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ANALYSIS OF BACTERIOLOGICAL COMPOSITION OF STORM WATER IN ONGATA RONGAI TOWN, KENYA

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Abstract: *The issue of storm water management is a big problem in developing countries. In Africa in general, and particularly in Kenya, urban planning is a threat due to pollution since it is done with inadequate involvement experts. One of the consequences is poor drainage, and inadequate and a lack of sewerage system. In Ongata Rongai, Kenya, heavy rainfall floods the settlements situated in the town and the effects are manifold, including poor sanitation, among other effects. This project investigated and assessed mainly the environmental challenges and effects associated with storm water management in Ongata Rongai town, specifically analysing the bacteriological composition of storm water resulting from poor sewage disposal. The study adopted an experimental and survey design where the experimental design involved analysis of storm water samples collected from clusters in the study area. The survey design adopted a structured questionnaire targeting 2000 households in Laiser Hill sub-location in Ongata Rongai. Spatial clustering of these households gave three clusters and sample size of 90 in the study area. Quantitative primary data gathered obtained analysed using descriptive statistics and inferential statistics. The study establishes that environmental pollution challenge in Ongata Rongai is a result of lack of established sewerage system to dispose septic tank contents. E coli were detected in high numbers during the bacteriological analysis of sampled storm water. High incidents of storm water-related diseases and several court cases were among the findings. Constructions of sewer lines, new drainages were some of the suggested solutions.*

Keywords - Environment, storm water, management, impacts, Sewage, pollution
Research Area: Social Science
Paper Type: Research Paper

1. INTRODUCTION

Urban storm water management is threatening urban developers due to pollution. This is particularly when there is heavy rainfall that floods the settlements situated in the lowest parts of towns and the large number of urban development issues. Storm water runoff after a rainfall or a snowmelt incident is a natural process but in urban areas, due to anthropogenic impacts of a changing landscape, this is not the case (Ferguson, 1998).With the growth of towns, storm water management has become more and more complicated, especially in developing countries. This is characterized by urban population explosion over a short period of time, unplanned urban development patterns, severe poverty amongst some of the urban population resulting in environmental problems (Novatech, 2007). These towns are faced with the absence of, or inadequate sewer systems both in coverage and in performance especially because of inadequate waste management strategies. Most of the urban areas are dominated by unplanned urban development patterns. This constitutes a major obstacle for effective urban drainage. Flood plain and flood-prone areas are occupied either legally or illegally for the purposes of human settlement and business activities. The county authorities quite often lack the skilled manpower and budget to cope with the magnitude of the problem. It also lacks commitment, awareness and good organization, which need considerable amounts of money (Novatech, 2007).

Ongata Rongai town, located in Kajiado County, which is one of the 47 counties in Kenya, is a fast growing town with an annual growth rate of 28%. It has a 2015 population projection of 52,513 people (GOK: Kajiado County Development Profile, Ministry of Devolution and Planning May, 2013, pg11), though according to the 2009 population census, Rongai has a population of 41000 people. The township also experiences high amount of rainfall, amounting to of 844mm annually, although with a lot of variability over the year (Kenya Meteorological Services, 2014).This generates a lot of runoff within the town and its environment and this is even complicated by the black cotton soils in the area which hardly drains water easily (Mulwa et al, 2005). Its storm water drainage system is inadequate and in a poor state. Sewage and wastewater systems do not exist and therefore residents use septic tanks to dispose their sewerage and waste water. These contents are in most cases released into open storm water drainage systems during the rainy season. This poses serious environmental problems to the residents and the animals living around these areas with the ministry of Public Health and Sanitation having reported complaints from residents living downstream that their animals are dying of diseases from poisonous liquids upstream (The Sojourner, 2014 and The District Public Health, 2014 reports). Solid waste disposal points are inadequate thus; garbage is collected from residents and is then dumped on the road side in the existing inadequate storm water drains blocking them leading to overflow of storm water. This overflow drains into residential areas, people's business premises and to the access roads making them impassable. The soaked garbage is mashed and rots releasing a bad odour becoming a breeding ground for mosquitoes and flies leading to disease outbreaks. This is a serious public health hazard that warrants urgent consideration.

