The Impacts of Unplanned Growth of Nyalenda Informal Settlement on Environment and Public Health, Kisumu Municipality, Kenya

By

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ABSTRACT

The unplanned growth of Nyalenda informal settlement, in Kisumu Municipality, is rapid. Consequently, this urban dwelling faces numerous problems such as high concentration of human population that affect the environment and public health either in the form of over-exploitation of natural resources for survival or environmental degradation through accumulation of wastes. Therefore, the objectives of this study were to: determine the environmental and public health problems associated with the unplanned growth of Nyalenda informal settlement; examine whether the unplanned growth of Nyalenda had led to bacteriological pollution of surface and ground water resources; and assess the effects of unplanned growth of Nyalenda on vegetation cover over time. The study area had approximately 11,822 households (family units averaging 5 persons each) from which a sample size of 76 household heads were interviewed. Purposive sampling was used to collect in-depth information on environmental and public health problems and vegetation cover changes over time. Water samples were randomly selected from 40 wells and 18 samples from Wigwa stream, from 7th July 2008 to 22nd August 2008, for laboratory analysis to determine the level of pollution by *Escherichia coli*, *Salmonella* spp and *Vibrio cholerae. Data* was collected, using in-depth interviews, questionnaires, focus group discussions and observations. Quantitative data generated were analyzed using descriptive statistics of mean, range, percentages and frequencies. Qualitative data were analyzed by identifying the themes, categories and patterns, then further scrutinizing the data to determine the adequacy of information in answering the research questions. The study revealed that the most common environmental diseases in Nyalenda informal settlement mentioned by the respondents are; malaria (90%), diarrheal diseases (36%), typhoid (32%), chest complications (6%). The causes of these diseases were attributed to poor sanitation (58%) and pollution of water (36%), by the respondents. The respondents also attributed the mode of spread of these diseases, except malaria which is vector borne, to consumption of polluted water (80%). Laboratory analysis revealed that water from the wells had an average of 17 colonies/100 ml of sample of *Escherichia coli* with a range of 0-68 colonies/100ml sample. Only 12% of wells sampled had nil *E. coli* colonies. The average count of organisms in stream water was 6 colonies /100ml sample, with a range of 0-14 colonies/100ml sample. The average levels of the colonies observed were above safe and recommended limits for drinking water and other uses. The results also showed that 88.9% of the stream samples were positive for *E.coli* presence. Tests for *Salmonella* spp in water confirmed the presence of the organism in both well (20%) and stream (27.7%) samples. *Vibro cholerae* detection in the laboratory showed that all the samples from both the wells and the stream waters tested negative. Clearly, 76% of the respondents were in agreement that vegetation cover had deteriorated, tremendously, over time in Nyalenda and they, further, attributed this trend to human settlement (80%). The study also found out that many wetlands that supported several plant species had been drained to give way to human settlement There is need to disinfect all the water wells before embarking on "boil water" campaign, proper lining of the pit latrines and proper protection to prevent surface water from entering the wells and residents of Nyalenda should avoid use of Wigwa stream water for domestic purposes.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

The environmental problems of the world's cities and towns are creeping up the political agenda of most governments and many international agencies. This is especially so for the major cities, where environmental problems are generally most visible. In many countries in Eastern Europe and Africa, South of Sahara, it has been spurred by the return of democracy, which often revealed a large legacy of environmental degradation that has been hidden under non-democratic regimes. There is need to pay greater attention to urban environmental problems and their impacts on the health, livelihoods of the people and on ecosystems within urban informal settlements. An increasing priority to environmental problems in urban informal settlements has been spurred by the unexpected recurrent disease epidemics, for example, the re-occurrence of cholera in Latin America in 1991, which had been eliminated in the region in early twentieth century through improvement in water, sanitation, sewerage treatment and food safety. The scare regarding an apparent outbreak of plague in the Indian city of Surat in 1994 also heightened fears of what lack of attention to water supply, sanitation, drainage and regular collection of solid waste can cause in an urban informal settlement (UN-HABITAT, 2004).

In his study, Almeida (2005) noted that informal land occupation in areas of water spring protection impacts not only on the ecological balance of the natural environment, but also brings about damages to the reality of life of urban inhabitants who directly depend on such resources. The foremost observed effects of informal settlements that are located in the surroundings of water bodies include; direct discharge of sewage into the water bodies, destruction of vegetation and silting of water reservoirs. Almeida (2005) further stated that the spread of informal settlement in the vicinities of water bodies and consequent discharge of waste water directly into them cause a much more serious impact on human health, rendering the communities living on the stream margins, which collect untreated water from such reservoirs, vulnerable to infectious and contagious

diseases such as cholera, diarrhea, hepatitis in the diverse form and many others. According to UN-HABITAT (1996), many surface water bodies in the South of Sahara are used as dumping ground for untreated or partially treated sewage, storm and urban run off. Many rivers flowing through informal settlements in cities in this region are literally large open sewers. In such instances, most of the liquid waste from households and considerable portion of solid waste, end up into nearby streams, rivers or lakes, adding greatly to water pollution and increased biochemical oxygen demand.

About half of urban population in Africa, living in the informal settlements (WHO and UNICEF, 1993) is served with safe drinking water but do not have running piped water connection to their homes. Approximately 32 million relied on public standpipes, while 15 million had pipes in the yard with the rest relying on other sources like boreholes, wells, springs and many others. UNEP (2007) discovered that in Khartoum, Sudan, significant environmental problems could be seen in informal settlements that offer negligible facilities for water, sanitation and solid waste management. The result is poor sanitation, high disease incidences and difficulty in accessing basic services. In studying the sanitational problems in the informal settlements in the cities South of Sahara, UN-HABITAT (1996) said that there are three obvious criteria by which to judge provision of sanitation for convenience and hygiene for the user, people need a toilet that if not in the home, is at least very close and accessible; the extent to which human contact with excreta can be avoided; and finally, the extent to which the facility is easily maintained.

The growth of urban centers in Kenya is estimated at about seven percent per annum (Wandiga, 1999). This has made urban centers face a myriad of problems such as mushrooming of informal urban settlements and slums, lack of purified water for human consumption, population explosion and lack of recreational facilities in the settlements occupied by the urban poor. All our urban centers are today, characterized by pollution, especially the garbage filth in the slums, inadequate quality shelter, violence and crime. According to Situma (1992), rapid urbanization and resultant heavy concentration of population in urban centers have led to many urban areas failing to provide the necessary infrastructure and amenities especially in the informal settlements or slums.

Concentration of human population will invariably affect the environment either in the form of over-exploitation of natural resources for survival or in form of environmental degradation through accumulation of wastes (Obudho and Mairura, 1991).

Over-exploitation of natural resources manifests in unplanned urban human settlement. As a result, developments in urban areas have been unsustainable and environmentally unsound. An example of such area is Zimmerman Estate in Nairobi, which has no road networks or solid waste disposal facilities, and flooding is the norm due to lack of drainage (Situma, 1992). In a study of informal settlements in Voi town, Hurskainen (2004) found out that poor environmental conditions, mass diminishing vegetation cover, polluted water bodies, which when combined to other factors, cause the informal settlements to experience bad sanitation and spread of diseases.

Kisumu is a fast growing municipality and its concentric patterns of expansion are breaking as the town extends to new areas. The informal settlement belt forms the outer ring as the residential area for the poor. Such informal settlements include Nyalenda area. However, this area naturally presents the most serious problems in terms of natural drainage due to combination of the type of soil, a low gradient, and a high water table leading to very high cost of infrastructure investment. The bulk of the poor are likely to settle in the Nyalenda informal settlement, a process adding pressure on the already fragile environment of the locality (KENSUP, 2005). Nyalenda is referred to as the "polythene town" because of the poor waste disposal methods (KENSUP, 2005). A number of residents burn the waste but those in the poorer neighborhoods dump waste at the roadside and in some cases end up blocking the drainage. Nyalenda is characterized by rapid expansion to accommodate more urban population, inadequate supply of piped water leading to the use of polluted well water, inappropriate and inadequate toilet facilities and inadequate public health facilities, all of which have contributed to the high rate of diseases related to poor sanitation and degraded environment (NEMA, 2005a).

1.2 Problem Statement

Main problems in Nyalenda informal settlement related to its unplanned growth include; prevalence and high morbidity of common diseases related to poor sanitation and inadequate public health facilities, inadequate drainage and sewage system have resulted in bacteriological pollution of both surface and ground water resources as, relatively, high cost of piped water from stand pipes, has led to Nyalenda residents using water from the dug wells and Wigwa stream for domestic purposes; last but not least, unplanned growth of this settlement has led to depletion of vegetation cover and wetlands to give way for human settlement. Therefore, the purpose of this study was to explore the impacts of unplanned growth of Nyalenda informal settlement on the urban environment and public health.

1.3 Objective of the Study

The overall objective of this study was to assess the impacts of the unplanned growth of Nyalenda informal settlement on urban environment and public health, in Kisumu Municipality.

Specific Objectives were -

1. To determine the environmental health problems associated with the unplanned growth of Nyalenda informal settlement.
2. To examine whether the unplanned growth of Nyalenda informal settlement led to bacteriological pollution of surface and ground water resources.
3. To assess the impact of the unplanned growth of Nyalenda informal settlement on the changes of vegetation cover, over time.

1.4 Research Questions

1 What are the major environmental health problems associated with the growth of Nyalenda informal settlement?

2. Has the growth of Nyalenda informal settlement led to bacteriological pollution of both surface and ground water resources?

