

Solid Waste Management Challenges and Environmental Impacts in Kisii County, Kenya

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Abstract: Solid waste management is a global challenge and countries worldwide are constantly seeking innovative and sustainable solutions to deal with the crisis. Tons of billions of wastes are generated annually and increase with increasing population. Developing countries generate less waste yet they bear the brunt of the crisis due to lack of financial resources and infrastructure to manage wastes effectively. Kisii county, like the rest of Kenya majorly relies on open dumpsites in comparison to other safer and more sustainable methods of solid waste management. Open dumpsites are breeding grounds for flies and rodents which significantly increases the risk of disease transmission. Leachate generated from the dumpsites flows into rivers and streams during rainy seasons and contaminates the water sources. It infiltrates the soil and percolates into underground water sources leading to pollution of underground water sources that people tap into for wells. Two dumpsites in Kisii county, one in Kenyenyia (a sub-county in Kisii county) and the other approximately 2km from Kisii town, were analyzed to provide insights into the broader solid waste management challenge across the county. The dumpsites are located in close proximity to habitual spaces and interfere with the daily routines of the people living and working near them. Waste segregation is hardly practiced which eventually increases the volume of the waste at the dumpsites. To successfully manage solid waste, the county should invest in environmentally friendly methods of management like incineration, sanitary landfills and composting and ensure that waste is segregated at the point of generation

Keywords: Solid waste management, Open dumpsites, Leachate contamination, Kisii county, Sanitary landfills.

1. INTRODUCTION

1.1 Background of the study

Kisii is one of the forty-seven counties located in the south western part of Kenya. The current population as of December 2025 was 1,370,000, 2.5% of the country's population [1]. The county covers an area of 1332.7Km² and has nine constituencies namely: Bobasi, Bomachoge Borabu, Bomachoge Chache, Bonchari, Kitutu Chache North, Kitutu Chache South, Nyaribari Chache, Nyaribari Masaba, South Mugirango. It's economy majorly stems from commerce and agriculture and is famously known for farming bananas, known to the locals as 'matoke'.

The task of regulating and managing solid waste in Kenya is devolved to county level hence each county is responsible for handling waste within its jurisdiction. The task is however regulated by National Environment Management Authority (NEMA) which sets the regulatory framework and oversees compliance by the counties. The county department of water, environment, natural resources, energy and climate change along with public works ensures the enforcement of rules governing waste disposal, collection and transportation to the dumpsites. The Kisii county solid waste management act 2015 was enacted to provide a framework for the management of solid waste within areas of the county.

Solid waste management is very crucial as lack of it poses risk to the environmental quality, public health and aesthetic value of the surroundings. Developing countries have faced challenges with solid waste management due to lack of resources and funds and Kenya is not an exception. The country has taken steps in the right direction through measures like banning the use of non-biodegradable plastics bags in 2017 and waste collection in residential areas to avoid dumping near homes and in road drainage structures. However, there are areas that are still lacking and require improvement. Wastes are being dumped in uncontrolled dumpsites which lead to contamination of underground water source. There is lack of waste segregation at the source of generation and lack of waste collection systems in low-income areas leading to dumping in undesignated areas.

1.2 Problem statement

Article 42 of the constitution of Kenya states that every person in Kenya is entitled to a clean and healthy environment and has a duty to safeguard and enhance the environment. The vision 2030 aims to provide a clean, secure and sustainable environment for its citizens and this effort is to be realized through efficient and sustainable waste management systems [2]. The vision has not been achieved so far in regards to solid waste management and its lack of therefore has caused detrimental effects to public health and environmental wellbeing. Effective solid waste management is a challenge due to increased population and urbanization which have led to increased amount of solid waste generated. Most urban centres are unable to handle the wastes effectively as they lack infrastructure, funding and governance mechanisms.

In Kisii for instance, wastes are dumped in open dumpsites with little regard to the environment. The waste dumped is not segregated and often contains plastics which do not decompose and add to the volume of waste in the dumpsite. Waste collection systems have not been mobilized in rural, low-income settlements leading to dumping of wastes in road drainage structures like culverts, in market places and near residential settlements.

One of the dumpsites analyzed is located on a high-altitude area, near a school and a construction site and is in direct contact with the soil hence allowing the flow of leachate into underground aquifers which supply water downhill to residential and commercial settings. The other dumpsite is located adjacent to the main market centre which receives high human traffic from the town twice a week on market days. No covering is provided both dumpsites hence causing air pollution. Rodents and houseflies infest the dumpsites and fly into nearby homes, institutions and commercial buildings increasing the vulnerability of the occupants to diseases. The county should invest and shift to safer sanitary methods of waste management and which will promote public health and help improve the aesthetics and reputation of the county.