Ongata Rongai is an area of high economic activities and is considered to be one of the four metropolitan towns in the process of expanding Nairobi City towards achieving vision 2030 (Nairobi Metro 2030: A world Class African Metropolis, 2008). The town is densely populated with business buildings and residential estates on either sides of the Magadi road. Global climate change has affected weather events including rainfall patterns so that there are unpredictable seasons and rainfall intensity which cause flooding and their consequent adverse effects. This calls for investigation into effective storm water management practices which are resilient and adaptive to changing climate especially in dealing with urban storm water runoffs (MOE, 2010).

Table 1: A comparison of mean, maximum, and minimum rainfall values between Ngong and Wilson stations from 1984 - 1993

Rainfall Variables		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean	Wilson Station	61.9	31.02	88.8	214.9	122.1	33.8	24.3	10.1	10.9	39.6	110.5	99.4
	Ngong Station	70.9	59.3	77.9	189.7	148	26.5	20.7	13.7	17.9	32.9	70.1	71.8
Max	Wilson Station	270.4	104	271	414.6	300.1	103.6	88.1	22.4	30.2	144.8	157.3	201.4
	Ngong Station	186.8	177.5	229.9	389.6	231.8	58.1	33	47	56.1	86.5	114.5	146
Min	Wilson Station	0	0	5.3	9.6	1.6	2.8	0	1	0	1.9	66.7	25.8
	Ngong Station	3.6	12	14.1	2.1	58.4	2.2	0	0	0	0	42.2	20.2

Source: Kenya Meteorological Services, 2014.

2. MATERIALS AND METHODS

This Paper draws on research conducted to investigate the environmental challenges and effects associated with storm water management in Ongata Rongai urban centre, giving emphasis to the bacteriological analysis of contents of storm water. It utilized both survey and an experimental research designs with descriptive and inferential methods of data analysis. Both designs were found to facilitate the collection of requisite data from primary sources using standardized questionnaires, personal observations and secondary sources from both published and unpublished sources. The study narrowed down to the target population of estimated 2000 households in Laiser Hill sub location which is mostly affected by storm water. The use of households was adopted from Nyariki (2009). The estimated population of 2000 households were grouped spatially into three clusters depending on their commercial and residential characteristics. The three clusters namely, A (the commercial cluster) of approximately 700 households, and B (Transition cluster between the commercial and the residential population of the study area), also ranging from 700 households was considered densely populated, and cluster C (Residential cluster) of approximately 600 households.

The sample size formula of Freund and Williams (1983) was applied to arrive at the sample size.

$n = \frac{(p(1-p)z^2}{\text{ME}}$(Freund and Williams, 1983) ……………………Equation 1

Where:

- ME is the desired margin of error 9.7%
- *z* is the z-score, e.g. 1.96 for a 95% confidence interval,
- *p* is our prior judgment of the correct value of *p* 30% of the households
- *n* is the sample size established using the formula

$n = 1.96^2 \times (0.7 \times 0.3) / 0.097^2 = 89.7$

Using this formula, the sample size (n) covered in Laiser Hill sub location was established as 89.7, which was rounded off to 90 households.

A list of households obtained from the location administrative chief was used to randomly select the 90 households sample from the three clusters where adults of above 18 years were sampled. From Cluster A and B 35 households (each?) were picked because of their high population density while cluster C zone of low population density, 20 households were picked. After the first household was randomly picked from each cluster, the rest were systematically picked after the 15th household until all the required number from each cluster was attained.

