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Research Paper

Environmental Impacts of Solid Waste Management Practices in Kiharu Sub- County, Murang'a County, Kenya

Murunga, P. K., [1] & Muriuki, S. W. [2]
[1]*School of Agriculture and Environmental Sciences of Kenyatta University [K.U], Nairobi, Kenya*
[2]*School of Agriculture and Environmental Sciences of Kenyatta University [K.U], Nairobi, Kenya*

Abstract
Waste management is a global concern due to the amount of waste produced. Globally, 2.01 billion tons of solid waste is produced annually with 33 percent of waste not managed safely. By 2050 waste generated is predicted to increase to 3.40 billion tons annually. Despite the weight of these threats on ecological balance, limited research has been conducted regarding the evaluation of the degree of which poor solid waste management practices influence the environment. Understanding the scale and seriousness of these effects is essential for planning powerful waste administration procedures, strategy execution, and local area commitment initiatives. This research therefore assesses the environmental impact of waste management in Kiharu Constituency in Murang'a County, Kenya. The study adopted a cross-sectional quantitative research design. The study targeted 19,404 households in Kiharu-sub-county and from it a sample of 200 was obtained. A total of 186 responded translating to a 93.0% response rate which was sufficient for analysis. The data was collected using a structured questionnaire where collected data was entered and analyzed using SPSS version 27.0. Descriptive statistical analysis was then conducted where statistics such as mean, frequency, standard deviation and percentage were produced. Pearson's correlation and regression analysis were used under inferential analysis to examine the significance, strength and direction of the association between waste management practices and the environmental impact. The findings of the study established that there were various wastes that were disposed in Kiharu where food wastes, construction wastes, tire wastes and agricultural wastes were identified as the most common types of solid wastes disposed. Others included Chemical and electronic wastes while industrial and biomedical wastes were present but not very common in the area. The study also established that the community used open landfills and burning waste management practices although they were not effective as they led to degradation of the environment. However, they had adopted reuse, recycling, avoidance and minimization of waste disposal, composting and energy recovery as effective waste management practices. The study also established that there was significant and positive association between solid waste management practices and the environmental impact. The findings indicated that if the wastes generated by humans were well managed through practices would lead to a better environment that is clean and healthy. The study recommended adoption of recycling and re-use methods by setting up recycling centers, awareness creation such as public training and campaigns to the community encouraging households and communities to manage their wastes efficiently, and also reduce reliance on burning and landfills. Lastly, the study recommended the use of modern waste handling equipment to enhance the efficiency and safety of waste management operations.
Keywords*: Waste Management Practices, Environmental Impact, Solid Waste*

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I. INTRODUCTION

Waste management is a public health concern due to the amount of waste produced globally. In the world, 2.01 billion tons of solid waste is produced annually with 33 percent of waste not managed safely. Waste generation per person per day is estimated to range between 0.11 to 4.54 kilograms. Developed countries generate about 683 million tons of the worldwide waste or 34 % of total waste. By 2050 waste generated is predicted to increase to 3.40 billion tons annually (World Bank Publications, 2013).

Research shows that waste generation is influenced by the income level. High income level countries collect 96 percent of waste, upper-middle income countries collect 82 percent of solid waste, lower-middle income countries collect about 51 percent and low income countries collect 39 percent of total global solid waste. Although this is the case composition of waste generated differs across income levels. High-income countries

produce about 51 percent of dry waste that is recyclable such as glass, and paper and 32 percent of biodegradable waste such as green waste. Conversely, low income countries generate 53 percent of biodegradable waste and only 20 percent recyclable waste (World Bank Publications, 2013).

Europe and Central Asia would generate 392 million tons of waste in 2016 and is predicted that by 2030 they will produce 440 million tons and 490 million tons by 2050. Similarly, East Asia and Pacific would produce 468 million tons of waste in 2016 and is projected that by 2030 they will produce 602 million tons and 714 million tons in 2050. North America would produce289 million tons in 2016, projected to generate 342 million tons in 2030 and about 396 million tons by 2050. Likewise, Sub-Saharan Africa would produce 174 million tons in 2016, predicted figure for 2030 is 296 and 516 by 2050. Additionally, Middle East and North Africa would generate 129 million tons in 2016, projected to produce 117 and 255 million tons by 2030 and 2050 respectively (World Bank, 2013). China has also recorded an increase in the amount of waste generated per year. In 2015 China produced191.42 million tons of waste, 203. 62 million tons in 2016, 215.21 million tons in 2017, 228.02 million tons in 2018, 242.06 million tons in 2019, 235.12 million tons in 2020, 248.69 million tons in 2021 and 244.45 million tons in 2022 (Statista, 2022).