2. LITERATURE REVIEW

2.1. Definition of solid waste

Solid waste is any unwanted or discarded material. Its composition varies and can be classified according to the source of generation, whether it is hazardous example asbestos, paint and medical wastes or non- hazardous, degradable like food wastes, paper, cardboard, wood and leaves or non-biodegradable like plastics, metals, electronics and glass and chemical composition.

2.2 Sources of solid waste

Wastes vary as per the source. In a school, for instance, the most common solid waste likely to be generated is paper. The same paper can be found in other sources like residential homes and urban centres. It is expected to encounter syringes as one of the most common solid wastes in hospitals and food wastes in residential homes. Sources of solid wastes therefore help in predicting the wastes likely to be encountered and henceforth gives insights on the mode of disposal and possibility of recycling and re using. The various sources of solid waste are:

1. Residential- these are sources that are generated in homes and residences. Common wastes in households include plastics, cardboards, glass, ashes, bulky items like electronics, batteries, tires, food remains, etc. Some wastes are degradable like food remains and cardboards while others are non-bio-degradable like plastics and electronics.
2. Industrial - These are wastes generated from industries. Wastes from industries are both hazardous and non- hazardous. Wastes include chemicals, medical wastes, food wastes, packaging wastes etc.
3. Commercial - these are wastes generated from commercial facilities like restaurants, hotels, stores, office buildings and markets. Wastes generated include paper, glass, wood, cardboard materials, metals and hazardous wastes.
4. Institutional- these are wastes generated from institutions like colleges, schools, prisons and other government centres. Wastes generated include paper, plastic, glass, metals, food wastes, rubber and hazardous wastes.
5. Municipal- these are wastes generated from urban centres like streets, benches and parks. They include paper, plastic, leaves, sludge.
6. Construction and demolition areas-these are wastes generated from construction sites. They include steel materials, wood, plastic, copper wires, glass, wood, concrete and wood
7. Biomedical- these are wastes generated from hospitals and chemical manufacturing firms. Wastes from these sources should be handled with care since they can be hazardous. They include bandages, syringes, gloves, drugs, chemicals, food wastes, plastic, paper and gloves.
8. Agriculture- these are wastes generated from farms, vineyards and orchards. They include pesticides containers, spoiled food and hazardous materials that should be handled with care.

Solid wastes vary in chemical properties including moisture content and density. Knowledge in the chemical properties of solid wastes is essential in management as it can give insight on the possibility of incineration and composting in waste reduction efforts.

2.3. Effects of industrialization and population growth on solid waste management

Solid wastes have changed over the years in terms of quantity and type. Industrialization has led to the generation of different types of wastes that were not common pre industrialization. Unlike before, people now consume packaged and disposable items leading to generation of wastes in form of plastic bags.

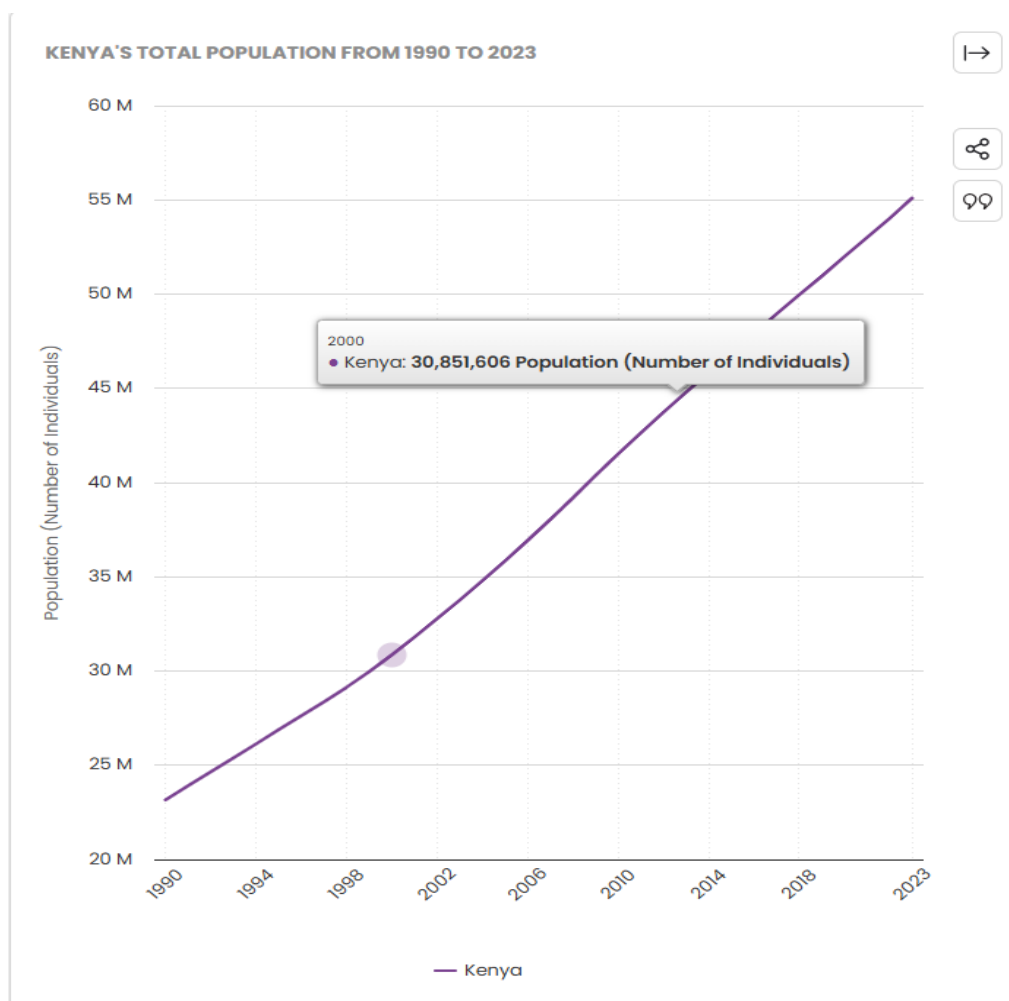
Population has also been on the rise globally leading to the increase in amount of waste generated. Total waste generated is directly proportional to the total population as shown.