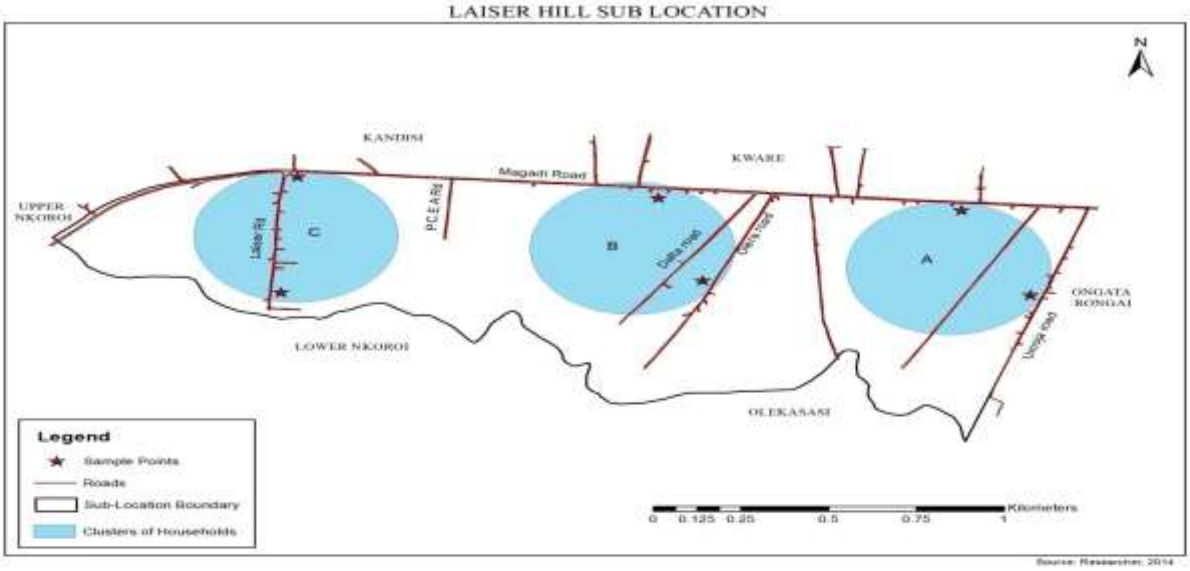

Figure 1: Clustered points in the study area

With the experimental design, two points were identified from each cluster where storm water believed to be contaminated with sewage was sampled for bacteriological analysis at the National Water and Conservation Laboratory and the Kenya Water Institute (Water Quality Microbiological Laboratories). Six samples each of 1 litre capacity were collected from drains immediately the rains stopped and the control sample of 1 litre capacity was also collected from harvested rain water in a tank for analysis. The quantitative data obtained from the field was subjected to processing and analyzing using descriptive and inferential statistics with the help of Statistical Package for Social Sciences (SPSS) tool.

A. *Study Area*

The study was conducted in Ongata Rongai, Kajiado County, Kenya.

