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Quantity of Sewage Generated in Secondary Schools for Potential Energy Generation in Kakamega County, Kenya

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Abstract: ***Free primary education in Kenya has led to an increase in student enrolment and the number of education institutions. This was expected to increase the generation of human waste and energy needs. This study sought to determine the quantity of sewage generated in secondary schools of Kakamega County, Kenya for potential bioenergy generation. Multistage/cluster sampling was used to select both public and private schools. A cross-sectional survey research design was employed and data collected through key informants, interviews, digital cameras and observation checklist. It was established that the quantity of Sewage generated was 17,662.3 tons per school academic year.***

Keywords: Energy, Quantity, Secondary Schools, Sewage

1. Introduction

This study discusses the results of determining the quantity of sewage generated in secondary schools for potential energy generation in Kakamega County, Kenya. The findings are fitted in the context of the previous researches in the light of the literature review. To achieve this objective, data from sampled schools were used to obtain the averages of the respective school categories. The school categories comprised of Boarding, Boarding & Day and Day schools. First, the study looked at the school enrolment characteristics, then the schools‟ disposal systems, the methods used to empty septic tanks and finally the quantity of sewage generated in these secondary schools for potential energy generation. The results were beefed up with information from key informants, observations by the researcher and interviews with various respondents. The school enrolment helped to establish the student population in the various sampled schools. The quantity of human waste generated from different categories of schools was determined using the dimensions of the disposal systems in the respective schools and the frequency of getting filled up and emptying them. The total quantity of human waste generated is per school academic year of 273 days. The waste disposal systems were useful parameters as indicators of potential risks posed to the school and the surrounding population. Schools had various means of managing their disposal systems that were full of human waste.

Studies have shown that sewage disposal from concentrated groups of people such as prisons is a major health hazard in the environment. Free primary education in Kenya has led to an increase in student enrolment and the number of education institutions. It is expected that this would lead to an increase in the generation of human waste. This study sought to determine the quantity of sewage generated in secondary schools of Kakamega County, Kenya for potential bioenergy generation.

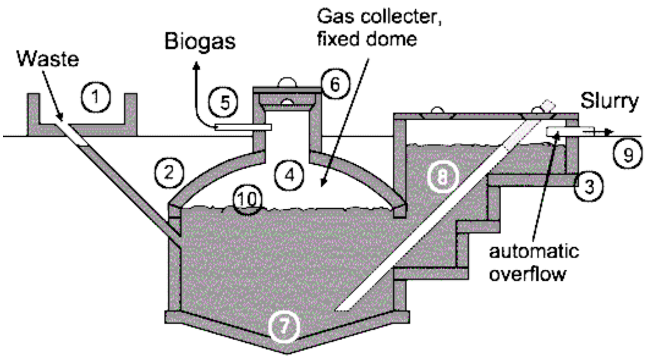
According to [1], there is need for research into the energy needs in places such as institutions to know if there are any sewage treatment plants or landfills that produce methane. This study was a response to this call. The Humanitarian Charter stipulates that safe disposal of human excreta creates the first barrier to excreta-related diseases, thus, reducing transmission through direct and indirect routes [2].Therefore safe excreta disposal is a major priority in most disaster situations that should be addressed speedily.

Modern technology of biogas generation can be utilised to produce biogas from such waste to mitigate these challenges. Biogas produces a clean alternative fuel, provides a use for organic waste streams that may otherwise be released into the environment, prevents the release of methane (a potent GHG) to the atmosphere, creates valuable liquid and solid fertilizers as a bio-product to enrich soils and enhance food crop production. According to KIPPRA (2008), failure to invest in alternative sources of energy is undermining the performance of the Kenyan economy thereby making vision 2030 a myth.

The uniqueness of Kakamega County hinged on the assumption that its large population would lead to an increase in student enrolment in schools. Consequently, this would over stretch the schools‟ energy needs leading to environmental degradation. The study focused on secondary schools in Kakamega County. This is because according to [3], Kakamega County has the highest number of Secondary schools in Kenya. It has 408 secondary schools (383 public, 25 private) with the highest student enrolment of 116, 732 (112, 632 in public, 4,100 in private) and also the highest number of boarding schools totaling to 280.