3. How has the growth of Nyalenda informal settlement affected vegetation cover over time?

1.5 Justification of the study

To have greater attention to the environmental problems of the informal urban settlement in Kisumu, there is need to encourage detailed documentation of environmental problems and their impacts on public health and livelihoods of the residents and the ecosystems within which they live. The study sought to draw linkages between environmental degradation and growth of the informal settlements, particularly Nyalenda that has had minimum intervention. The study, thus, enhanced people's knowledge on the impact of informal settlement development on environment and highlighted the major environmental problems facing the residents. It further generated data that could be used by interested development agencies to come up with a holistic, sustainable, environmental conservation programme for the study area. In addition, the study came up with appropriate recommendations for sustainable environmental management in such settlements.

Development agencies seeking to improve the environmental conditions in the informal settlement may find data collected, here in, useful as baseline information for any project to be undertaken. The Nyalenda community may also use the data, as evidence of deteriorated environment, when seeking assistance from external development agencies, through proposal writing. Existing information on Nyalenda informal settlement in relation to environmental health, bacteriological pollution of water bodies and clearance of vegetation cover over time is scanty. These studies were aimed at bridging the information gap and providing relevant, long term and sustainable urbanization and development strategies for Nyalenda.

1.6 Scope and Limits of the Study

The scope of the study was limited to environmental issues in the informal settlement in Nyalenda of Kisumu municipality and confined to environmental issues related to environmental diseases, bacteriological pollution of water bodies and clearance of vegetation cover. Remote Sensing and Geographical Information System technologies

could not be used to monitor vegetation changes over time due to financial constraint by the researcher.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

According to World Bank (2003), in Asia and Pacific region, rapid urbanization and expansion of urban-based economic activities have led to very substantial rural-urban migration. The human migration to urban areas has put pressure on housing and other services leading to the development of informal settlement. The nature of poverty - environment interlink in the urban areas is, therefore very, different from that in the rural setting. The study, however, fell short of mentioning specific areas of difference for further analysis. The environmental issues like health problems, water quality deterioration and biodiversity loss were not adequately given prominence in the report.

The economic and social survey of Asia by World Bank in 2003 reveals that the urban poor live in places that are ecologically more vulnerable and are forced to earn their living from low-productivity natural resources. The survey further reveals that the urban poor are found in the informal settlements within towns, which are often build on flood-prone low-lying areas around city drains, many of the urban poor earn their living from environmentally hazardous scavenging. Another outcome of the survey state that the urban poor, most of whom live in the informal settlements, often create unhygienic sanitation conditions because of lack of access to formal toilet facilities. However, the study also revealed that there is over-whelming evidence that the poor suffers damage to livelihood and health, owing to environmental degradation not caused by them. The report did not go further, however, to give the nature and source of pollution agents that are not originating from the poor. The finding of unhygienic sanitation due to lack of adequate toilet facilities is in line with the objectives of this study of assessing the situation of environmental diseases and bacterial water body pollution in Nyalenda informal settlement. In another Word Bank report by Ekbom and Bojo (1999), poverty is highlighted as a major cause and effect of global environment problems. The report emphasizes that the urban poor are often seen as compelled to exploit their surrounding for short-term survival, and are assured to be the ones most exposed to natural resources degradation. This report ties very well with my objective number three which seeks to

establish the effect of the growth of Nyalenda informal settlement on vegetation cover changes, over time. The report by Ekbom and Bojo (1999) did not particularly point out the dimensions of poverty that are responsible for global environmental problems. The authors, in quoting Leach and Means (1991), further showed that 60 percent of the urban poor live in ecologically vulnerable areas in the squatters. Poor people lack resources to relocate from these areas and adapt to defensive measures against negative exposures. The lower level of education increases their vulnerability to health risks. The associated political marginalization decreases opportunities for environmental protection and provision of basic services such as safe water for drinking, access to clean air, functioning sewerage and waste collection. The findings, therein, ties very well with my examination of water samples from wells and stream to ascertain bacteriological presence and the state of environmental related disease.

2.2 Environmental health problems

A study done in Accra, Ghana by Ekbom and Bojo (1999) indicates that the urban poor enjoy significantly less environmental services (safe water, sewerage). The report does not disclose other environmental services the poor lack in informal settlements. However the report ties with the assessment of bacteriological pollution of the water resources in my study. The poor lack knowledge or means to efficiently prevent diseases, are exposed to more health hazards, and are subject to more crowding i.e. more people share pots, toilets, living rooms. The study also revealed that urban poverty is statistically related to higher prevalence of parasitic and diarrhea infections. World Bank (1992), as cited by UN HABITAT (1996), asserted that poor people are agents of environmental degradation that result in poor health, which can further reduce income opportunities. There is need to establish in what particular aspects are the poor agents of environmental degradation. Unless positive measures are taken, the rapid increase of the urban population will exacerbate the prevailing health problems associated with rapid expansion of informal and squatter settlements (Obudho and Mhlanga (1988), Obudho and Aduwo (1992) and Kayongo (1988). Such settlement constitutes a living environment for over half of the Kenyans urban population. In many urban areas, there is overcrowding and unauthorized construction of unplanned dwellings built with unsuitable materials. Combined with a

lack of basic infrastructure in the informal and squatter settlements will create an unacceptable environment ripe for the spread of diseases, outbreak of fires or even violence. Even though the report was so exhaustive, there is need for more research to determine the actual quality of the houses in these localities that can prevent spread of diseases.

People living in the informal settlement are frequently ill as a result of the poor quality of their environment and exposure to diseases (Santosa, 2003). However, it would be credible to also ascertain the frequency of these diseases in the up market urban estates for comparison. The poor are unable to overcome their problems, as finances are scarce. They are in a state of persistent poverty and frustration. Disasters may cause death and loss, while the poor housing and sanitation also threatens their health. As noted by World Health Organization (WHO) in 1999, in the developing world, 21% of the children die as a result of diarrhea, acute respiratory infections, malaria, measles and perinatal (childhood) conditions (Santosa, 2003). The proportion of adults dying from these diseases also needs to be confirmed for comparison as an opportunity for further research. The high population density in the informal settlements means that the diseases are easily spread. According to WHO, although South-East Asia has only 25% of the world's population, it has 39% of the cases of tuberculosis. In quoting Cole (1995), Ali and Suleiman (2006) stated that sprawling of poorly controlled informal settlements development had resulted in many environmental and health related problems

Uncontrolled urban settlements development is causing physical disorders, uneconomical land use, environmental degradation and pollution risks. Lack of access to services, in informal settlements, play part in the spread of diseases. In developing world, most childhood medical conditions are linked to factors such as limited access to clean water, poor sanitation, use of biomass fuel and overcrowding (Napier, 2000). Nyakaana, et al (2007), further stated that problems of leaking water pipes is not just loss of water, but also loss in pressure may allow contaminants to enter the pipes. It is very easy for sewage and household wastewater to enter the water distribution system under such circumstances The poor maintenance of water distribution system and storm water

networks has created avenue for contamination in the supply networks from widespread pit latrines and open disposal of human wastes. There is need to unearth, through research, the weaknesses of the water distribution system and also come up with strategies to control storm water in the informal settlements, including Nyalenda. Also contaminated, from underground seepage of pit latrine, are the alternative water sources such as streams, ponds, boreholes and shallow wells. Nyakaana, et al (2007) in citing Byabakana (1998) stated that presence of *Escherichia coli* is an indication of feacal contamination of water sources in the urban set up. Kreibich and Schultz (2003) stated that solid waste accumulation in the informal settlements leads to environmental and health problems. Liquid waste from washing, laundry, kitchen, bath and other domestic uses is hazardly discharged on site. This disposal practice pollutes the ground and surface water and is a major source of water borne diseases.

2.3 Bacteriological pollution of water resources

Expansion of the informal settlements has been the major cause for pollution of ground water sources (Ali and Suleiman, 2006) and in citing Cole (1995), the authors stated that loss of vegetation around water sources reduces water flow while poor disposal of both liquid and solid waste also cause water pollution. There has been a frequent outbreak of water borne diseases like diarrhea and dysentery in the high rainfall season due to contamination of both ground and surface water bodies (Ali and Suleiman, 2006). However these researchers did not compare the occurrence of these diseases in both dry and wet seasons. The rivers and streams are now considered as environmental health problems due to high concentration of chemical and bacteriological pollution (Kahara, 2007), despite this, nearly half of the urban population are at one time or another depend on them as a source of water for domestic use in the informal settlements.

National Primary Drinking Water Regulation (NPDWR), updated most recently in 1990, apply to all public potable waster systems. Generally, the only drinking water not regulated is private well water, but NPDWR guidelines should be applied to well water usage as a safety precaution (WHO, 1989). NPDWR specify a maximum contaminant level, which is the highest concentration of a particular contaminant allowed in drinking

water. Maximum contaminant levels are set at levels low enough to prevent health problems. The presence of microbiological contaminants indicates the possible presence of pollution, which can cause health problems. The maximum biological contaminant level goal is zero total coliform per 100 ml of sample (WHO, 1989). The study sought to establish the level of these contaminants in both well and stream water and compare with this standard.