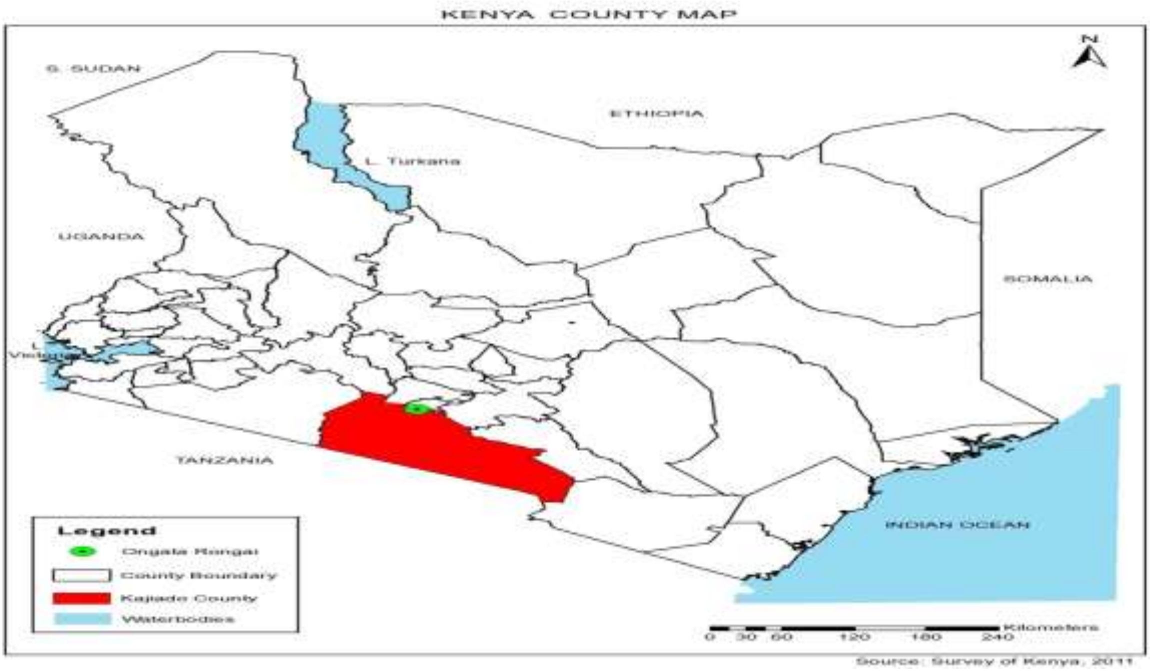

Figure 2: Location of Ongata Rongai in Kajiado County, in Kenya

3. RESULTS AND DISCUSSION

The data of the rainfall believed to generate runoff in the town was collected from two rainfall gauging stations in the area. The processed data generated a rainfall pattern that exhibits a bimodal distribution in the two rainfall gauging stations with maximum rainfall of over 30 mm throughout the year. The wet seasons are between March and May (long seasons) and between October and December (short seasons) for both stations. It is clear that the Wilson's station receives slightly higher rainfall than the Ngong' D.O.S office meteorological stations. The intensity of the runoff generated is what causes storm water management challenges in Ongata Rongai. Some of these challenges include flooding, environmental pollution due to poor sewage disposal, water borne diseases and damage to infrastructure. The comparison of the rainfall data from the two stations is significant for accuracy and control purposes.