2. Literature Survey

The anaerobic decomposition of human excreta produces methane gas, which can be harnessed by biogas plants to produce energy [4]. The ambient temperature in most locations in Africa is sufficient to maintain the fermentation process due to the generally prevailing warm climate. As such, no artificial heating is required. Biogas installations are generally based on psychrophilic (<20°C) or mesophilic (30-42°C) anaerobic digestion. Digesters for biogas generation available in Sub-Saharan Africa are of 3 main types: flexible balloon, floating drum, and fixed dome (Figures 1 to 4). The choice of the design of the digester is a key determinant in the success of the implementation.



[1. Mixing tank with inlet pipe and sand trap. 2. Digester. 3. Compensation and removal tank. 4. Gasholder. 5. Gas pipe. 6. Entry hatch, with gastight seal. 7. Accumulation of thick sludge. 8. Outlet pipe. 9. Reference level. 10. Supernatant scum, broken up by varying level].

Figure 1: Fixed dome plant-Nicarao design
Source: [5]

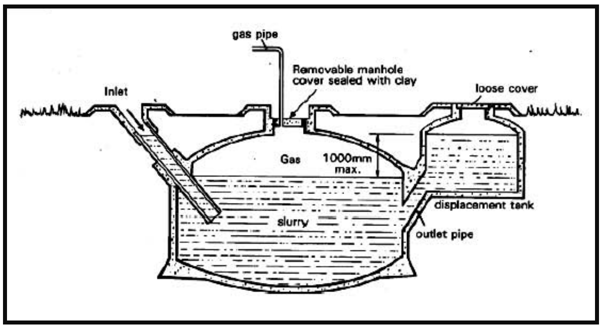


Figure 2: Design of biogas plant-Fixed dome (Frankel 1986) *Source:* Cited in [6]

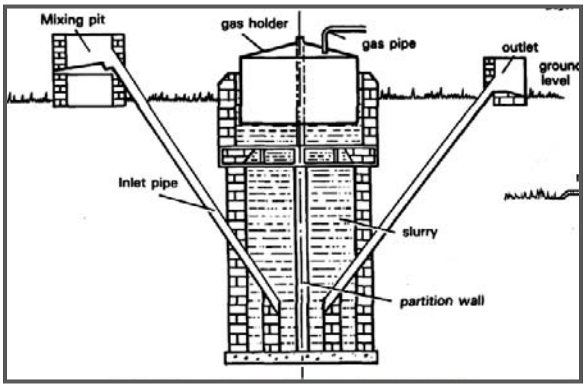


Figure 3: Design of biogas plant-Floating drum (Frankel 1986) *Source:* Cited in [6]

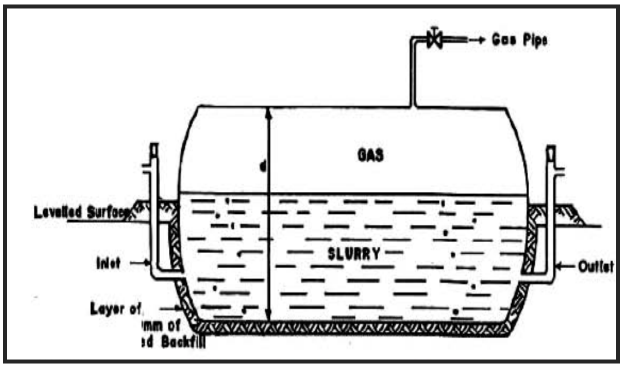


Figure 4: Design of biogas plant-Flexible balloon (FAO 1996) *Source:* Cited in [6]

3. Problem Definition

In Kenya, student enrolment in schools has increased due to the enactment of free primary education. This increase in student population has not only increased demand for energy but also increased sewage generation and consequently challenges on environment. The UN General Assembly‟s Agenda 21 resolution 44/228, Section I, paragraph 12 (g) affirmed that environmentally sound management of waste is among the environmental issues of major concern in maintaining the quality of the Earth's environment (UN, 1989).