Pollution of the rivers becomes most apparent as it flows through the informal settlement. In areas where urban population lives in the unplanned informal settlements that lack basic water and sewerage facilities, the rivers and streams begin to exhibit alarmingly high levels of organic and bacteriological pollution (Kahara, 2007) Lack of access to basic urban services such as water and sanitation can also be taken as indicator of prevalence of unserviced settlements (Napier, 2000). In these areas, most households have no access to piped water and flushing toilets within the houses. Many urban households, in informal settlements, which normally have piped water, have systems that have not been maintained and therefore not fully operational. This affects the operation of water borne sanitation systems in those households (Napier, 2000).

A study of Buffalo River, Buffalo City, East London (www.buffalocity.gov.za) noted that natural environment in informal settlements, including rivers, streams, dams, and others, is at risk of periodic high bacterial pollution levels which can, partly, be ascribed to the discharge of untreated or partially treated sewage into the natural environment. The study did not go ahead and isolate different types or some of the bacterial pollutants in this river. McGraham, et al (2004) reported that urban water systems could harm downstream users. The depleted ground cover in human settlements intensify runoffs which carry with it sewers and human waste into surface water bodies. They further stated that human waste not only pose health risk for people who might ingest the contaminated water but also damage aquatic system. There is need to find out if animal wastes in these grounds also pose threat of bacterial pollution to the surface water bodies.

Nyalenda wells provide a widespread source of water in the informal settlement given the high water tables in these areas. However, these high water tables make it difficult to construct proper latrines, which put shallow wells under constant threat of contamination. According to NEMA (2005a), the consequences of informal settlements in Kisumu municipality have negative impacts on the environment as waste generated have ended up polluting the water bodies, both surface and underground. NEMA only reported that waste generated is a source of water pollution but did not go ahead and determine the specific pollutants, their nature and levels of presence in the water samples. Pit latrines are the most commonly used sanitation facilities in the informal settlement. In areas prone to flooding, like the lower parts of the informal settlement, there is a common problem of collapsing latrines due to unstable soils. The high water table reduces the volumes of these latrines, hence frequent emptying or digging new pits. This has resulted in contamination of ground water with feacal matter (NEMA, 2005a). There is necessity to come up with ways of mitigating this environmental issue in the informal settlement.

2.4 Vegetation degradation.

Ali and Suleiman (2006) stated that natural vegetation and catchment areas are being invaded by expanding informal, urban, human settlement, a practice that has reduced the amount of ground water and resulted in environmental degradation. It is true that it is more difficult to manage the waste generated from informal settlement and it is also not easy to reduce dependency on, or to manage the collection of natural resources, which in some cases can lead to the loss of biodiversity in the area. According to Nyakaana, et al (2007), the ever-expanding urban informal settlements are increasingly degrading the environment through wetland degradation, solid waste accumulation, water contamination and poor sanitation. As natural resources, including vegetation, are sought for survival, it has been difficult for urban authorities to enforce environmental regulations. They further stated that as the environment deteriorates so is the increase in extraction of the natural resources like vegetation. Nyakaana, et al (2007), in their report on the study of informal settlements in Kampala City, stated that the haphazard way the settlements were growing has greatly contributed to the unsustainable

utilization of vegetation within the localities resulting in environmental degradation through wetland encroachment and destruction of land cover.

2.5 Conceptual framework

The conceptual framework offers a basis for an assessment of the linkages of various factors that contribute to the environmental degradation and public health problems in Nyalenda informal settlement. Such an assessment is envisaged to make a significant contribution to knowledge about the effects of the unplanned growth of Nyalenda informal settlement on environment and public health. Figure 1, below, depicts a situation where unplanned growth of Nyalenda settlement resulted to level two problems like; poor disposal and management of solid waste, lack of planned sewer system, change of land use and loss of vegetation and lack of treated piped water reticulation. The third level of problems would include; general pollution of the environment, unplanned or unprotected pit latrines, increased run off and conveyance of microbial and chemical pollutants which, directly, lead to pollution of water bodies and unplanned or unprotected shallow wells which are exposed to bacterial water pollution. Environmental and public health problems is the ultimate level, where the residents of Nyalenda experience increased incidences of water borne diseases as a result of the above factors.

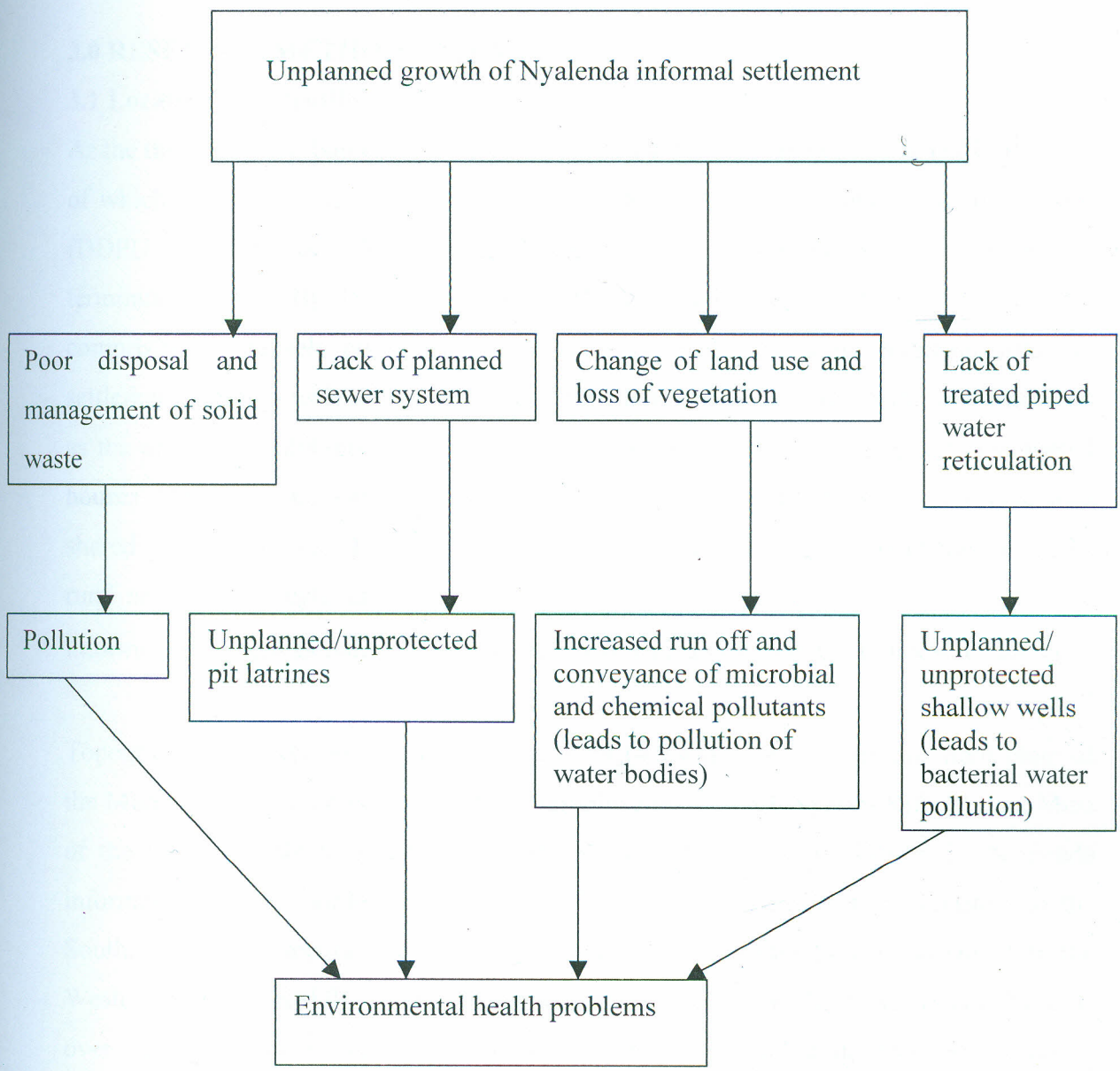

Figure 1: Conceptual framework. The arrows show the direction and sequence of events.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Location and Profile of Study Area

As the third largest urban centre in Kenya, with an estimated area of about 417 km^2 of which 71% is dry land and a projected human population of approximately 320,000 (DDPU, 2007), Kisumu Municipality has grown from a humble beginning as railway terminus in 1901. By 1971, Kisumu municipality had annexed about 53 km^2 to it comprising of densely populated peri-urban settlements, including Nyalenda informal settlement together with a large portion of rural land. Nyalenda area is in rapid transition as the original inhabitants are selling land to newcomers who put up quality residential houses. Typically, housing in Nyalenda informal settlement is of single-room type with shared social facilities. Land tenure in Nyalenda is of freehold and is characterized by rural settlement caught up in urban expansion. The average income is low within the informal settlement as indicated by the quality of living environment (KENSUP, 2005).

Topographically, Nyalenda informal settlement (4.9 km^2), lies on the Southern plain of the Municipality, which is part of the geographically complex Nyanza Rift System. Most of the land is liable to flooding, largely because of topography. Generally, Nyalenda informal settlement borders with Kisumu-Nairobi road to the East, Nyamasaria to the South, Ring Road separates it from up market Millimani to the North and Dunga to the Western side (KENSUP, 2005). (Refer to maps in the Appendices X, XI and XII). At over 1,100 meters above sea level, the Municipality, including Nyalenda informal settlement, falls within the relatively hot and humid climate (lower midland zone three, LM3, agro ecological zone), with an average annual rainfall of 1,245 mm falling in a bimodal form of distribution, that is, the long rains between March and June and the short ones between October and November. The annual mean minimum and maximum temperatures are 17.3°C and 28.9°C respectively (KENSUP, 2005).