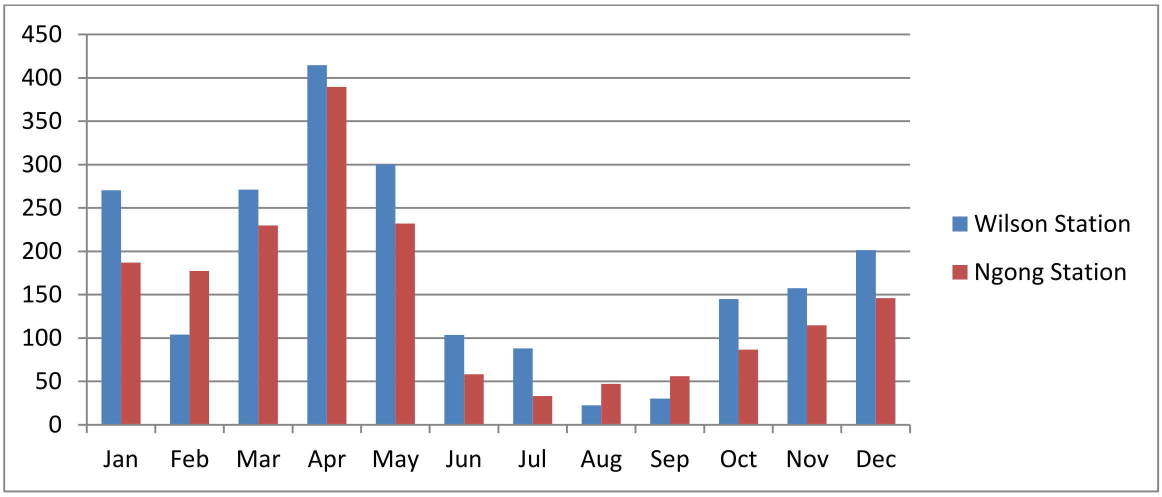

FIGURE 3: COMPARISON OF MAXIMUM MONTHLY RAINFALL BETWEEN NGONG' AND WILSON STATIONS FROM 1984 -1993

SOURCE: KENYA METEOROLOGICAL SERVICES, 2014

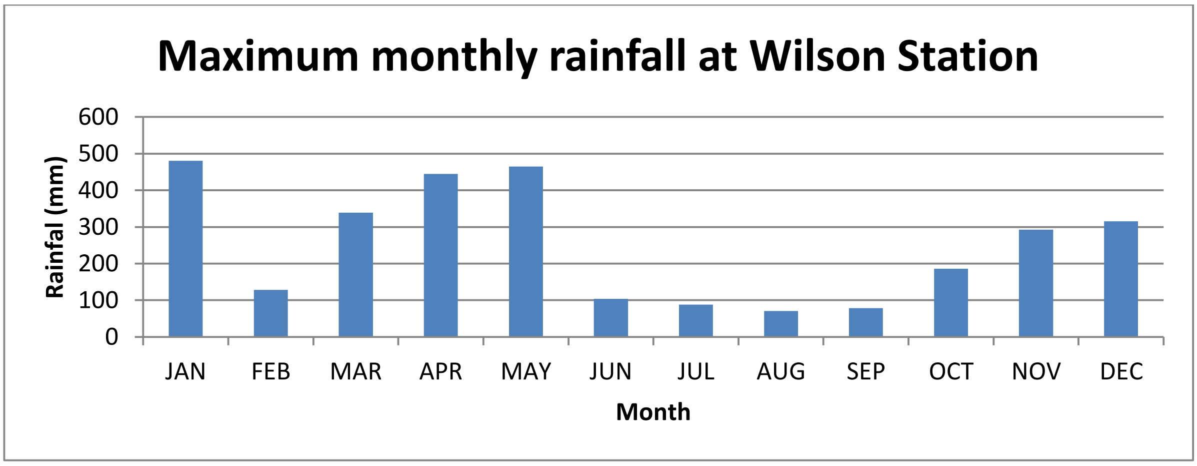

Figure 4: Maximum monthly rainfall at Wilson's station between 1980 – 2013

Source: Kenya Meteorological Services, 2014

The rainfall data from the Wilsons station was available from 1980 - 2013 unlike from Ngong station which was available from 1984 – 1993. This data shows two distinct rainfall seasons; long season (between March and May) and short season (between October and December) experienced in the study area. There is rainfall throughout the year though with variability and this explains the flooding experienced in the study area during these seasons.

4. AN INVESTIGATION OF FLOODING EXPERIENCE IN ONGATA RONGAI

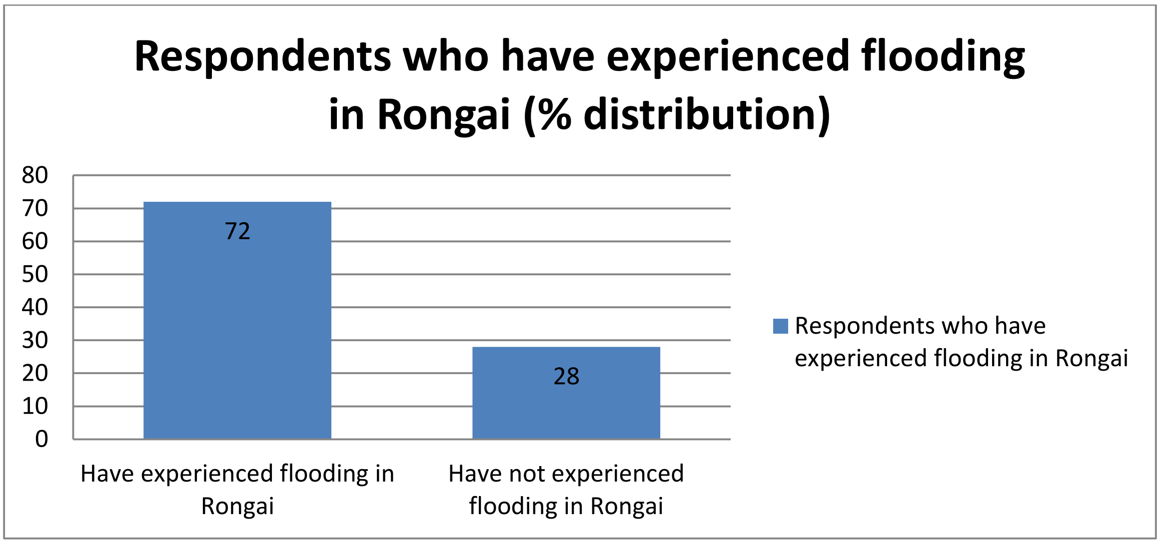

FIGURE 5: RESPONDENTS WHO HAVE EXPERIENCED FLOODING IN ONGATA RONGAI (% DISTRIBUTION)

Source: Researcher (2014)

Responses of the presence and frequency of flooding in the area shows that majority of the respondents have experienced flooding in the area with 72% indicating that they witness flooding twice in a year. This tallies with the meteorological report of annual high rainfall of 844 mm in figure 3 and 4 which show that there is a bimodal rainfall pattern in the area. The black cotton soils in Ongata Rongai that poorly drain water and also the location of the town in upper Kajiado plains within the Athi drainage basin has further complicated the flow of storm water runoff thus the flooding. The 28% who have not experienced flooding in Ongata Rongai as indicated in figure 5 could consist of those who have been residents for duration of less than a year.

