effective
20	I often feel like there is a need for improvement in the waste management and segregation in my barangay.***	3.67	Very Effective

The assessment of most barangay leaders on the waste management of their community is slightly effective, which has a frequency of 132 (61.7%). 38 (17.8%) thought their community's waste management was moderately effective, while 44 (20.6%) thought it was completely ineffective.

Based on table 1, question 8 has the highest weighted mean of 3.94, which indicates that the respondents perceive this as very effective. In contrast to a case study conducted in Malaysia, trash management seems to be promising as a result of the government's reaction and complete commitment, which are motivated by worries about public image as well as waste management challenges (Norkhadajah, 2014). Conversely, the question that is perceived as the least effective, with a weighted mean of 1.28, is the street sweepers. In support of that, the scene in most cities, especially in impoverished areas as described in various studies, is one of overflowing garbage containers in which animals and residents rummage through overcrowded toilet facilities, choked drains, indiscriminate waste disposal, and a general sense of disorder in the environment (Owusu, 2010).

Taking that into account, the researchers believe that the waste management practices in the selected barangays of NCR are only slightly effective due to the inefficient and inconsistent waste management implementation in these barangays. The researchers believe that the inefficient and inconsistent waste management practices are because of the barangay officials' commitment to the program as well as the community citizens' discipline towards the policies and regulations regarding the waste management program in their barangay.

3.2 Attitudes Towards Recycling

The study reveals, with a frequency of 98 (45.8%), that most of the attitudes of the barangay officials in selected areas are extremely negative. Additionally, 70 (32.7%) and 46 (21.5%) leaders are moderately negative and neutral, respectively. Based on table 2, the question with the highest weighted mean is about the use of plastic bottles, which has a 3.38 mean and is interpreted as neither positive nor negative.

The findings of this study led to the conclusion that half of the barangay officials feel that using plastic bottles is more convenient than using glass bottles. On the other hand, half of the barangay officials say that using plastic bottles reflects a negative attitude toward the community and should be avoided.



Table 2. Attitude of the Barangay Leaders Towards Recycling

	Statements	Weighted Mean	Verbal Interpretation
1	I only generate a small amount of waste, so I do not believe I am responsible for cleaning up.***	1.94	<i>Moderately Negative</i>
2	I would recycle plastic bottles.	1.48	<i>Extremely Negative</i>
3	We should not clean up all waste disposal sites.***	1.90	<i>Moderately Negative</i>
4	Enough is being done to clean up the community's environment.***	3.24	<i>Neither Positive nor Negative</i>
5	The community is not in need of cleaning up by people.***	1.88	<i>Moderately Negative</i>
6	Recycling is too much of a hassle to bother with.***	2.26	<i>Moderately Negative</i>
7	People should share the responsibility of cleaning up the community.	1.37	<i>Extremely Negative</i>
8	I would recycle aluminum cans.	1.50	<i>Extremely Negative</i>
9	I would take an active role in recycling.	1.47	<i>Extremely Negative</i>
10	I see no reason to recycle.***	1.73	<i>Extremely Negative</i>
11	I would take advantage of the recycling programs available to me.	1.49	<i>Extremely Negative</i>
12	I think all packaging, no matter what the cost, should be recyclable.	1.87	<i>Moderately Negative</i>
13	I would recycle even if pick-up services for recycling were not available.	1.82	<i>Moderately Negative</i>
14	Some people exaggerate the true amount of pollution in the world.***	2.80	<i>Neither Positive nor Negative</i>
15	Non-recycled and unsegregated waste created in the past is not an issue worth addressing.***	2.20	<i>Moderately Negative</i>
16	I would use plastic bottles because it is more efficient to use when drinking.***	3.38	<i>Neither Positive nor Negative</i>
17	If I were asked to volunteer for a clean-up group, I would do so.	1.38	<i>Extremely Negative</i>
18	I would use BPA-free cans.	1.90	<i>Moderately Negative</i>
19	I would not vote in favor of a measure to ban the use of plastics.***	2.79	<i>Neither Positive nor Negative</i>
20	I see no purpose in sorting waste.***	1.77	<i>Extremely Negative</i>

Conversely, the question with the lowest weighted mean is about the shared responsibility of cleaning up the community, which has a 1.37 and is interpreted as extremely negative. Without the initiative of the barangay units, positive changes are less likely to happen. Additionally, this supports the study which indicates that the barangay greatly impacts the habits of its community (Torres, 2020). If the barangay is not active or not motivated to make a positive change, the residents may also be unmotivated to participate in solving contemporary environmental issues.

3.2 Prototype Testing

The researchers conducted a test run to assess the prototype's limitations and results. Through thorough observations from the trials, the prototype has its weak points. First, the user must not have any static on their hands since it may affect the sensor's ability to detect the static from the hands itself rather than the waste. Second, the prototype can only accept small to medium sizes due to the plate

connected to the servo motor and its passage to the respective bins. Lastly, the user must put the waste directly in front or as close as possible to the sensors to prevent any misdetection. Regardless of its limitations, the prototype can detect various types of plastic and metal waste materials based on the table shown below.

Table 3. Material Detection Testing

Plastic Materials	Results	Metal Materials	Results
Coke mini bottle	DETECTED	Small metal cup	DETECTED
Coke mismo	DETECTED	Small metal container	DETECTED
Small plastic container	DETECTED	Tin can	DETECTED
Bottled spray	DETECTED	Canned goods	DETECTED
Average medical bottle	DETECTED	Spray paint	DETECTED

4. CONCLUSIONS AND RECOMMENDATIONS

When it comes to waste management, gender does not have any effect. Anyone can practice waste management. Additionally, age does not fully represent people's environmental concerns. However, older people are more engaged in waste management as they are more capable of managing waste in their community. Males and barangay officials, specifically kagawads, are more involved in waste management practices in their barangays because they are the majority of elected local government officials. A barangay with ineffective waste management techniques may encourage residents to emulate these negative behaviors because the residents are aware of waste management but there is a lack of understanding of its context. Therefore, LGUs in NCR must partake in the role of calling out these barangays and barangay officials to improve the town's current environmental state.

To help improve cities' eco-friendliness, the proposed prototype of the researchers, which is called "MANG-KALAKAL," will serve as a waste segregating machine in which it separates plastic waste and metal waste and disposes of them accordingly. This will help motivate residents in a community to partake in waste management since the prototype trades goods as a reward for helping with waste collection. Furthermore, this study may benefit environmental government agencies, LGU's, materials recovery facilities, sanitary engineers, community citizens, robotics students, and future researchers. To help improve cities' eco-friendliness,



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