3.2 Hydrology

The Southeast part of the town, towards the lake is associated with poorly drained, black cotton soils, flat land subjected to flooding with permanent and seasonal swamps, which

cover almost the entire Nyalenda informal settlement. Wigwa stream transects the informal settlement and drains into Lake Victoria. The stream is a source of water for livestock, and to some extent, human domestic use. During the rainy season the stream bursts its banks as a result of increased runoff in the upstream and the informal settlement. Ground water, harvested in wells, is another source of water for various domestic uses. The wells are, however, dug shallow due to the high water table in this area.

3.3 Land-use and livelihood profile

Land in Nyalenda informal settlement is on a freehold tenure. Families transfer land to successive generations as is typical of rural set up. Cultural land use practices persist despite its location and proximity to up market Millimani residential area, resulting in periodic conflicts with Municipal authorities as grazers invade parks and other amenities in pursuit of pasture. Traditional culture of burying the dead within compounds, still persist. To the Southern part of the informal settlement, lies a large tract of agricultural land, which is seasonally flooded. This land forms an important component of the community livelihood (KENSUP, 2005). Main sources of income include wage employment in manufacturing and processing plants, petty and informal trade and public transport especially non-motorized "boda boda" or bicycle taxis (KISWAMP, 2003). Most residents work as petty traders within Nyalenda and beyond. Many work in the informal sector in the town centre as well as in the near by Millimani area as domestic help for subsistence. A small number of Nyalenda residents are in the formal employment. Farming takes place in "Nam Thowe", a prime area for developing urban agriculture. Fishing in Lake Victoria, also, provides a significant source of income to the Nyalenda residents (KISWAMP, 2003).

3.4 Sampling Procedure

The study adopted purposive sampling technique that allowed the researcher to use cases that have the required information with respect to the objectives of the study. This sampling method was convenient for this study because the researcher was not interested in selecting a sample that was representative of the population but focus on in-depth

information not making inferences or generalizations. The environmental health problems were determined through questionnaires and interview schedules with the local private health clinic owners, public health facilities and heads of households. Bacteriological contamination by *Escherichia coli*, *Salmonella species* and *Vibrio cholerae* of both surface and ground water was investigated by collection and laboratory analysis of water samples from 40 out of 42 documented wells (DWE, 2007) and Wigwa stream, which runs behind the informal settlement. Vegetation degradation changes in the study area were determined by interviewing the respondents of 41 years of age and above.

Table1: Projected population of Nyalenda informal settlement 1999-2008

Nyalenda A							
		Males	Females	Total	Area sq km	HH	Density
Po	1999	12507	11224	23731	2.8	4746	8475
Pn	2008	14974	13438	28411	2.8	5682	10147
	Rate	0.02	0.02	0.02			
	Time	9	9	9			

Nyalenda B							
		Males	Females	Total	Area sq km	HH	Density.
Po	1999	13162	12482	25644	2.1	5129	12212
Pn	2008	15758	14944	30701	2.1	6140	14620
	Rate	0.02	0.02	0.02			
	Time	9	9	9			

NB. Population 1999 census = 49375 Projected population 2008 = 59112 Average HH size = 5
Households (HH) = 9875 Projected (HH) = 11822

Formula used in projection;
$Pn = Poe^{rt}$
Where Pn =projected population, 2008, Po = population census 1999. e = mathematical exponential, r = rate of population growth (estimated) and t = time difference (years)

Source: Kenya National Bureau of Statistics (2008), Kisumu.

According to Table 1, the projected population 2008 of Nyalenda 'A' is 28,411 and Nyalenda 'B' is 30,701. A total human population is 59,112, average household size of 5 members and projected households of about 11,822. Sample size (n) calculated if target population is greater than 10,000, in this case 59112.

$$\text{Sample size } n = \frac{z^2pq}{d^2}$$

Where, n = desired sample size if target population is greater than 10,000, z = required confidence interval (1.96), p = proportion of target population with desired characteristics (0.50), while q = 1-p and d = the level of statistical significance (0.05). Therefore on substitution;

$$n = \frac{(1.96)^2 \ (0.50)\ (0.50)}{(0.05)^2} = 384.$$

Purposive sampling method was used in interviewing 76 heads of households living around the 40 sampled wells.

3.5 Data Collection

Interviews and observation methods were use to collect primary data on environmental health issues in relation to availability of potable water and sanitation facilities. To investigate the adequacy of latrines, the number of individuals sharing each facility was also determined. Secondary data and interview schedules were use to gather information on disease incidences and general health problems. Surface and ground water quality were determined through laboratory tests. Damping sites distance in relation to water bodies was determined; wastewater disposal system and possible interaction with water sources were determined through observation and interviews. Effect of the unplanned informal settlement on vegetation cover was determined by observation and interviewing of elders to determine the historical background of initial flora and the trend to date. Situation analysis method included self-administered questionnaires to key stakeholders such as departments in Municipal Council of Kisumu like Physical Planning, Environmental Planning and Public Health and to health facility and pharmacy owners in

Nyalenda informal settlement. Questionnaires were also administered to the heads of households in the study area. Observations, photography, focus group discussions (Appendix VII) were other tools used. Secondary data included census data, reports, case studies on individual study areas, surveys undertaken by national and international institutions, as well as informal settlement mapping exercises done by the dwellers organizations supported by non-governmental organizations (NGOs). Counter checking of facts was done by cross-examination of the relevant technical authorities in public health, water quality and natural resources.

3.5.1 Bacteriological pollution of water

Although water can contain unwanted chemicals, the greatest risk to human health is from feacal matter contamination that may result in serious ill health due to presence of intestinal pathogens (WHO, 1998). The presence of enteric pathogens in water can be confirmed by documented bacteriological tests in the laboratory. Feacal coliforms are utilized as indicator organisms since they are thermotolerant (thermophilic) especially the *Escherichia coli*. Some strains of *E. coli* are pathogenic, for example, Enteropathogenic *E. coli* (EEC). Other pathogenic organisms in water include the *Salmonella*, *Vibrio*, *Shigella*, *Yersinia* species and some protozoa like *Girdia* and *Cryptosporidium* (Hach, 2000). This study was only focusing on *E. coli*, *Vibrio cholerae* and *Salmonella* species and bacterial load checked against the WHO standards in Table 2.

Table 2: World Health Organization water standards and guidelines

Water source	Recommended levels of *E. coli* colonies
Domestic piped or unpiped supply	0/100 ml sample
Fresh recreational	≤ 126/100 ml sample
Marine recreational	≤ 35/100ml sample

Source: World Health Organization (1989)

3.5.2 Water sample collection

Collection of water samples from the wells and stream was done aseptically or under sterile condition and details of the wells, like depth, protection, locality, and proximity to pit latrines and dumps sites were documented. Out of documented 42 wells, samples from 40 wells (20 Nyalenda "A" and 20 Nyalenda "B", for equal representation in both sub-locations) and 18 samples of Wigwa stream (6 Kasagam School, 6 Nyalenda "A", and 6 Nyalenda "B") were collected at three different points, randomly and analyzed. At the first collection point the stream is just entering Nyalenda, second point it is flowing past Nyalenda A' while at the last point the stream is leaving Nyalenda 'B' and into the lake. Weighted bottles, by use of sterile stones, were used to collect sample from open wells. Bottles were lowered into the wells to a depth of about 1.0m from water level and given enough time to fill, with air space left. Bottles were labeled appropriately before placing in a cool box for transportation to the laboratory. Testing was done within 6 hours of collection. Only 18 samples of stream water were analyzed because there was homogenous presence of *E. coli* in 88.9% of the samples tested and this was found to be representative and reliable.

3.5.3 Enumeration of *E.coli*

E.coli is abundant in human and animal feaces (MDH, 1999). It can also be found in sewage, effluents, natural waters and soil subject to recent feacal contamination (Samira, 2006). The most reliable test for this organism is based on the ability of *E.coli* strains to produce an enzyme, β- glucuronidase that hydrolyses the glucuronosyl-o-bond of the glucuridine conjugates such as 4- methyl-umbelliferyl- β- D- glucuridine (MUG). Among the Enterobacteriaceae family, only *E.coli* and some *Shigella* and *Salmonella* species produce the enzyme capable of hydrolyzing the glucuridine conjugates (Hach, 2000). In the enumeration method adopted, it is this factor that is utilized. The medium used, m-coliBlue 24® results in formation of *E.coli* colonies that are blue in color. Membrane Filtration (MF) method was aseptically (used under sterile condition), adopted. The MF comprise of filtration unit for holding 47mm diameter membrane filters with suction device, grid membrane filters of 47mm in diameter with pore size of 0.45μm, 47mm diameter cellulose pads on which broth culture medium is added before use, aluminum

petri-dishes of 50-60cm in diameter, magnifying glass and Broth medium, m-coliBlue 24®. About 100ml of sample water was filtered through a membrane of 0.45µm, aseptically, membrane was then placed on membrane pad already saturated with sterile m-coliBlue 24® broth culture medium in already sterile petri-dish, incubation was done at $35^0C \pm 2^0C$ for 24 hours then with aid of magnifying glass, the blue colonies of *E.coli* were enumerated and result recorded as the count per 100ml of sample

3.5.4 Detection of *Salmonella* species

Salmonella species are enteric organisms that are pathogenic. *Salmonella typhi* is the causative organism for typhoid fever. These organisms are found in contaminated water sources and food (FDA, 2000). Isolation process involves five stages; Pre-enrichment in Buffered Peptone Water (BPW) to resuscitate the injured organisms non-selectively, selective enrichment in tetrathionate broth and selenite cystine broth to enhance growth of *Salmonella* organisms whilst suppressing the non-*salmonella* related organisms, selective plating on Brilliant Green Agar (BGA) to visualize the growth of *Salmonella* organisms, biochemical confirmation of *Salmonella* species via various tests and serological confirmation were done. The requirements included the following; Buffered Peptone Water (BPW), Tetrathionate Broth (TTB), Brilliant Green Agar (BGA), Urease Test Broth (UTB), Selenite Cystine Broth (SCB) and Triple Sugar Iron (TSI) agar.