A research by Okumu &Nyenje (2011) showed that Uganda generates0.3 to 0.66 kilograms of waste daily. Waste composition produced in Uganda is made up of organic waste at 92 percent , soft plastics at 3 percent, paper 1 percent , and hard plastic at 2 percent (Komakech eat al, 2014). Only 28000 tons of solid waste is transported to landfill every month the uncounted waste is dumped in unauthorized areas (Komakech eat al, 2014). Kenya produces 22, 000 tons of waste daily totaling to 8 million tons per year. It estimated that by 2030 the country will be generating an estimate of 5.5 million tons per year due to urbanization. 60 percent of waste produced is organic, 30 percent constitutes of recyclables such as paper, glass, plastics, and cardboard while 10 percent constitutes other types of waste (World Bank, 2021).

Murang'a County the focus of this study generates 390 tons of solid waste per day and have an ongoing process of construction of a landfill to deal with disposing of solid waste in the county (World Bank, 2021). Kiharu Constituency in Murang'a County, Kenya, is not exempted from these developing regions. Improper solid waste management in the region raises concerns because it does not only pose significant environmental threats but also undermines the public health, social well-being, and economic development for residents in the region. In recent years, the region has witnessed rapid population growth, resulting to increased generation of wastes due to population growth and ineffectiveness of existing waste management infrastructure and practices. In many areas within the region, waste is untreated and disposed in open dumpsites, thus increasing the risks of hazardous substances in soil and water bodies and exposing residents to the adverse ramifications of exacerbating pollution and environmental degradation. Poor solid-waste disposal and management may also be attributed to increasing prevalence of air and water pollution, soil degradation, and the propagation of pollution-related diseases (Al-Dailami *et al.,* 2022). Furthermore, poor waste disposal and management practices poses threats on the delicate ecological balance due to the negative impacts it poses on the environment in the region.

Despite the weight of these threats on ecological balance, limited research has been conducted regarding the evaluation of the degree of which poor solid waste management practices influence the environment. Understanding the scale and seriousness of these effects is essential for planning powerful waste administration procedures, strategy execution, and local area commitment initiatives. The research paper seeks to connect this knowledge gap by conducting an exhaustive and precise evaluation of the ecological outcomes and environmental consequences of solid waste management practices in Kiharu Constituency in Murang'a County, Kenya. Using an interdisciplinary approach, consolidating ecological science, prioritizing general wellbeing, and improving the socio-economic variables, the study seeks to provide valuable insights to local specialists, authorities, policymakers, and community networks, thus enabling them devise reasonable, coordinated, and sustainable waste management solutions, preserving the natural environment, and safeguarding the well-being of local residents in the region.

The study sought establish:

1. What types of solid wastes are generated in Kiharu Sub-County?
2. How do waste management practices impact the environment in Kiharu Sub-County?

II. LITERATURE REVIEW

This section of the paper reviews past literature on types of solid wastes, waste management practices and their impact on the environment.

2.1 Types of solid waste

Solid waste is any unwanted or discarded materials from human activities such as industrial, mining, commercial, and agricultural operations. Sludge from water treatment is also part of solid waste (EPA, 2023). On the other hand solid waste management encompasses various elements such as waste generation storage, collection, and disposal of waste. Poor implementation of the whole solid management system results to pollution

of environment. According to Kaur & Rajpurohit (2021) and ESCAP (2020) Types of solid waste can be classified according to the source of waste. Each source of waste necessitates specific management practices. These categories include; industrial residential, commercial, construction, institutional, agricultural, and open areas waste.

Table 1
Solid waste classification

Source	Type of waste	Waste generators
Industrial	Packaging, food waste, special waste, hazardous waste, construction waste, ashes	Construction sites, fabrication, chemical plants
Residential	Food leftover, plastic, ashes, vegetable peels, clothes, electronics, batteries, hazardous waste	Apartments, family dwellings
Commercial	Food waste, ashes, metals, glasses, plastics, paper, special waste, and hazardous waste.	Hotels, motels, farm stores, medical facilities
Agricultural	Food waste, pesticides, spoiled vegetables, and grains,	Fields, farms, crops, diaries, orchards, vineyards
Institutional	Plastic, paper, glasses, food waste, bio waste, hazardous waste	Prisons, schools, government offices, hospitals, colleges,
Demolition and Construction	Steel, glasses, concrete, wood, dirt	Construction sites, renovation sites, road repair, and demolitions
Open areas	Food waste, paper, plastic, clothes, litter	Streets, parks, beaches, highways, beaches, recreational centers

2.2 Solid Waste Management practices and their Environmental impacts

The increasing volume of waste especially in urban areas associated with growth in economy endangers human health and the environment. According to UNEP (2024), an estimate of 11.2 billion tons of solid waste is collected globally. Hazardous waste such as electronic equipment containing a hazardous substance poses a serious risk in developing and developed countries because of its increased production. Similarly, Kenya produces an estimate of 3000 to 4000 tons of solid waste daily (Fie Consult, 2023). The highest composition of solid waste produced in Kenya constitutes of organic waste such as food refuse, yard, and agricultural waste (Fie Consult, 2023).