In the City of Oslo, Norway, sewage biogas has been used to fuel public transport buses [8]. In Rwanda, all the 14 prisons are running on biogas using both human waste and cow dung feedstock (KIST, 2005). The „flying toilets‟ in Kibera slum of Kenya have been turned into biogas production. Ramba High School in Nyanza is utilising its pit latrines for biogas production for cooking (personal observation).

In Kenya, wood fuel has remained the most important source of energy since it meets over 70% of its total energy consumption needs [9]. About 90% of Kenya‟s 20,000 educational institutions use wood fuel for cooking [10]. Although the exact quantity of firewood consumed by these institutions has not been established, there are concerns about their ecological foot prints with regard to wood fuel consumption. In fact Kenya‟s forest cover is diminishing rapidly making biogas a very attractive alternative cooking fuel (Sky Link, 2011).

Methane, which is a main component of biogas is a greenhouse gas with a much higher "greenhouse potential" than CO_2 [11]. Converting methane to carbon dioxide through combustion is a contribution of biogas technology to the mitigation of global warming. Otherwise, biomass used for biogas generation can still undergo anaerobic decomposition and release methane to the atmosphere. These cases illustrate the important role that biogas technology can play in improving human waste management and mitigate energy and environmental challenges. It is against this backdrop that this study, as one of the emergency responses essential for people‟s dignity, safety, health and well-being evaluated anaerobic digestion of sewage for energy production and environmental protection in secondary schools.

4. Methodology

The study was carried out in Kakamega County in Kenya. The County was chosen because its number of schools and student population had increased remarkably. This meant a significant implication on the quantity of sewage generated for energy production. Kakamega County is one of the four Western Kenya Counties. Its geographic coordinates are 1o 00′N, 38o 00′E. The County is composed of twelve sub-counties. The County (Figure 5) lies within an altitude of 1,250m to 2,000m with an average annual rainfall ranging **from 1250-1750mm per annum.**

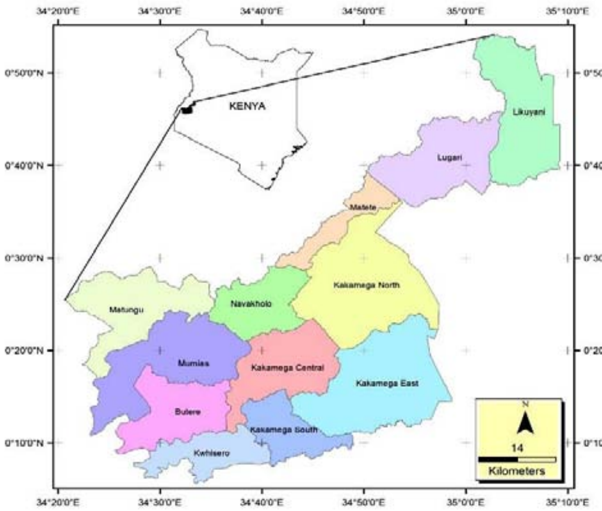


Figure 5: Map showing Kakamega County the study site. (Source: Researcher)

Its average temperature is 22.50oC. It is home to 1,660,651 people with 800, 989 males (48%) and 859, 662 females (52%). This makes it the second most populous County in Kenya after Nairobi, GOK, [12]. It has an area of 3,051 km² and a population density of 544 persons per km2. There is an age distribution of: 0-14 years (46.6 %), 15-64 years (49.7 %), 65+ years (3.6 %). Population growth rate is 2.5% and a fertility rate of 5.6 against the national average.
The target population was secondary schools in Kakamega County since they were considered centres of heavy waste generation with the potential for biogas production as well as high health risks to the environment. They were also heavy consumers of fire wood. In this study, each school was viewed as a single entity and treated as a unit of observation.