Total waste generated= Waste per capita * Total Population.

Kenya's population has increased from approximately 7.69 million people in 1960 to 57.32 million in 2025 as has been recorded by [3]

Year	Population
1960	7.69
1970	11.37
1980	16.02
1990	22.89
2000	30.64
2010	41.60
2020	52.22
2025	57.32

A linear graph by [4] shows the progressive increase in population in Kenya from 1990 to 2023 as shown. The population is projected to continue increasing as the years go by and similarly the amount of waste generated is also projected to increase.



2.4. Stages of solid waste management

I. Onsite handling and storage

This is at the point of generation where waste is separated into biodegradable wastes and non-biodegradable wastes and stored in storage bins. The separation of wastes helps in distinguishing the wastes to determine the method to be used in solid waste management.

II. Collection, transfer and transport of solid waste

Waste is then collected by individuals licensed to partake the task and held at transfer stations before being transported to final disposal sites.

III. Resource recovery and processing

It involves process of converting the waste into valuable resources through recycling, composting and energy recovery.

IV. Disposal of solid waste

The residual waste is then taken to the final disposal sites. It can be through open dumping which is unsanitary, sanitary landfills which are safer or incineration. [5]

2.5. Modern trends in waste management

In the pre-colonial period, waste generated was organic and biodegradable. Materials like glass, plastics and specialized metals were almost nonexistent. Wastes comprised of food remains, crop residues and animal excreta. The organic wastes could occasionally be used as fertilizers to improve the soil fertility. Waste reduction was heavily practiced through repurposing, repairing and recycling. The population was less than it is currently hence amount of waste generated was less. Therefore, simple methods of waste management were used. Waste disposal was decentralized and handled at household level [6]. Necessity is the mother of invention. The inception of industrialization that brought wastes that were more complex to manage like plastics, asbestos and paint and increased population, brought the need for a more strategic and complex way to manage the solid wastes.

Currently, solid waste management is based on a framework that aims in minimizing waste generation, conserve natural resources and reduce the environmental impact. The framework is based on the 4R's that is reduce, reuse, recycle and recover.

1. Reduce- this aims to encourage lower consumption of the wastes by buying less and choosing products with minimal packaging. This can be through opting to use digital receipts over paper receipts.
2. Reuse- this aims to encourage ways to extend the life of the materials through finding new uses instead of disposing. This can be through re purposing a used and old ladder into a shoe rack or book shelf.
3. Recycle- this encourages processing wastes like used paper, glass and plastics into new products.
4. Recover- this encourages conversion of the wastes to resources. It can be done by using the wastes to generate electricity and heat or converting organic wastes like food remains into compost [7]

2.6. Modern technologies in solid waste management

Various technologies have now been developed over the years in an effort to manage the solid wastes and protect the environment from degradation. They include