Poor waste management waste management due to poor collection systems and improper disposal of waste causes soil and water contamination, air pollution, and environment at large. Conversely proper solid waste management practices have positive impact on the environment as it involves; waste minimization and avoidance, recycling and re-using, composting, and open landfills.

Utilization of landfills is a modern method of solid waste disposal that involves adherence to engineering principles to confine waste in a small area, reduce waste volume through compaction, and cover the waste to reduce environmental pollution. Landfills reduce the negative effect of solid waste to public health and environmental nuisance. Landfills can either be open landfills, operated landfills, and sanitary landfills. Developing countries mainly utilize open landfills where solid waste is dumped in an open land haphazardly. Operated landfills where solid waste is compacted and covered each day to prevent pollution. Sanitary landfills are mostly used in developed countries where they have facilities for trapping and treatment of percolates using various ponds (Sankoh, 2020).

According to a study by Sankoh (2020), if landfills are not properly managed they can can pollute the air by producing bad odour due to the breakdown of biodegradable waste by the bacteria. The bad smell poses negative health effects on the people living around the area. Research shows that biodegradation of solid waste produces gas such as carbon dioxide and methane and liquid emissions. Liquid emissions produced percolates in groundwater causing pollution on the water. Similarly, a study by Vaverkova (2019) investigating impact of landfill on environment concluded that disposal of municipal solid waste in landfills poses major environmental risks. Kenya is yet to upgrade to the modern standard landfills hence utilizes open landfill commonly known as dumpsites within the 47 Counties (Ministry of Environment & Forestry, 2019). These poor management of waste pollute the air due to open burning of waste and production of bad smell on dumpsites, pollute water and soil due to infiltration of waste and impact on aesthetics (Ministry of Environment and Forestry, 2019).

Recycling is the most effective way to preserve the environment. Recycling and reusing materials reduce the amount of solid waste that goes to landfills hence reducing the negative environmental impact of solid waste. According to Lamma (2021) recycling plastic reduces the tons of raw materials used to produce new ones, similarly, for every tone of paper recycled 18 trees, 7650 gallons of water, and 472 gallons of oil are saved. Research by Munayi (2023) shows that only 7 percent of plastics materials are recycled in Kenya, 92 percent is mismanaged leading to 37 kilotons of plastic materials littering the ocean and the environment each year. To reduce this menace recycling rate should be increased. According to EPA (2023), recycling refers to the process of collecting and processing disposable materials that are not needed by their consumers to make new products.

Recycling disposable materials have major benefits on the environment and public health. First, recycling conserves natural resources such as water, mineral products, and trees. Secondly, it reduces the negative impact on climate change. According to EPA (2023) composting and recycling saved about 193 million tons of carbon dioxide. Thirdly, recycling reduces the volumes of waste dumped in landfills hence reducing the effects of pollution (EPA, 2023). Fourthly, recycling reduces the impact on global warming due to reduction in production of Green House gases. Lastly, recycling conserves energy, for instance recycled paper reduced energy consumed by 62 percent, and 94 percent for recycled aluminum (Lamma, 2021). A different research studying environmental effects of plastic waste recycling on climate change by (Tonini et al, 2021) also agrees that recycling of polymers was beneficial to the climate change compared to use of virgin materials.

Composting is also a key method in waste management practices. It is the natural decomposition process of transforming organic waste into helpful product. Organic waste used in composting include market waste, agricultural, kitchen waste, and farm waste. If this waste is left or dumped in the landfills they produce greenhouse gases which contribute to global warming (Hassan et al, 2023). Composting can either be aerobic (requires oxygen) or anaerobic (does not require oxygen) and is affected by temperature, ph, moisture, Aeration, microbial activity, carbon /nitrogen ratio, and lignin content.

A study by Sayara et al (2020) demonstrated the that adding compost recovers soil structure by 29 and 63 percent hence reducing risks of erosion, improves drainage, and reduce evaporation of water from the soil. Similarly, application of compost in soil reduce bulky density of soil. According to Sayara et al (2020) application of compost in loamy, and sandy soil decreased the soil bulkiness at a rate of 15 to 26 percent and to 14 to 25 percent after 15 months. Moreover, composting reduce waste dumped in landfills and reduce the quantity of methane emitted in landfills hence reducing climatic change. Although Sayara et al (2020) highlights positive impact on the environment, Ramusch and Mostbauer (2005) investigating composting and its impact on climate change with regard to process engineering and compost application-A case study in Vienna found that compositing is associated with emission of carbon-dioxide in the environment hence polluting the air. Similarly, a study by Peigne & Girardin (2004) concurs with the conclusion by Ramusch et. al. (2006) that compositing pollute air through accumulation of methane, Ammonia, and Nitrous Oxide in the atmosphere.