Multistage/cluster sampling was used to select both public and private secondary schools in the county. The schools categorized as private, extra-county, county and sub-county were randomly obtained by utilising a sample frame from the county education office. These schools formed the units of analysis. Key informants within the schools were the principals, their deputies, senior or boarding teachers, school bursars, nurses, head cooks and one member of the executive board. These key informants were selected purposively. Proportions were used to randomly pick the teachers and the students in the selected schools. Other key informants were stakeholders from organisations such as National Environmental Management Authority (NEMA), Ministries of Education, Health, Energy & Petroleum, Environment and Natural Resources (Kenya Forest Services) from whom representatives of Focus Group Discussions (FGD) were sourced.

The respondents included the school principals, deputy principals, boarding/senior teachers, teachers, school bursars, head cooks, school prefects, selected students, members of the Board of Management (BOM) and Parents‟ and Teachers‟ Association (PTA). Other units of analysis included the sewage systems and toilets.

A cross-sectional survey research design was used to determine the quantity of sewage generated in the secondary schools for potential energy generation. Data was collected through use of Key Informant Interviews. Besides, questionnaires, Focused Group Discussions, Observation Check list, document content analysis and digital cameras were employed in their respective areas to collect both primary and secondary data. Primary data were personally collected by the researcher through Observation Checklist (OC), Key Informant Interviews ((KIIs), questionnaires and digital cameras. Key Informant interviews were used to solicit information that was addressing the issue of energy in the schools. This research was carried out by a core team which travelled to all of the target institutions in Kakamega County. The core team consisted of the principal researcher and three assistants. The principal researcher played an important interventionary role during this non-structured interview.

5. Results and Discussion

5.1 School Enrolment Characteristics

The results of the school enrolment characteristics were as summarised in Figure 6.

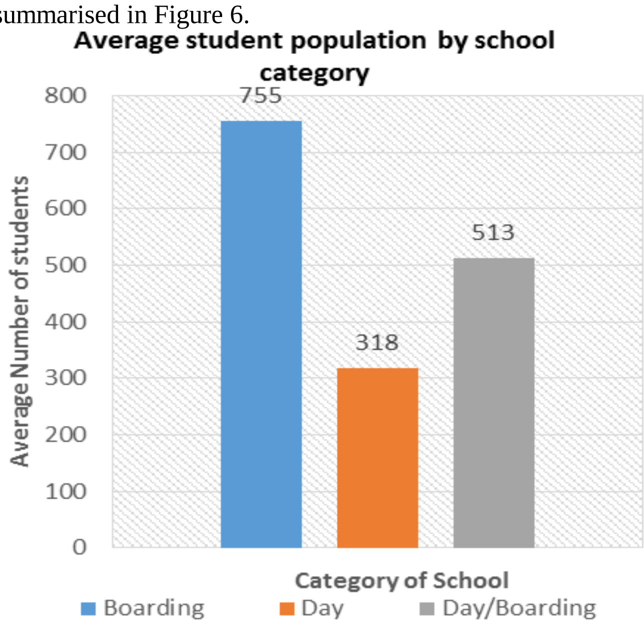


Figure 6: Average student population by school category

As presented in Figure 6, it was established that boarding schools had the highest mean student population of 755 (47.60%) followed by Boarding & Day schools with a mean student population of 513 (32.35%). The least populated schools were the day schools with a mean population of 318 (20.05%). Analysis of variance indicated that the difference in student population was statistically significant ($p<0.05$) between all the three categories.

5.2 Quantity of Sewage Generated in Secondary Schools for Energy Generation

The quantity of human waste generated from different categories of schools was determined using the dimensions of the disposal systems in the respective schools and the frequency of getting filled up and emptying them. The total quantity of human waste generated is per school academic year of 273 days. The results were as presented in Figure 7