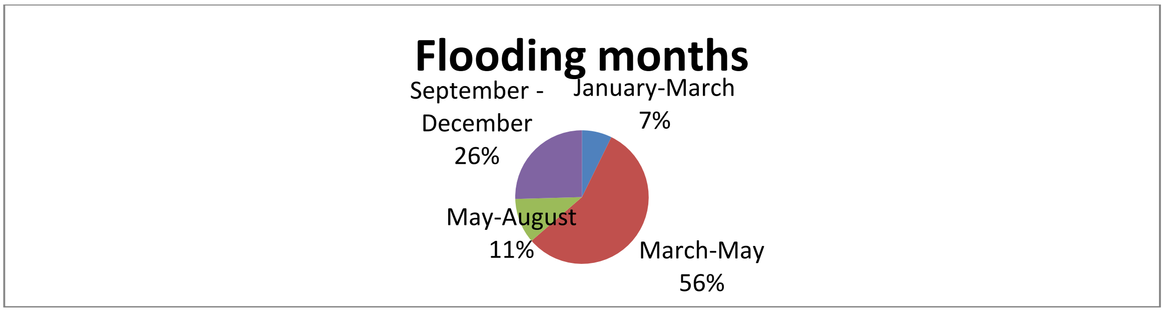

Figure 6: Flooding months

Source: Researcher (2014)

A comparison of the flooding months was done and the results were that 56% of the respondents usually experience flooding in the period between March and May, while 26% of the respondents usually experience flooding in the period between October and December. This coincides with the long and the short rainy seasons respectively. The respondents further indicated that these two periods always record the worst flooding months in Ongata Rongai. These results are a reflection of the monthly rainfall data of Ongata Rongai, obtained from the Ngong' and Wilson Meteorology stations as seen in figure 3 and 4.

4.1.Sewage Disposal in Ongata Rongai Town

The lack of sewerage system in this town has led to residents adopting alternative sewerage disposal mechanisms. Septic tank contents are disposed as:

TABLE 2: HOW SEWAGE WASTE IS DISPOSED BY OWNER/RESIDENTS OF THE PREMISE

	Frequency	**Percent (%)**
Disposed in a sewer line	4	5
Use the services of sewer exhauster	48	65
Allowing sewers to overflow in the surrounding area	13	18
Using sewer as farm manure	1	1
Don't know	8	11
Total	**74**	**100.0**

Source: Researcher (2014)

Options of sewage disposal methods in the premises were given where majorities of the respondents (65%) indicated that they or their landlords use sewer exhausters to dispose septic tank contents. Only 18% allow sewers to overflow into the surrounding area, while 1% use sewer as manure and 5% of the respondents indicated that there is an existing sewer line for disposing sewer waste into the river. This cannot be true because there is no known sewer line in Ongata Rongai. The answers might have come from visitors or tenants who are new in the study area. Some also fear stating the truth because they fear the repercussions that come with such unhealthy disposal of sewage. A cross tabulation of sewage disposal methods and status of respondents in the premise indicate that 80% of landlords use the services of sewer exhausters, while only 20% of landlords allow sewers to overflow in the surrounding area. About 30% of resident tenants indicated that sewers are allowed to overflow into the surrounding area by their landlords. This could be the percentage believed to be polluting storm water through improper sewage disposal. This finding is supported by the Kloss Rolf (2009) report which indicated that Kenya experiences inefficiency in sewer and drainage systems within urban settings.

There is a big number of court cases between individuals and institutions such as schools, public health and business premises on improper sewage disposal. This was obtained from the areas' public health office.

4.2. An analysis of Bacteriological Composition of Storm Water due to Poor Sewage Disposal

The six samples of water collected from the study area were tested for the presence of *E coli*, a microbial indicator for human fecal waste. The control sample was collected from a tank containing harvested rain water sampled immediately after rain. The experiment samples were collected direct from drains from two different locations for each of the three clusters. The results showed high levels of *E. coli* in the experiment samples while the control sample had no *E coli* as given in table 3. This could be attributed to the lack of established sewerage system in the study area forcing residents to dispose their septic contents unethically. Flooded storm water also seeps into septic tanks making them to overflow its contents thus flowing into the inadequate storm drains and eventually to the environment.