Additionally, waste minimization is the process of reducing the amount hazardous waste produced. Environmental Protection Agency establishes three hierarchies of waste minimization which include; source reduction (reducing or eliminating generation of waste), recycling (putting waste material to another use), and treatment which involves neutralization of waste. A study by Mallak, et al (2015) assessing the effectiveness of waste minimization methods in solid waste reduction at the source by manufacturing firms in Malaysia found that after embracing waste minimization at source the quantity of waste generated reduced. There was a positive correlation between waste minimization and waste reduction resulting to a healthier environment. Similarly, research by Mostaghimi & Behnamiam (2022) found a positive correlation between waste minimization and cleaner production strategies.

2.3 Research Gap

Despite the global concern on solid waste management, specific environmental impact on Kiharu Constituency in Murang'a County is under researched. While many studies focus on environmental impact of solid waste on urban areas, impacts of solid waste practices in Kiharu remain undocumented. This paper highlights gaps that need more focus in Kiharu Constituency. There is need to assess environmental impact of solid waste management practices in Kiharu since most research focus on urban areas. Studies neglect the impact of solid waste on soil quality, water, and air.

III. RESEARCH METHODS

This study was conducted in Kiharu Sub-County, Murang'a County in Kenya. The study was conducted in all the six 6 administrative wards namely: Wangu, Gaturi, Mbiiri, Township, Mugoiri ward, and Murarandia wards.

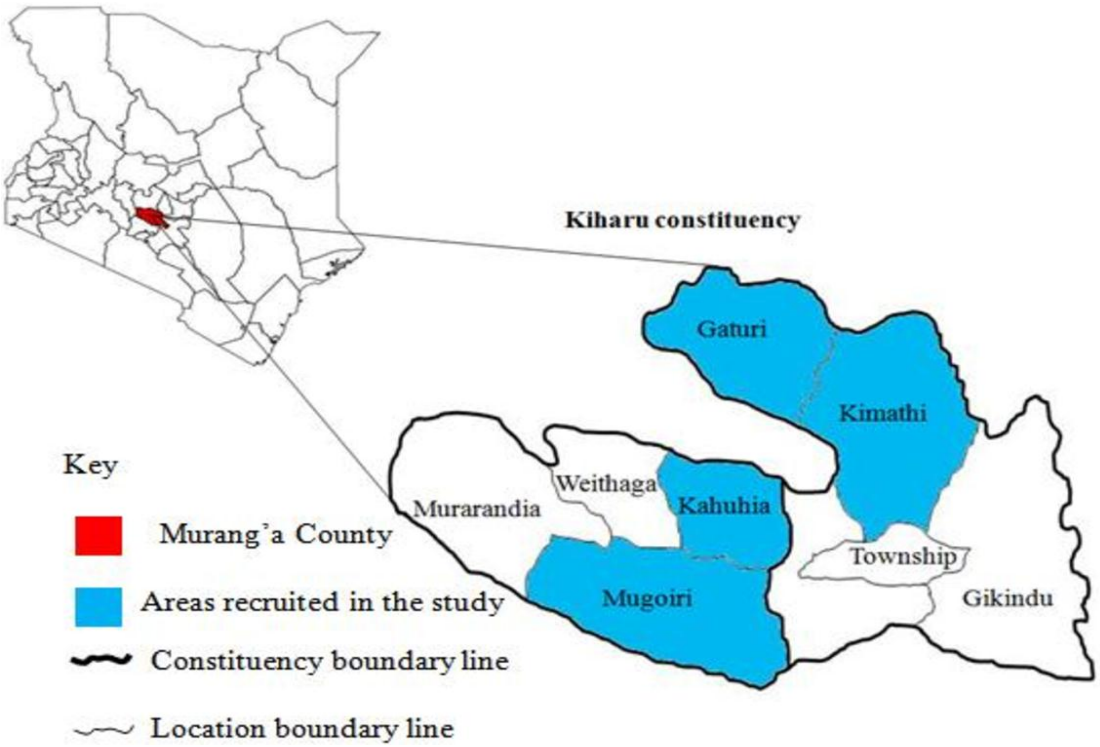

Figure 3.1: A Map of Kiharu Sub-County in Murang'a County, Kenya

Source:

The study employed a cross-sectional quantitative research approach which involved collecting data at a single point in time which was used in examining relationships between solid waste management practices and the environmental in Kiharu Sub-County.