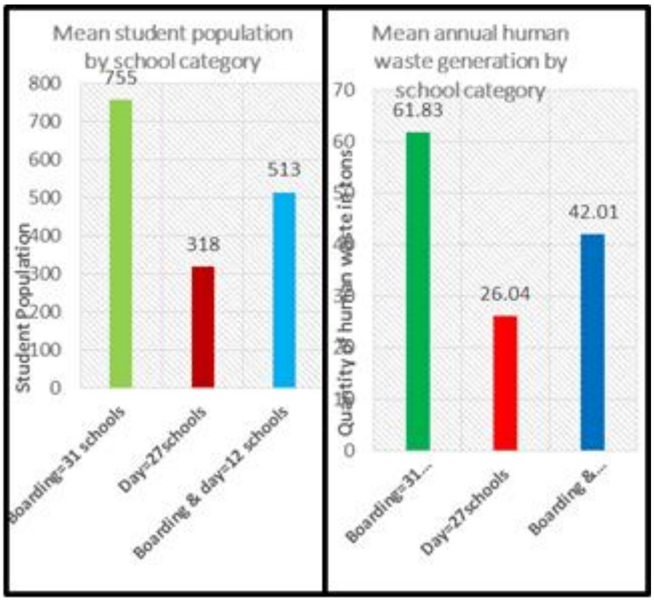


Figure 7: Comparison of student population and human waste generation

The results show that boarding schools with a higher mean population of 755 students have the highest human waste generation of 61.83 tons (47.60%) per school academic year (39 weeks=273 days). They are followed by boarding & day schools that generate a mean of 42.01 tons (32.35%) per school academic year. Day schools generate 26.04 tons (20.05%) per school academic year and a mean of 43.29 tons per school per school academic year. A correlation analysis revealed that there was a highly significant correlation between student population and the quantity of human waste generated in the various school categories. A tabular correlation analysis using graph pad prism software gave a P value of 0.0001 (alpha=0.05). A measured correlation coefficient (r) of 1.000 was also found to be highly significant. This implies that, Kakamega County with a total of 408 secondary schools (280 Boarding, 45 Day and 79 Boarding & Day with 116,732 students) generates 17, 662.32 tons of human waste per school academic year. This gives 43.29 tons of human waste generated per day per school (17, 662.32/408).

5.3 Means of Waste Disposal Systems

Means used by schools for human waste disposal were as summarised in Figure 8 and Plate 1 which shows some pit latrines that they used by the sampled schools.

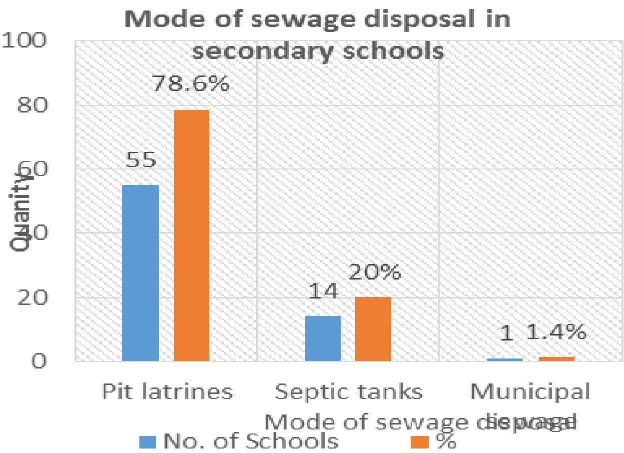


Figure 8: Mode of sewage disposal in schools

As shown in Figure 8, the dominant mode of human waste disposal system at the time of the study was pit latrines which were used by 55 schools (78.6%) out of the 70 sampled schools in Kakamega County. Out of these, 14 schools (20%) used improved systems of septic tanks and only 1school (1.4%) used piped sewerage system linked to the Municipal system.

Plate 1 shows some of pit latrines that were common in the schools as Plate 2 shows the bad state of some of the sewage disposal systems as evidenced by the exposed manholes of the septic tanks.

Plate 1: Common human waste disposal systems in schools

Plate 1: Septic tanks in different schools

Filled up and collapsed pit latrines were condemned since they posed serious danger to the students, Plates 3a and 3b.

Plate 3a: Condemned & Plate 3b Collapsed pit latrine

5.4 Management of the Disposal Systems

Schools had various means of managing their disposal systems that were full of human waste. Figure 9 gives a summary of various means that were used by the school to manage the full disposal systems.