4.3.Summary of the water sample results from the National Water Laboratories and the Kenya Water Institute

Bacteriological analysis of positive and negative controls of storm water samples using microbial techniques is presented as follows:

Table 3: Summary of Results obtained from Sampled Storm Water Analysis

Water Samples	Results Summary	
	MPN of Coliforms organisms per 100ml	E coli per 100ml
Control sample: No. 0911	12	0
Experiment sample 1: No. 0904	2.420×10^6	1.3×10^6
Experiment sample 2: No 0905	2.420×10^6	2.966×10^6
Experiment sample 3: No 0906	2.420 x 10^6	2.986 x 10^6
Experiment sample 4: No 0907	2.020 x 10^6	1.672 x 10^6
Experiment sample 5: No 0909	2.40 x 10^6	1.31 x 10^6
Experiment sample 6: No 0910	2.611 x 10^6	1.4 x 10^6

Source:Researcher(2014)

E. coli strains (Enteropathogenic (EPEC) and Diarrheagenic DEC *E coli* among other strains) are the leading causes of bacterial diarrhea and deaths among children less than five years in Kenya and in developing countries. This is exacerbated by factors such as harsh climatic conditions, poor sanitation, malnutrition and immunosuppression by HIV and AIDS, Clarke S.C., (2001). Safe samples of water should always have nil *E. coli* and coliforms. Thus these samples except for the control are hazardous as they can cause fatal diarrhea.

Sickness associated with improper storm water management

The researcher also investigated whether the respondents have fallen sick or have witnessed a household member falling sick during flooding seasons and this is presented as follows:

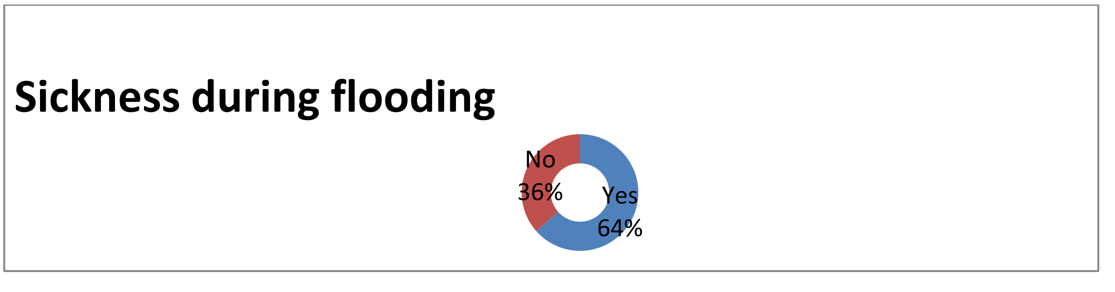

FIGURE 7: AN INVESTIGATION INTO WHETHER THE RESPONDENTS OR ANY MEMBER FALL SICK DURING FLOODING SEASONS

Source: Researcher, (2014)

Majority of the respondents indicated that they have experienced sickness or seen a member of their household fall sick during the flooding season at 64%.This implies that at least during the rainy season there is a member of the household who falls sick and this indicates a serious social problem which needs to be contained. Sickness due to water borne diseases is stated to be among the socio-economic effects of storm water management challenges in the study area.

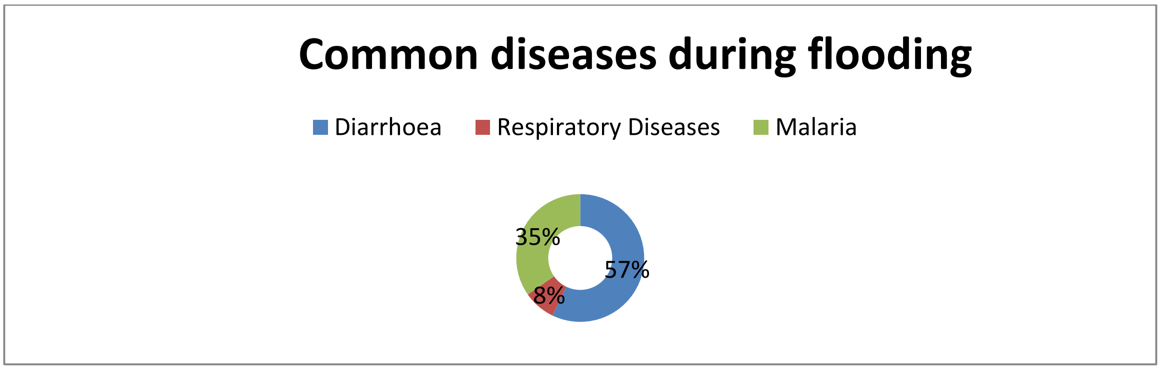

FIGURE 8: COMMON DISEASES DURING FLOODING SEASONS

Source: Researcher (2014)

Ratings of common diseases during the rainy season indicated that malaria and diarrhoea are the most common diseases that affect them and members of their households during the flooding months at 35% and 57% respectively as indicated in figure 8. This is also clarified in figure 9, showing the health records data of diseases common during the rainy season in Ongata Rongai between 2012 and 2014. During rains it is believed that the storm water distributes microbes by transporting it around in floods and run offs, hence causing diseases. This is even worse when there is no adequate and proper storm drains as is the case in Ongata Rongai.