The study targeted all the 19,404 households within the six wards in Kiharu Sub- County (KNBS, 2019). A sample of 200 households was determined using Cochran's sample size formumal as used by Nasiuma (2000). The study employed stratified random sampling technique to select households and study participants from the target population where Kiharu was subdivided into six strata which were the wards. The specific households were then selected using a simple random method and a representative of the household mainly the household head responded on behalf.

The data was collected using a structured questionnaire and administered to the respondents to collect quantifiable data on the waste generation patterns, and waste disposal practices. The questionnaires used close-ended questions, which allowed easy data analysis and comparisons in the research project (Taherdoost, 2022).

The collected data was keyed, cleaned and analysed using SPSS software version 27. The study employed mixed analysis methods including descriptive and inferential analysis methods. Descriptive analysis was used to summarize the collected data using frequencies, mean and standard deviations while under inferential analysis Pearson's correlation and regression analysis were used to examine the relationship and the environmental impact of solid waste practices. In addition, regression analysis was used to test the study hypothesis. A significance level of 5% was adopted which is commonly used.

The regression model was as follows:

$Y = \beta_0 + \beta_1 X + \varepsilon$

Where:

Y =environmental impact (dependent variable)

X = Solid Waste Management Practices (Independent variable)

ε = Error term

IV. RESULTS

This section presented the results of the study. First, the study presented the demographic information of the respondents, followed by types of wastes found in Kiharu Sub-County and lastly waste management Impact on the environment.

4.1 Demographic Information

The study had a 93% response rate where 186 respondents returned the duly filled questionnaire. They came from all the six wards where Gaturi, Murarandia, Township, Kahuro, Wangu, Mbiri, and Mugoiri. Gaturi had each 29

participants (15.6%), Murarandia had 37 (19.9%), Township had 31 (16.7%), Wangu had 30 (16.1%), Mbiri had 34 (18.3%), and Mugoiri has the fewest with 25 respondents (13.4%). Majority who responded were male (58.6%) and the largest group was single (47.0%) and married (37.3%). Majority had secondary education (37.0%) as their highest education level. Regarding their source of income, majority, did business (31.9%), farming (21.7%) and formal employment (27.1%). The age of the participants ranged between 19 years to 70 years, with a mean age of 31.11 years and a standard deviation of 10.852. The study participants also indicated they had lived in their current area for an average period of 14.40 years and an estimated annual income of ranging from 0 to Ksh, 480,000 with a mean of Ksh, 68,619.56.

4.2 Types of solid waste in Kiharu Sub-County

The respondents were asked to express their opinions on the types of wastes generated by humans in Kiharu Sub-County. Table 1 presents the various types of solid waste that were found in Kiharu Sub-County in Murang'a County.

Table 1
Types of solid waste in Kiharu Sub-County

	Yes %	No %
Construction waste	161 (87.5%)	23 (12.5%)
Chemical Waste	107 (58.2%)	77 (41.8%)
Electronic Waste	102 (55.1%)	83 (44.9%)
Industrial Waste	86 (46.5%)	99 (53.5%)
Food Waste	177 (96.2%)	7 (3.8%)
Agricultural Waste	175 (94.6%)	10 (5.4%)
Biomedical Waste	71 (38.6%)	113 (61.4%)
Waste Tires	171 (92.4%)	14 (7.6%)

From the findings in Table 1, there were various wastes that were found to be present in Kiharu sub-County. The most common wastes were food wastes (96.2%), Agricultural Wastes (94.6%), waste tires (92.4%) and construction wastes (87.5%). Others that were reported to be significantly present were Chemical wastes (58.2%), and Electronic wastes (55.1%). The least common wastes found in Kiharu were biomedical wastes (38.6%) and Industrial Wastes (46.5%)

4.3 Solid Waste Management practices

The study went ahead and investigated the waste management practices in Kiharu sub-county. The respondents gave their opinions on various waste management practices on a scale of 1 to 5 where the lowest represented Strongly Disagree (SD) and the highest was Strongly Agree (SA).