1. Sanitary landfills

It is a controlled method of disposal of solid waste on land. It was an advancement of the open dumpsites where wastes were dumped in open land and left to decompose with little consideration to the environment and to human health. It was first introduced in England in 1912 [8]. The process of creating a landfill is engineered, controlled and well thought out. The location is first chosen and environmental impact studies are carried out prior to the selection. A trench is dug and a plastic liner is placed into the trench before dumping the wastes to preserve the quality of ground water. Wastes are then dumped in bits, compacted and covered with soil to prevent odors and windblown debris before addition of more wastes. They contain methane collection systems to collect methane gas and storm water management systems to prevent erosion [9]

2. Incineration/ Conversion of waste to energy

It is a method of solid waste management that involves the combustion of combustible waste in incinerators. The wastes are fed into furnaces which have high temperatures of 850⁰C to 1100⁰C. They are then burned, fumes filtered and neutralized before they are released into the environment. The heat generated can be used to generate electricity and drive turbines. It is an effective method since it reduces the solid waste by 90-95%, saves on land that could be used in dumping and converts waste into energy that can be useful [10]

3. Biological treatment

This can be through both anaerobic digestion and composting.

Anaerobic digestion is the process of breaking down biodegradable waste in the absence of oxygen to form carbon dioxide, methane and water. The methane, carbon dioxide mixture together with some traces of other gases form biogas which can be used for fuel for engines, gas turbines, boilers or manufacturing process. Aerobic digestion also known as composting is the breakdown of

biodegradable waste in the process of oxygen to form stabilized bio solids which are utilized as nutrient-rich fertilizers, carbon dioxide and water [11].

4. Pyrolysis

It is the thermo-chemical decomposition of organic waste in high temperatures forming carbon rich solid residue which can be used as fuel, a gas and a liquid. The process has been used in Kenya in local production of charcoal but has not been practiced as a method of managing solid waste. It has been successfully practiced in the UK, Turkey and Japan and reduced municipal solid waste by over 80% [12]

5. Smart waste management

It is a system used in waste management that involves the use of sensors and IoT (Internet of things) networks to monitor bins at collection sites, discover the optimal time for collection and for route optimization that eventually saves on fuel, labour and protects the environment by ensuring more frequent collection of wastes in high population areas.

Public-private partnerships (PPPs) have also gained popularity in solid waste management and have become common in rapidly growing cities like Nairobi. Private firms have better technical know-how, more advanced equipment and technology than public systems hence improving solid waste management efficiency.

3. METHODOLOGY

3.1. Research design

A qualitative research was conducted to investigate the environmental effects and community perceptions of the uncontrolled dumping at two dumping sites within the county. The case study approach enabled an extensive analysis of the problem within its real-life context.

3.2. Study area

The study was conducted at two dumpsites within the county, one adjacent to the Kari primary school and close to the ongoing construction works at the Kisii Cancer Centre and the other adjacent to a market centre in Kenya.

3.3. Target population

The target population included teachers and students at Kari school, personnel working at the Kisii Cancer Centre construction site and residents living near the Kenya dumpsite as they are directly affected by the waste management activities.

3.4. Sample size and sampling technique

A purposive sampling technique was used to select the participants with relevant knowledge regarding the dumping site. It involved 8 people at the dumpsite near Kari primary and 6 at the dumpsite located in Kenya.

3.5. Data collection methods

Multiple methods of data collection were used to ensure the reliability of the information.

I. Observations

Direct observations at the dumpsites were conducted to assess the types of waste disposed and the possible environmental and health hazards likely to be caused.

II. Interviews

Interviews were conducted with residents, construction workers working near the dumpsite, teachers and students at the school and detailed information gathered about the effects of the uncontrolled dumping and the possible solutions to the problems and responses recorded through note taking.

III. Field visits and photography

Field visits were conducted and photographs taken to provide visual evidence of the effects of the dumpsite.

IV. Documentary research

Journal articles, environmental policies, previous studies and relevant books concerning waste management were reviewed and helped to compare the existing literature with findings from the field.

3.6. Data analysis

Thematic analysis was used to analyze the data collected where the information was organized into themes related to environmental impacts, health impacts and waste management challenges at the sites. The findings were interpreted and presented descriptively.

4.FINDINGS AND DISCUSSION

4.1. Findings from dumpsite A (near KARI school)

The dumpsite is located approximately 50 metres from Kari primary school, 150 metres from ongoing construction works at the Kisii Cancer Centre and 200 metres from Kisii School. The wastes at the site are not segregated prior to dumping. Plastic materials which are non-biodegradable were observed which should be separated at the site of waste generation and managed through other methods like recycling.