The Procedure was as underlined below: 25ml of sample was added to 225ml of sterile Buffered Peptone Water and incubated at $35^0C \pm 2^0C$ for 18-24 hours, 1.0 ml of the above pre-enrichment was then pipetted into 9.0ml of Tetrathionate Broth and incubated at $35^0C \pm 2^0C$ for 18-24 hours, streaking of the second enrichment was done on Brilliant Green Agar plate and incubated at $35^0C \pm 2^0C$ for another 18-24 hours, the plate was then examined for the presence of Salmonella suspicious colonies that appeared pink-white to pink, opaque or translucent with the surrounding medium pink to red, one of the suspicious *Salmonella* colonies was selected from each of the TTB and SCB streaking and inoculated into Triple Sugar Iron (TSI) agar, prepared slants, by stabbing the butt and streaking the slant. Then, incubation was done at $35^0C \pm 2^0C$ for 18-24 hours. *Salmonella* organisms produced an alkaline slant (red) and an acidic butt (yellow) with or without

production of hydrogen Sulphide gas (blackening of the butt), all positive TSI slants were subjected to biochemical tests for further confirmation then serological confirmation tests were also done as indicated in Table 3 below.

Table 3: Biochemical and serological tests and reactions of Salmonella species

Test/substrate	Results		Salmonella spp Reaction
	Positive	Negative	
1. Glucose (TSI)	Yellow Butt	Red Butt	+
2. Lysine Decarboxylase (LIA)	Purple Butt	Yellow Butt	+
3. Hydrogen Sulphide (TSI and LIA)	Blackening	No blackening	+
4. Urease	Purple- red Colour	No colour change	-
5. Potassium Cyanide (KCN) Broth	Growth	No growth	-
6. Indole Test	Violet colour at surface	Yellow colour at surface	-
7. Polyvalent flagellar test	Agglutination	No agglutination	+
8. Polyvalent somatic test	Agglutination	No agglutination	+

Source: FDA (2000), Bacteriological Analytical Manual

3.5.5 Detection of *Vibro cholerae* (01,0139)

These are members of genus *Vibrio* and are defined as gram-negative, asporogenous, rods that are straight or have single, rigid curve. They are motile and most have single flagellum when grown in liquid medium. Most produce oxidase and catalase and ferment glucose without producing gas. *Vibro* species account for a significant proportion of human infections caused by consumption of raw, polluted water. *Vibro cholerae, 0139* strain is the causative agent of cholera outbreaks. Various biochemical properties and antigen types characterize it and can be differentiated from other *Vibro* species because of its obligate requirement for sodium ion (Na^+) can be satisfied by trace amounts present

in most media constituents. *V. cholerae* is excreted in great numbers in feaces of cholera patients (FDA, 2000). The diseases are transmitted by feacal-oral route, indirectly through contaminated water. Vibrio species grow in presence of relatively high levels of bile salts or alkaline conditions. Isolation of this organism from water is facilitated by use of media formulated with alkaline PH, that is, Alkaline Peptone water (APW). Basic requirements included alkaline peptone water (APW) and Thiosulfate –citrate- Bile salts –sucrose (TCBS) on plate. Initially, the samples had been collected aseptically and cooled at 7^0C- 10^0C before commencing analysis within 6 hours. Enrichment and platting was done. This involved adding of 225ml of APW to sample and incubating at 35^0C ± 2^0C for 18-24 hours, a loop of the enrichment was transferred from the surface of APW culture to TCBS plate and streaked before incubating at 35^0C ± 2^0C for 18-24 hours, typical *Vibro* colonies on TCBS agar are supposed to be large (2-3mm), smooth, yellow, slightly flattened with opaque centres and translucent peripheries. Finally, biochemical confirmation tests (Table 4) were done on suspicious *V. cholerae* colonies.

Table 4: Biochemical tests and reactions of suspicious *V. Cholera* colonies.

Test/substrate	Reaction of suspicious colonies	Expected reaction of *V. cholerae*	Presence of *V. cholerae*
1. TCBS	Yellow	Yellow	Probable
2. Oxidase test	+	-	Nil
3. Lysine Decarboxylase test	+	-	Nil
4. Urease test*	-	+	Nil

*In the final urease test, presence of *V. cholerae* in sample would give a red-purple color as a result of urea break down. Source: FDA (2000), Bacteriological Analytical Manual

3.6 Data Analysis and Presentation

Data collected were examined, analyzed to establish authenticity by relating to existing data sources and crosschecking with relevant technical authorities. Descriptive statistics of means, range, frequency and percentages were used to analyze quantitative data realized from laboratory analysis, presented in tabulation and compared to required standards (Table 2). Qualitative data analysis technique of comparison of categories and themes within Nyalenda community such like attitude towards sanitation, level of education and environmental awareness, sought to make general statement on how categories and themes were related. Data collection and analysis using computer package of Statistical Package for Social Scientists went on simultaneously. Photography and bar charts were used to present environmental health problems, as vegetation degradation data, in form of bar charts and text.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

The chapter attempts to present the results and analysis of data drawn from various primary and secondary sources during the research. It is broadly divided into: environmental health problems associated with the growth of Nyalenda informal settlement, microbiological contamination of well and Wigwa stream waters as a result of growth of Nyalenda informal settlement and the effects of Nyalenda informal settlement on the trends of vegetation cover over time. The characteristics of interviewed households were as follows; by age (Figure 2), as 82% of the respondents were above 40 years of age and only 4% were below 30 years old; by occupation (Figure 3), 46% were unemployed and only 13% had formal employment; by level of education (Figure 4), 78% had formal education from primary to tertiary level and finally by household size (Figure 5), 88% of households had 4-10 members in the study area. The under 20 years old, interviewed as heads of households, were orphaned and formed part of the 46% of the unemployed respondents.

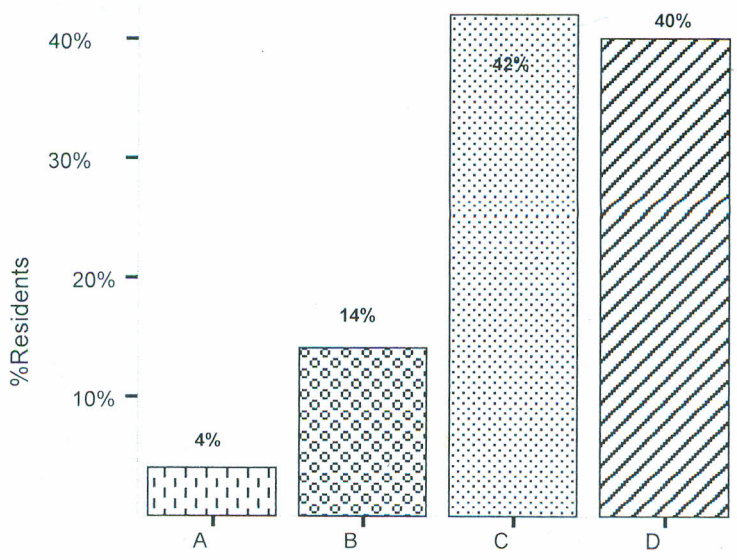

Figure 2: Distribution of interviewed residents by age; A= 20-30yrs, B= 31-40 yrs, C= 41-50 yrs and D= Over 50 yrs. Source: Field data

The only public health institution near this residential place is Joel Omino dispensary owned and run by the Municipal Council of Kisumu. Most residents work as petty traders within the locality, in "jua kali" sector in the town centre and domestic work in nearby Milimani area as a widespread means of subsistence. Some sort of agriculture takes place in "Nam thowe", a prime area for developing productive urban horticultural agriculture. However, in almost all sectors, income levels are low and the availability of serviced plots continues to be a major challenge in establishing small-scale enterprises in Nyalenda.

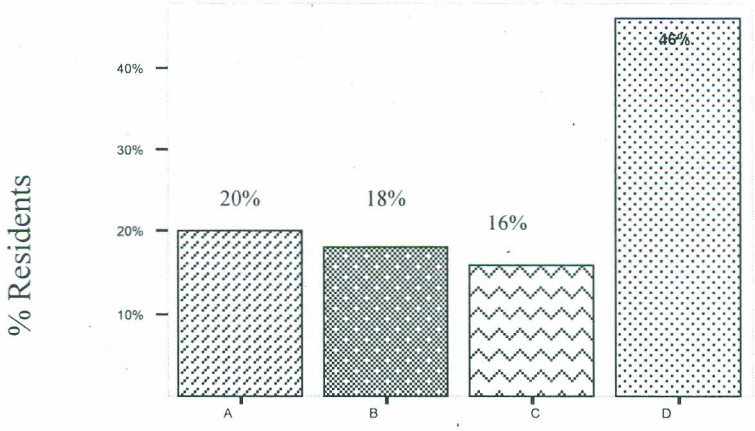

Figure 3: Distribution of Interviewed Residents by Occupation; A=Business, B= Employed, C= under employed and D= Unemployed.