Hospital records were obtained from the area dispensary, from Ongata Rongai (Saitoti) Dispensary. These records were used to generate the data of the common diseases that the area residents suffer from and this was presented as below:

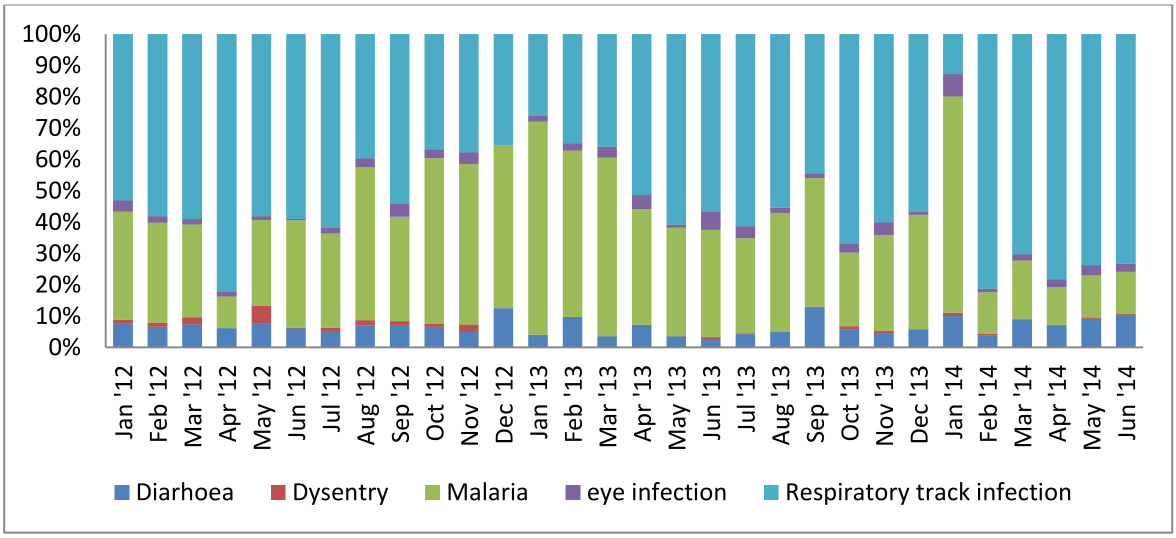

FIGURE 9: SECONDARY RECORDS FROM SAITOTI DISPENSARY (MBAGATHI), ONGATA RONGAI, FOR DISEASES RELATED TO STORM WATER BETWEEN 2012 AND 2014

Source (Ongata Rongai Saitoti (Mbagathi) dispensary, 2014)

Figure 9 shows results of the secondary data of common diseases during the rainy season received from Ongata Rongai Saitoti (Mbagathi) dispensary. The results shows the percentage of cases recorded per month of common diseases associated with storm water management challenges, including respiratory tract infection, eye infection, malaria, and diarrhoea. From the results, malaria, respiratory tract infection and diarrhoea are the most common illnesses in the area. It is clear that these illnesses have high incidence during the flooding months or the rainy seasons with diarrhoea and dysentery as the leading cases of storm water-related illnesses. In as much as the precursor to sicknesses is poor sanitation and immunity factors, poor storm water management is also a contributing factor as the runoff from the storm water accelerates the spread of pathogenic microbes during the rainy seasons.

5. CONCLUSION

The study has established that sewers, waste water, and storm water drainages are a huge problem in Ongata Rongai. A lack of established sewerage system is the ultimate cause of poor sewage disposal experienced in the town, leaving residents with the option of sewer exhaust services. However, sewer exhaust services are unreliable, thus landlords in most cases dispose their septic tank contents in the surrounding, and adjacent storm drains especially when it rains. This is supported by significant levels of bacteria isolated from storm water sampled from storm drains and the numerous records of court cases in the local dispensary public health department. Blocked storm water drainages, poor planning of the town, and failure by the county government to properly implement water Policies are among storm water management challenges experienced in the study area.

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