The site is on a hilltop and lacks plastic liners between the soil surface and the wastes. This makes it environmentally unsuitable as the rainwater passing through the waste produces leachate that infiltrates the soil and seeps into the underground water sources leading to contamination of the groundwater and nearby aquifers. During rainy seasons, the leachate mixed with rain water flows as surface run off downhill. Furthermore, it is located too close to two schools and a construction site. Leachate from the site may seep into underground water sources at the schools and the construction site posing a health hazard to the workers, students and teachers. No cover is provided at the dumpsite hence the odour generated spreads to the schools and the construction site affecting the comfort and well being of the people around. The population of flies has also increased and has become a serious concern as they disperse to the schools and the construction site as reported from the interviews.

Several students at the school have fallen ill from water borne diseases and the parents have made complaints to the school administration. The school administration claimed they are lobbying for the removal of the dump site. Workers at the construction site have complained of unsuitable working condition due to the high population of flies and odour from the dumping site. They stated that an excavator is usually taken to gather the wastes dispersed by wind and rain. Due to the agitation of the wastes, the odour intensifies and becomes unbearable.



Figure 1 Physical location of the dumpsite



Figure 2 Current state of the dumpsite

4.2. Findings from dumpsite B (near Kenyena market)

The dumpsite is located in Kenyena town, approximately 30 km from Kisii town. It is located adjacent to the main market centre and in close proximity to hotels and residential homes. The wastes disposed as observed during the site visit are majorly organic generated from market activities, although a small number of plastics was observed.

The dumpsite lacks plastic liners that would act as barriers between the wastes and the soil. This increases the likelihood of infiltration of leachate which would contaminate the underground water sources which are tapped in as wells by residents of the area. The waste is left uncovered. Flies and rodents which are associated with the spread of diseases move within the dumpsite and into the market, hotels nearby and residential homes as reported during the interview. Odour is a major issue that was also reported by market vendors and buyers who mostly frequent the market twice a week on market days.

Open burning is regularly practised leading to air pollution through the release of smoke and other harmful gases into the atmosphere. The scattered waste materials greatly affect the aesthetic value of the area and the business activities within the market area and hotels. The dumpsite is also not fenced and therefore poses a risk of access by un authorized personnel and livestock as depicted by the image below.



Figure 3 Physical location of the dumpsite



Figure 4 Current state of the dumpsite

4.3. Comparative analysis of dumpsite A and dumpsite B

Aspect	Dumpsite A	Dumpsite B
Waste volume	High	Moderate
Waste segregation	Very poor	Poor
Burning practices	Never	Occasional
Nearby settlements	Moderate distance	Close
Environmental impact	Soil pollution	Air pollution Soil pollution
Management level	Weak	Very weak

4.4. Discussion of findings

Poor enforcement of waste management policies was observed in both sites. The findings showed waste segregation at the source of generation was hardly practiced as is recommended. The dumpsites are also poorly located as they are situated near residential homes, hotels, schools and work areas exposing the surrounding population to unpleasant smells, disease causing vectors and possible pollution of wells by leachate. The findings are in line with previous studies on waste management challenges in developing countries, where waste segregation, open burning and open dumping were established as common challenges. They also indicate that although challenges in waste management are common in Kisii County, the nature and intensity of the impacts differ based on the location and surrounding land use activities.

5.RECOMMENDATIONS AND CONCLUSIONS

Several recommendations are proposed based on the findings of this study with an aim to improve solid waste management practices in Kisii county.

- i. Increase in funds allocated to solid waste management by the county to facilitate efficient and sanitary methods of waste disposal.
- ii. The county should consider venturing into more engineered methods of waste management as discussed above.
- iii. Waste segregation should be encouraged and practiced at the site of generation through providing separate, well labelled disposal bins at residential and commercial settings.
- iv. Public participation should be carried out prior to selection of a dumpsite to acquire the views of the people likely to be affected by the dumpsites.
- v. Enforcement of laws and policies on solid waste management should be practiced and anyone infringing on them held responsible according to the law.
- vi. Public awareness campaigns should be practiced to educate the public on proper waste disposals and environmental conservation.
- vii. The county should encourage research on more sustainable methods of waste disposal and facilitate recycling and composting initiatives.

Effective solid waste management is a crucial issue that should be handled with the seriousness it deserves. Lack of it is detrimental to public health and endangers the environment which is relied upon to sustain all life. Extensive research should be carried prior to selection of a waste disposal method and enforcement carried out to ensure the laws and policies set are followed to the letter. If all parties collaborate and work towards improving solid waste management, challenges such as poor waste disposal practices and environmental pollution can be significantly minimized in an effort to achieve sustainability.

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