The underemployed were those residents who had tertiary institution certificates but were involved in petty businesses like hawking and doing menial jobs for the rich people staying in the neighboring Milimani estate because of shortage of opportunities for formal employment.

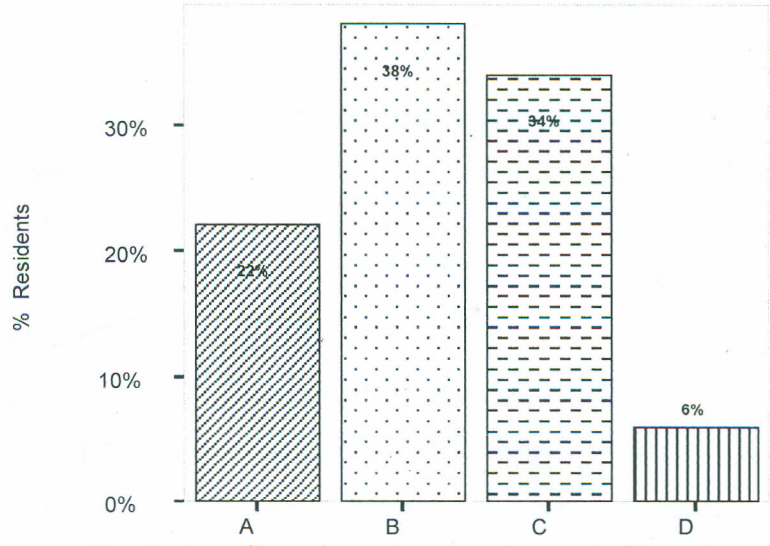

Figure 4: Distribution of Interviewed Residents by Level of Education; A= None, B= Primary, C= Secondary and D= Tertiary. Source: Field data

Figure 5 shows that majority (42%) household size is 4-6 members in a room. The consequences of overcrowding include household accidents and airborne infections whose transmission is increased for example, acute respiratory infectious diseases, pneumonia, tuberculosis, coughs and flu. Effects of overcrowding of such households also extend to shared facilities.

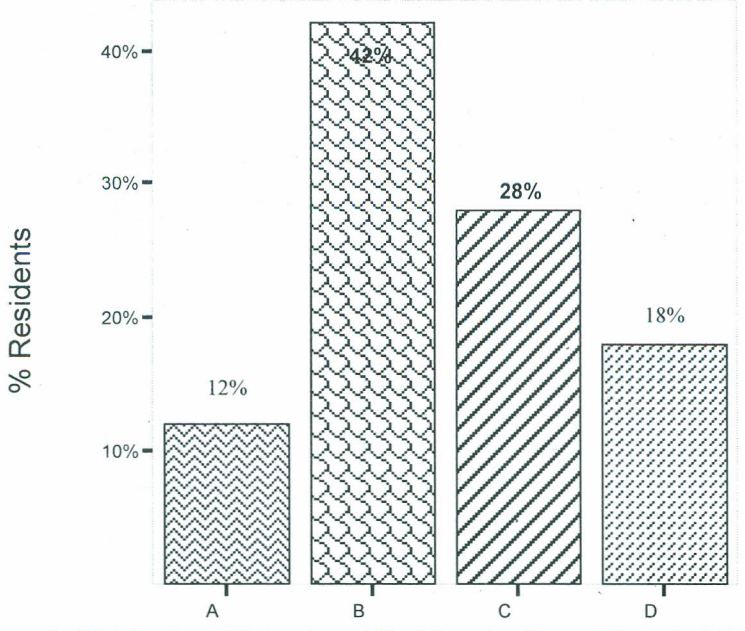

Figure 5: Distribution of Interviewed Residents by Size of Household; A= 1-3, B=4-6, C=7-10 and D= Above 10. Source: Field data

4.2 Environmental health problems

Residents' opinion on frequency of environmental disease occurrence in Nyalenda informal settlement was that 70% of the total respondents stated that the diseases are frequent while 28% reaffirmed that, infact, the frequency was even higher (Figure 6). Further, Figure 7 indicates that 72% of the households experience environmental diseases on monthly basis while 18%, weekly. This was an indicator that about 90% of the households encounters these diseases on monthly basis. Figure 8 shows that most common environmental diseases affecting Nyalenda households are malaria (28%), diarrheal diseases (2%), typhoid (4%) and chest ailments (6%) and (62%) reported combination of 2 or 3 of the diseases. This investigation results are supported by the data on most prevalent cases, on the average, handled at the local health institutions per month; malaria (369 cases), pneumonia (188 cases), diarrhoeal diseases (106 cases),

typhoid (55 cases) etc; (Table 5a), on commonly off the counter: bought prescriptions in the local pharmacies.

Table 5: Drug Sales and Reported Cases of Diseases in Nyalenda: a) Drug sales, b) Disease cases reported

a)

	Junction Chemist	Shekem Chemist	Oboch Chemist	Medlane Pharmacy	Nyalenda Pharmacy	*Ave*	*Max*	*Min*	*Range*	*Std Dev*
	Doses per Day									
Malaria	20	5	30	10	10	15	30	5	25	10.00
Typhoid	4	5	5	4	4	4.4	5	4	1	0.55
Amoebiasis	2	3	10	20	6	8.2	20	2	18	7.29
Genital ulcers	1	3	0	1	0	1	3	0	3	1.22
Skin infections	2	6	30	2	2	8.4	30	2	28	12.20
Pneumonia	0	3	15	2	1	4.2	15	0	15	6.14
Fungal infection	1	4	25	4	3	7.4	25	1	24	9.91
Flu	4	6	35	15	12	14.4	35	4	31	12.34
Cough	13	6	35	50	10	22.8	50	6	44	18.91
Dysentery		4	35	30	2	17.75	35	2	33	17.17
	Doses per month									
Malaria	600	150	900	300	300	450	900	150	750	300.00
Typhoid	120	150	150	120	120	132	150	120	30	16.43
Amoebiasis	60	90	300	120	180	150	300	60	240	94.87
Genital ulcers	30	90	0	30	0	30	90	0	90	36.74
Skin infections	60	180	900	60	60	252	900	60	840	365.95
Pneumonia	0	90	450	60	30	126	450	0	450	184.20
Fungal infection	30	120	750	120	90	222	750	30	720	297.44
Flu	120	180	1050	450	360	432	1050	120	930	370.23
Cough	390	180	1050	1500	300	684	1500	180	1320	567.39
Diarrhoeal diseases		120	1050	900	60	532.5	1050	60	990	515.19

b)

Disease	Ring Road Medical Services	Nyalenda Health Center	God's Will Health Center	Community Health Clinic, Pand Pieri	Average cases per month
Malaria	70	123	83	1200	369
Typhoid	50	21	150	0	55
Pneumonia	30	0	0	720	188
S.T.I.s	20	59	0	0	20
Helminthiasis	20	0	0	0	5
Diarrhoea	0	22	67	336	106
Others	20	0	0	80	25

Drug sales for common environmental diseases in Nyalenda in a month, averaged cough (684 doses), diarrhoeal diseases (532.5 doses), malaria (450 doses), flu (432 doses) and pneumonia (126), among others (Table 5b).

Plate 1: Semi open water well, fixed with pump but sited near pit latrine (arrowed) and solid waste dumpsite in Nyalenda "B" informal settlement. Source: Field photography.

As a consequence of use of well water for domestic purposes (Plate 1), Nyalenda residents have to contend with bigger burden of diseases as they have to contend with frequent exposure to environmental diseases, depriving them of much needed income for other household needs. In the study area, construction of pit latrines is further inhibited by high ground water table of 4.0-5.2 m (Appendix 1) and the flash floods inherent in the area. The two factors exacerbate pollution of ground and surface water resources in this area, hence the higher frequency of diseases in the locality and within families.