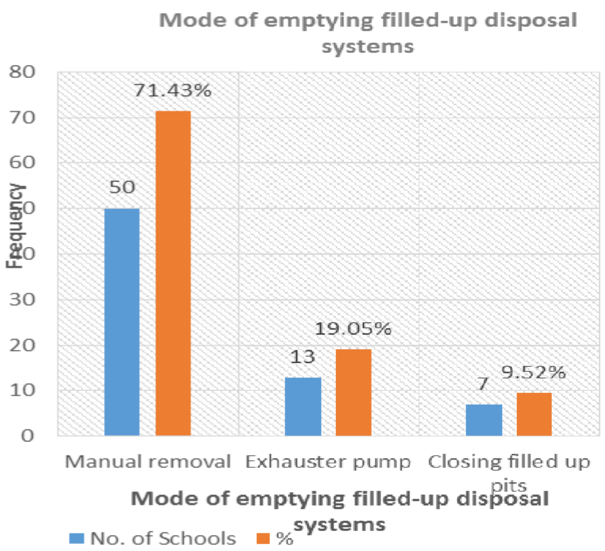


Figure 9: Mode of emptying filled-up disposal systems

When the disposal systems were full, some schools closed them up while others emptied them. The predominant means was that of emptying where 63(90%) of the sampled schools emptied their filled up disposal systems. The other 7 schools (10%) closed up their schools. It was established that 50 of the 70 sampled schools (71.43%) adopted manual means for emptying the pit latrines, 13 schools (19.05%) used exhauster pump for emptying, as 7 schools (9.05%) close up the filled pit latrines and opted for digging up new ones. The challenge that schools faced here included exposing their students to dangers of sinking of the pits that even led to deaths in some schools. Figures 4 and 5 show the mechanical and manual means respectively used by some schools to empty their filled up disposal systems.

Plate 2: Mechanical means of emptying pit latrines

Plate 3: Manual means of emptying pit latrines

Mechanical means (municipal exhauster) of emptying the pit latrines and other sewage systems had designated sites for disposal of the sewage. These means were hired by schools at a fee. Some schools used manual means for emptying their filled up pit latrines, Plate 5. As evidenced from the plate, the people carrying out the activity do not have any protective gear to safeguard from the potential infections. Besides, the designated sites that are dug within the school premises for disposal of the human waste, exposed the students and the surrounding community to health risks as evidenced in Plate 5. This study established that schools used various means of sewage disposal. Figure 10 shows the key findings.

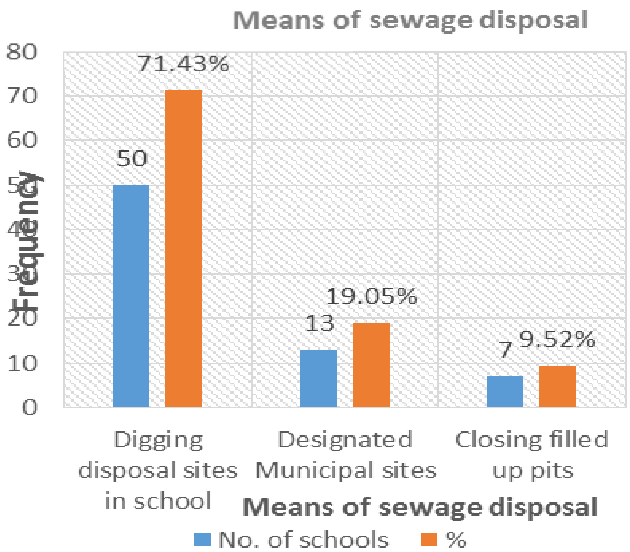


Figure 9: Means of sewage disposal

Figure 10 shows that 50 of the sampled schools (71.43%) disposed of their human wastes by digging up disposal sites within their school compounds, 13 schools (19.05%) disposed of their human waste at designated municipal waste disposal sites as 7 schools (9.52%) of schools disposed their wastes by closing filled up pits. This implies that majority of the schools dispose of their human waste by digging up disposal sites within their school compounds. Reasons advanced for this practice were financial constraints since hiring of mechanical means proved to be expensive to a large number of the sampled schools. Thus, it was established that schools faced some challenges during the final disposal of their sewage. The challenges were as summarised in Figure 11.