Table 2
Waste management practices

	SD %	D %	N %	A %	SA %	Mean	Std. Dev
Open landfills and open burning							
The use of open landfills is a common method for managing waste in Kiharu Sub-County.	7.5	14.0	6.5	48.4	23.7	3.67	1.198
Open landfills contribute significantly to environmental pollution in our community	1.6	6.5	9.1	63.4	19.4	3.92	0.828
Open burning is a common practice for waste disposal in my area.	0.5	3.8	14.0	58.1	23.7	4.01	0.760
Open burning of waste has a negative impact on air quality in Kiharu Sub-County.	1.6	0.0	9.2	60.0	29.2	4.15	0.714
Recycling and Re-use							
Recycling programs are effective methods for waste management.	4.9	7.6	16.8	53.3	17.4	3.71	1.003
I am willing to participate in recycling programs if they are made more accessible.	1.1	1.1	16.8	55.7	25.4	4.03	0.751
Re-using items is an effective way to reduce waste in our community	1.6	2.7	17.9	59.2	18.5	3.90	0.783
I actively look for ways to re-use items instead of disposing of them.	0.5	2.7	12.4	59.7	24.7	4.05	0.726
Composting and energy recovery							
Composting organic waste is a beneficial practice for managing household waste.	1.6	8.1	12.4	63.8	14.1	3.81	0.837
I would be interested in composting my household waste if resources were available	1.1	2.7	14.6	61.1	20.5	3.97	0.748
Converting waste to energy is a viable option for waste management in Kiharu Sub-County.	1.6	4.3	10.8	57.3	25.9	4.02	0.831
I support initiatives to recover energy from waste as a part of our waste management strategy.	0.5	3.2	10.3	59.5	26.5	4.08	0.736
Avoidance and Waste Minimization							
Waste avoidance and minimization should be prioritized over other waste management practices.	1.1	1.6	12.4	57.8	27.0	4.08	0.744
I make conscious efforts to minimize the amount of waste my household produces.	0.0	0.5	14.1	58.4	27.0	4.12	0.649

The respondents stated that open landfills was a common waste management practices where majority, 48.4%, agreed and 23.7% strongly agreed on prevalence of open landfills in Kiharu Sub-County (M=3.67, SD=1.198). However, the respondents stated that although the use of open landfills was common, it was linked to environmental pollution (M=3.92, SD=0.828). Open burning was also a common practice (M=4.01, SD=0.760),

with 58.1% agreeing and 23.7% strongly agreeing. However, the respondents stated that the practice negatively impacted the environment especially the quality of the air (M=4.01, SD=0.760)

The respondents viewed recycling and re-use practices as positive and effective waste management practices. Majority, 53.3% agreed and 17.4% strongly agreed that recycling programs were effective and they stated that they were willing to participate in accessible recycling programs (M=4.03, SD=0.751). Re-using was also perceived to be an effective waste management practice (M=3.90, SD=0.783) and many, 59.7%, stated that they sought ways to re-use things.

In addition, strategies of energy recovery and composting were perceived as beneficial waste management practices in Kiharu. Majority considered composting organic waste advantageous (M=3.81, SD=0.837) and Waste-to-energy conversion was seen as viable (M=4.02, SD= 0.831) where the respondents supported initiatives of energy recovery, with majority, 59.5% agreeing. Lastly, the respondents stated that they prioritized waste avoidance and minimization, with most people, 57.8% agreeing and 27.0% strongly agreeing. Additionally, majority of the respondents stated that they made efforts to minimize household waste (M=4.12, SD=0.649).

4.4 The importance of proper waste management practices

The study went ahead and sought to investigate the importance of proper waste management practices in Kiharu. The results were presented in Table 3

Table 3

The importance of proper waste management practices

	Yes %	No %
Its protects the environment	183 (100.0%)	0 (0.0%)
Recycling helps you to get money	114 (62.6%)	68 (37.4%)
It prevents water, air and soil pollution	176 (96.2%)	7 (3.8%)
Reusing conserves the resources	167 (91.8%)	15 (8.2%)
Saves depletion of landfills	169 (92.3%)	14 (7.7%)

There was a unanimous agreement that proper waste management leads to protection of the environment (100%). The respondents also agreed that proper waste management benefits individuals economically where they stated that recycling of items enables one to generate an income (62.6%). Another importance of proper waste management was stated as prevention of pollution that is water, soil and air pollution (96.2%). This shows that the respondents were fully aware of the hazards that come with improper disposal of wastes. Also, conservation of resources through reusing (91.8%) was also cited as an advantage of proper waste management. Lastly, a significant number of respondents, 92.3%, stated that proper waste management practices help save landfill space, thereby preventing the depletion of landfills.

4.5 Environmental Impact

The study also sought to investigate the extent of environmental degradation in Kiharu County. The results were presented in Table 4.