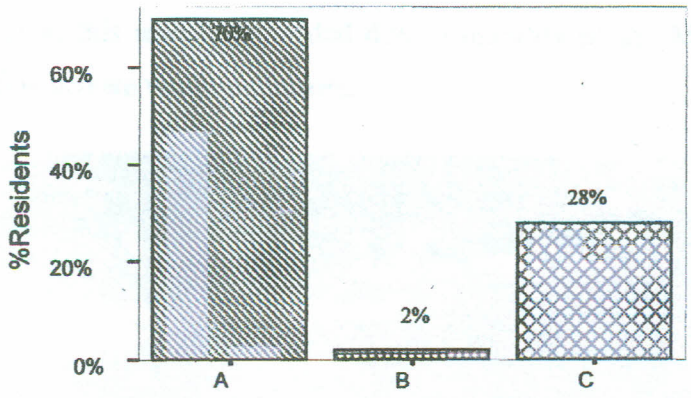

Figure 6: Resident's Opinion on Frequency of Disease Occurrence in the Area; A= Frequent, B= Rare C= Very Frequent. Source: Field data

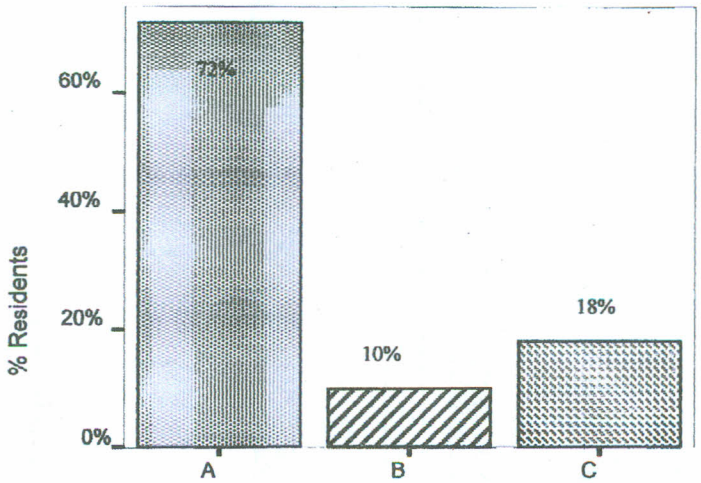

Figure 7: Frequency of Diseases within Families; A= Monthly, B= Yearly and C= Weekly. Source: Field data

Respondents, overwhelmingly, attributed the causes of environmental diseases to poor sanitation (56%) and contamination of water (6%) and 30% to both, as depicted in Figure.9. The results are supported by the Deputy Chief Public Health Office's (DCPHO) view that main reasons for the prevalence of the environmental diseases in Nyalenda informal settlement are, among other things, lack of essential sanitation and sewer system, both of which leads to contamination of ground and surface water. Plate 1, shows a dumpsite and a pit latrine close by water well, within 10m, as opposed to Public Health recommendation of at least 50m. Plate 2 shows a case of burst water pipe within a pool of sewerage water, another potential source of water pollution. Mode of spread of environmental diseases, according to the households, is mostly through consumption of contaminated water (80%), as depicted in Figure 10, according to UNHABITAT report of 1996; access to piped water supplies does not necessarily mean adequate or safe supplies. Waste collection in this area is grounded due to inability of the Municipal Council to cope and very few private waste collectors.

Plate 2: Broken water pipe (see the arrowed jet of water) in a pool of standing sewage water in Nyalenda "A". Source: Field photography

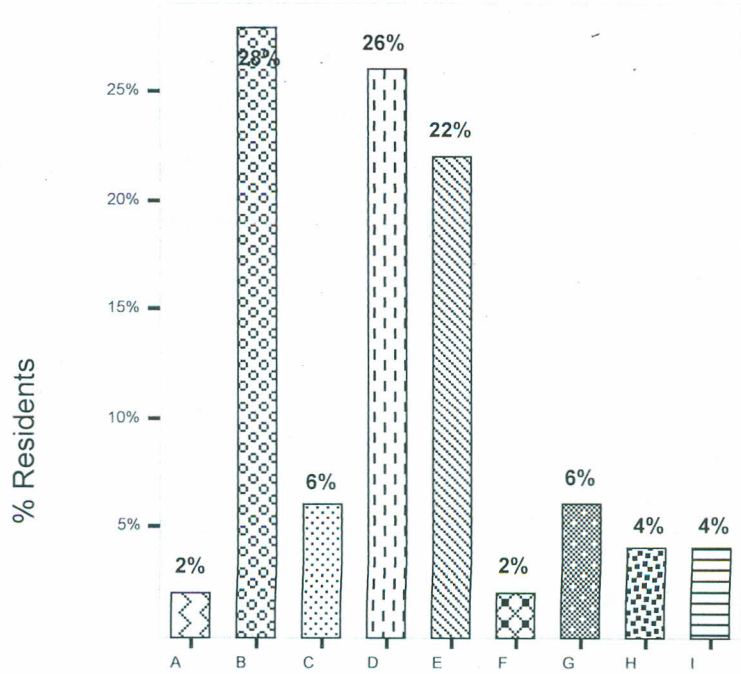

Figure 8: Common Diseases According to Interviewed Residents
A= Diarrhea, B= Malaria, C= Malaria & Chest Problems,
D= Malaria & Diarrhea, E= Malaria & Typhoid, F= Malaria, Diarrhea & Chest Problems, G= Malaria, Typhoid & Diarrhoea, H=Typhoid and I= Others. Source: Field data.

Diarrhoea and typhoid were found to be closely linked to limited supply of piped water and poor sanitary conditions where shallow well waters and pit latrines provide alternatives to the conventional water and sanitary systems.

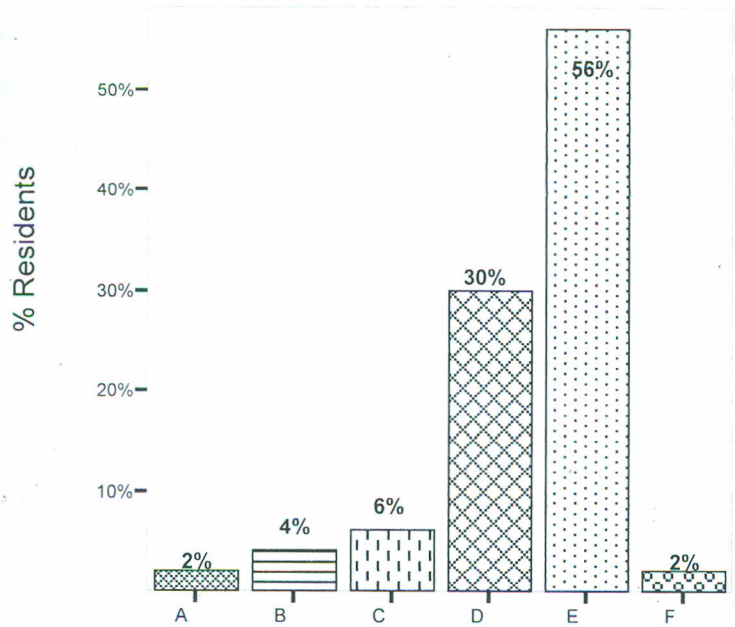

Figure 9: Residents View on Causes of Diseases; A= Others, B= Pollution of Air, C= Pollution of Water, D= Pollution of Water & Sanitation, E= Sanitation and F= Sanitation & Pollution of Air. Source: Field data

Poor management of solid waste has resulted into generation of leachate, which pollutes the ground water hence, the spread of diseases, blockage of water ways and scavengers and others getting exposed to health risks as no separation of hazardous waste fractions is done.

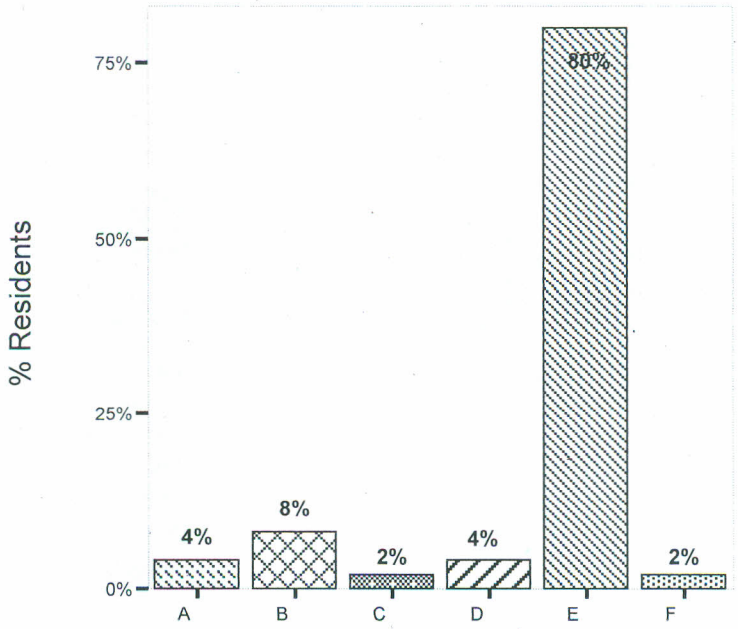

Figure 10: Residents View on Mode of Spread of Diseases;
A= Air& contact, B= Air & Water, C= Contact, D= don't know, E= Water and F= Water & Contact. Source: Field data

Among the remaining respondents, some mentioned water along with other possible causes of spread of diseases; air and water (8%) and water and contact (2%). Other modes of spread mentioned were contact (2%) and air and contact (4%). From these figures, it can easily be shown that the residents of Nyalenda are aware that water is the main mode of spread of environmental related diseases in the locality. On how to reduce the disease incidences, 34% of respondents said that sanitation should be improved, 12% were for improved drainage, 8% clearance of garbage while 26% for both improved drainage and sanitation (Figure 11).