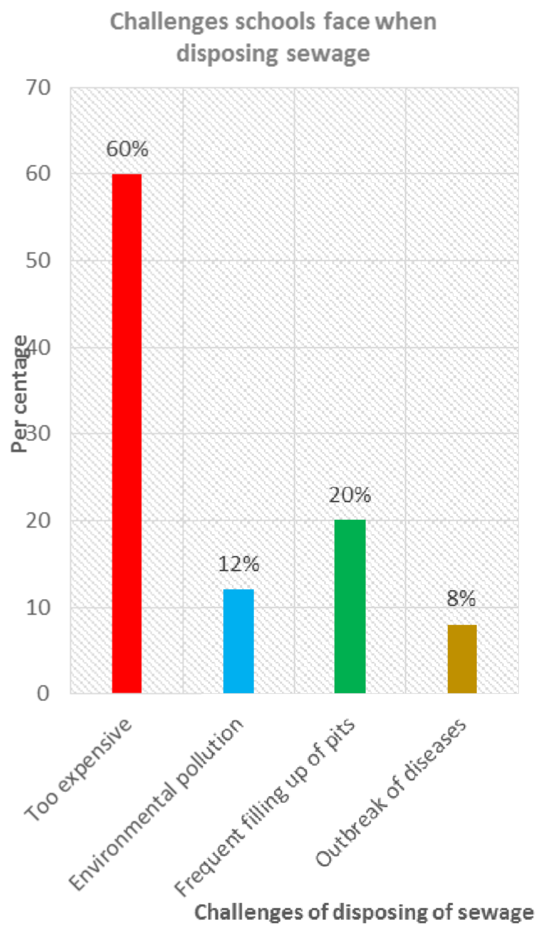


Figure 11: Challenges schools face when disposing sewage

It can be seen from Figure 11 that during sewage disposal, schools faced different challenges that ranged from economic to health and social aspects. 60% of the schools (42 schools) found sewage disposal at designated municipal sites to be too expensive. 20% of the schools (14 schools) also experienced high costs through the frequent filling up of the pits with human waste. 12% of the schools (8 schools) indicated that they experienced environmental hazards such as bad smell and contamination of water sources as 8% (6 schools) showed that sewage disposal led to disease outbreaks. This implies that majority of the schools dug up disposal sites since they considered it cheaper than use of municipal exhauster.

6. Conclusion

In view of these findings, the study concludes that there is a substantial quantity of sewage that is generated in secondary schools of Kakamega County with a high potential for bioenergy generation. If everything is held constant, wood fuel would be replaced by a high percentage of sewage energy.

7. Future Scope

The following suggestion for future scope was made since it was underscored. This study only investigated the potential of anaerobic digestion of sewage in secondary schools for bioenergy generation in Kakamega County, the study suggests similar studies in Primary schools.

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Author Profile

Ibrahim Barasa was born in Kenya in 1967. He received the B.ED (Science) degree from Kenyatta University and M.Sc. degree in Environmental Studies from Masinde Muliro University of Science and Technology (Kenya) in 2003 and 2010 respectively. He is a Ph.D. candidate in Disaster Management and Humanitarian Assistance at the Centre for Disaster Management and Humanitarian Assistance (CDMHA), Mmust. He has received an award from Barclays Bank International for being a lead teacher of International Climate Challenge (ICC) at St. Ignatius Mukumu Boys" High school. He is a member Kenya Institute of Management (KIM). He has been a part time lecturer at the Jomo Kenyetta University of Science and Technology (JKUAT), Kakamega Campus. Some of his publications include: "Attitude and Knowledge of Students on Alternative Sources of Energy", Lambert Academic Publishing, Germany. 51 pages. (ISBN 978-3-8465-1092-6) and "Secondary School Students" Perception of the role of using Alternative Sources of Energy in Sustainable Development," International Journal of Disaster Management and Risk Reduction, Volume 4 Issue 2, November 2012, pp. 1–8. (ISSN: 1992-2744). Barasa has a keen interest in environmental conservation issues, climate change, sustainable development and humanitarian assistance

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