Table 4

Environmental impact

	SD %	D %	N %	A %	SA %	Mean	Std.dev
The solid waste disposed in our area has affected the quality of soil.	3.8	11.3	15.6	41.9	27.4	3.78	1.085
Solid waste disposed has contributed to air pollution in our community.	0.0	4.8	18.3	46.8	30.1	4.02	.825
The solid waste disposed in our area has affected the quality of water sources such as rivers and streams.	1.1	4.3	18.4	45.4	30.8	4.01	.875
Waste disposal in our area is linked to health problems in our community	1.6	7.5	12.9	43.0	34.9	4.02	.964
Waste disposal in our area has brought harm to natural habitats (like forests or wetlands)	1.6	8.6	10.8	47.0	31.9	3.99	.961

From the study findings in Table 4, waste disposal was found to have negatively affected the soil quality (M=3.78, SD=1.085). Additionally, it was pointed out that the waste disposed in Kiharu polluted the air (M= 4.02, SD=0.825) with nearly half (46.2%) of the respondents linking air pollution with improper disposal of wastes. The study findings also showed that water quality in local rivers and streams was polluted as a result of improper waste disposal (M=4.01, SD=0.875). In addition, a concern about health problems linked to waste disposal (M=4.02, SD=0.964) was raised which showed that there were health risks which were associated with the current waste management practices in Kiharu sub-county. The community also raised alarms that the poor waste management brought about harm to natural habitats, including forests and wetlands (M=3.99, SD= 0.961).

4.6 Impact of Solid waste management practices on the Environment

The study conducted a Pearson correlation analysis and regression analysis to examine the association between solid waste management practices and Environmental impact. The test helped in determining whether there was a relationship between each independent variable and the dependent variable, the strengths of association, and the direction of the relationship, whether positive or negative.

Table 5
Environmental Impact of waste management practices

	β	Std. Error	*t*	*p*-value
(Constant)	0.334	0.638	0.523	0.601
Solid Waste Management Practices	0.911	0.160	5.687	0.000
r (p-value)		0.397 (<0.001)		
r^2		0.158		
$F_{(1,173)}$ value		32.344		
p-value		(<0.001)		

From Table 5, the regression model was as follows:

Environmental Impact = 0.334 + 0.911*Solid waste management practices

From the correlation results, solid waste management practices was found to have had a moderate positive and significant relationship with the environmental impact, r=0.397, p<0.001. Further, the findings were illustrated in Figure 2. Further, the study established that solid waste management practices explained 15.8% of any change or variation occurring in the environmental impact (r^2 = 0.158).

The ANOVA results suggested that the model of environmental impact as explained by solid waste management practices was significant, $F_{(1,173)}$ = 32.344, p<0.001.

From the model, the relationship between solid waste management practices and the environmental impact was found to be significant and positive, β = 0.799, t=4.836, p < 0.001. This meant that solid waste management practices impacted the environment greatly and that a unit increase in the waste management practices betters or increases the environmental impact by 0.799units.

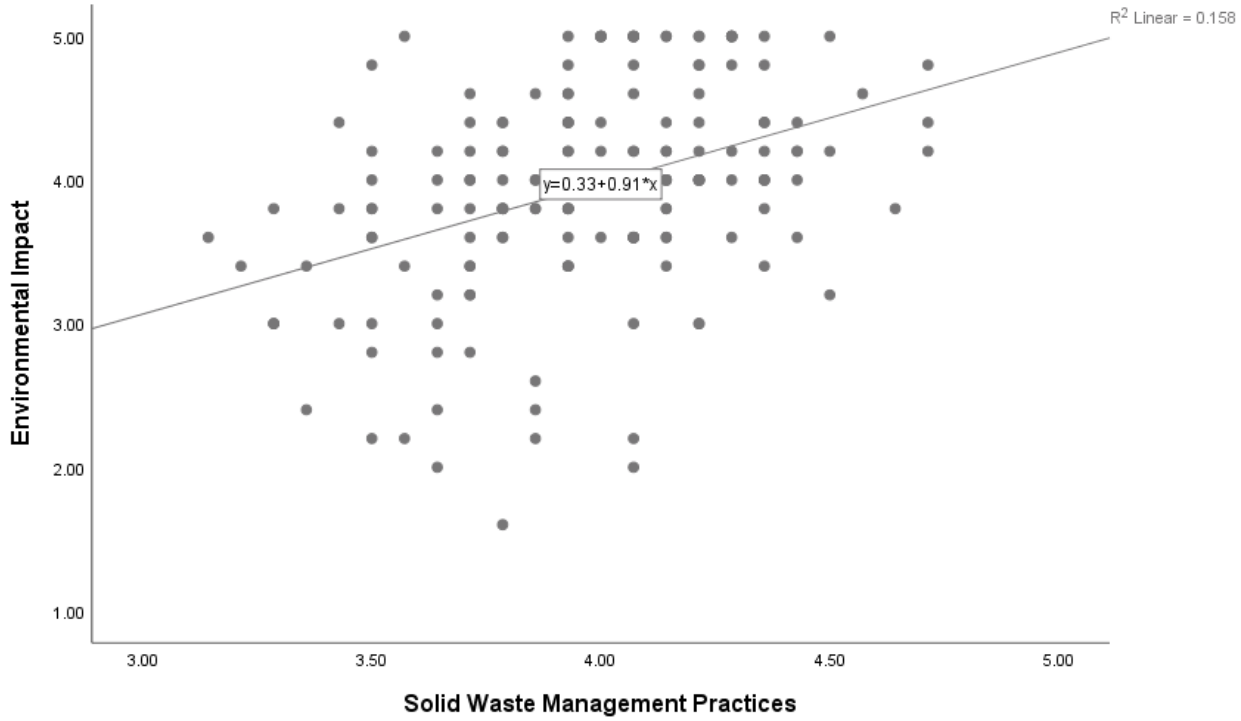

Figure 2 *Scatter plot for waste management practices and environmental impact*

Figure 2 showed that there was a positive relationship between waste management practices and environmental impact implying that the better the waste management practices in place, the more and positive the impact on the environment is.

4.7 Discussion

This paper sought to assess the environmental impacts solid waste management in Kiharu, Murang'a County, Kenya. More specifically, the study looked at the types of wastes in Kiharu and how solid waste management practices impacted the environment. The findings of the study established that there were various wastes that were disposed in Kiharu. They were classified in various categories. Food wastes, construction wastes, tire wastes and agricultural wastes were identified as the most common types of solid wastes in Kiharu sub-county. In addition, other wastes present in Kiharu included Chemical and electronic wastes while industrial and biomedical wastes were present but not very common in the area. The wastes were found to degrade the environment where they affected the quality of the soil, air and also affected water sources such as rivers and streams in the area. The disposed wastes also harmed the natural habitats and was also linked to poor health of the community at large.

The paper also established common waste management practices which included burning and open landfills. However, the practices were found to affect the environment negatively. Open landfills degrade the environment through soil pollution as well as underground water especially when the wastes disposed comprise of harmful chemicals and heavy metals. Open burning of wastes also produce harmful gases such as carbon monoxide and sulfur dioxide which in return affects the quality of air. If humans breathes the contaminated air, it may lead to respiratory issues harming their health greatly. Therefore, open landfills and burning of wastes are not proper waste management practices as they are detrimental to the environment and public health.

The paper instead established waste avoidance and minimization, recycling and re-use of waste products as proper waste management practices. Although the community in Kiharu was well aware of the best waste management practices, they were generally dissatisfied by how the management practices were conducted to save the environment. The study findings identified benefits associated with proper waste management practices which included prevention of pollution, protection of the environment and empowerment economically. The findings align to past literature which established that effective waste management is critical for reducing environmental pollution (Kaza et al., 2018). In addition, Singh et al. (2019) noted that recycling and re-use of wastes not only reduces the environmental pollution but also generates significant income, especially in urban areas. Also, a study noted that proper waste management prevents air, water and soil pollution (UNEP, 2021).

Despite the existence of waste management practices, the community was generally dissatisfied with the way the waste was being managed necessitating the need to improve the waste management infrastructure.

To establish how solid waste management affected the environment in Kiharu, this paper performed regression and correlation analysis to test for the relationship. The findings established that there was moderate significant and positive association between solid waste management practices and the environmental impact. This emphasized that effective waste management practices were crucial for reducing environmental pollution and preserving natural resources.The wastes present in Kiharu, if well managed through practices such as recycling and re-using, waste minimization, composting among others would lead to a better environment that is clean and healthy. These findings agree with findings by past literature. For instance, a study by Wang et al. (2020) stated that proper waste management practices, were crucial while reducing the environmental pollution and preserving natural resources. Similarly, Smith et al. (2018) argued that communities with well-established waste management practices experience lower levels of environmental degradation.

V. Conclusion

The study concluded that in Kiharu the common types of wastes were food wastes, agricultural, construction and tires. Other wastes were chemical, electronic while biomedical and industrial wastes were uncommon although they were present. These wastes were disposed and due to improper waste management systems, the wastes polluted the air, water sources, soil and natural habitats leading to poor health of the people living near dumpsites.

The study also concluded that waste management practices significantly and positively affected the environment. Therefore, the better and effective the waste management practices are, the more the reduction of environmental pollution which results to preserving natural resources. Therefore proper waste management practices were crucial in reducing pollution of the environment.

VI. Recommendations

The study made several recommendations. First, the paper recommends recycling and re-use waste management practices be adopted in Kiharu sub-county as a way of dealing with wastes such as construction, tires, food and agricultural wastes. Although present, there should be vibrancy in adopting the measures such as setting up recycling centers and creating awareness on the importance of recycling and reusing wastes. Secondly, the study recommends adoption of public training and campaigns to the community encouraging households and communities to manage their wastes efficiently, and also reduce reliance on burning and landfills to help improve

soil and air quality in the area. Lastly, the study recommends the use of modern waste handling equipment to enhance the efficiency and safety of waste management operations.

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