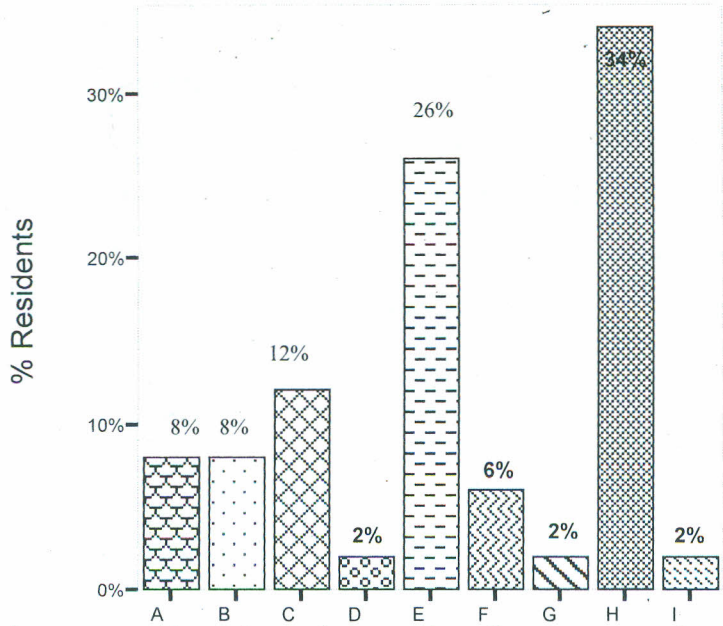

Figure 11: Residents view on how to reduce diseases common in study area; A= clear garbage, B= clear garbage & Improved sanitation, C= improved drainage, D= improved drainage & clear garbage, E= improved drainage & sanitation, F= improved drainage, clear garbage & provide safe water, G= improved drainage, sanitation & provide safe water, H= improved sanitation and I= improved sanitation & clear garbage

Source: Field data

When the household heads were asked whether growth of Nyalenda informal settlement had any relationship with environmental disease incidences, their responses are indicated in Figure 12 and majority (78%) responded positively as 8% felt the unplanned growth of the settlement had no direct link to public health.

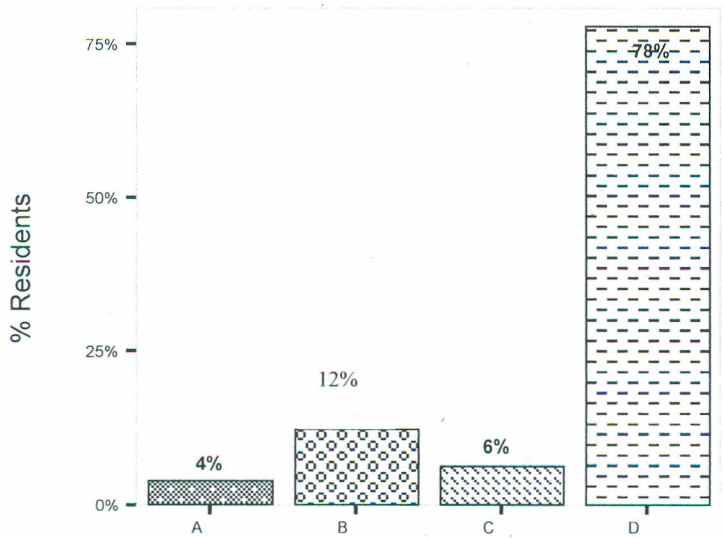

Figure 12: Residents view on if development of the informal settlement is associated with disease incidences; A= don't know= No, C= not sure and D= yes. Source: Field data

In gender perspective (Figure 13), 85% female and 72% male heads of households were able to relate, positively, disease incidences and unplanned growth of Nyalenda informal settlement. Same time, 10% females and 14% males did not see any direct link between the two variables. Quite interestingly, all the females had an idea on the issue at hand while 7% of the males gave a definite "don't know" answer.

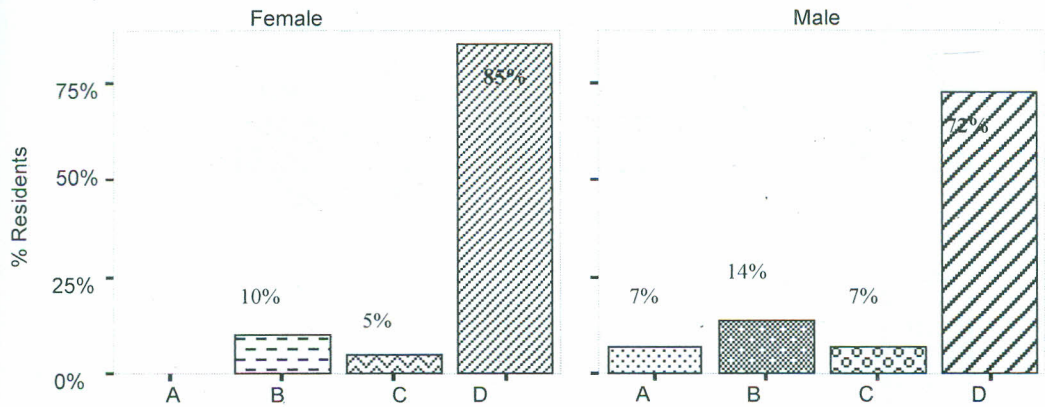

Figure 13: Views of males and female on disease association with the growth of the informal settlement; A= don't know, B= no, C= Not sure and D= yes. Source: Field data.

Variation on the views of households, on the same issue, based on level of education (Figure 14) was; tertiary level (100%) group included those that had attained University degrees, Diploma Colleges and Certificate level colleges like Teacher Training Institutions, secondary (94%) category included all those respondents who had reached any of the Form 1 to 4 classes, primary (63%) level respondents were those who never had opportunity to enroll in any secondary school and non-schooled (70%) respondents were those that never had any level of formal education. The results indicate that those who had formal education were more aware of environmental conservation and were able to relate, positively, the unplanned growth of Nyalenda informal settlement to environmental and public health problems facing them in the locality.

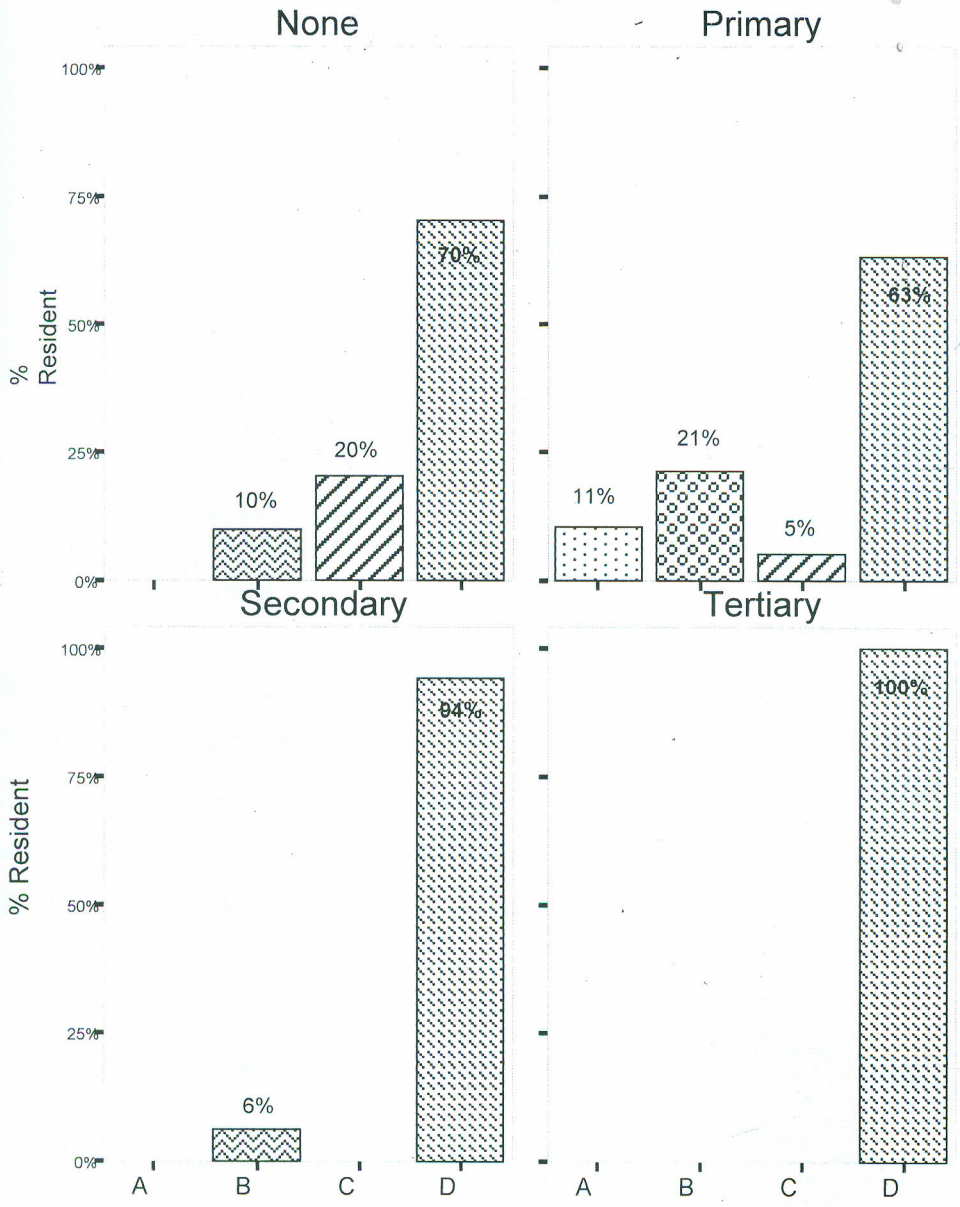

Figure 14: Variation of views on diseases association with growth of informal settlement by level of education; A= don't know, B=no, C=not sure and D=yes

Source: Field data

4.3 Bacteriological pollution of ground and surface water resources

To underscore the importance of ground (well) water in Nyalenda, 78% of the respondents indicated to be aware of a well nearby and use of such water for domestic purposes. According to (Figure 15), 36% of the wells in the study area were situated within 50m of nearest dumpsite down slope.

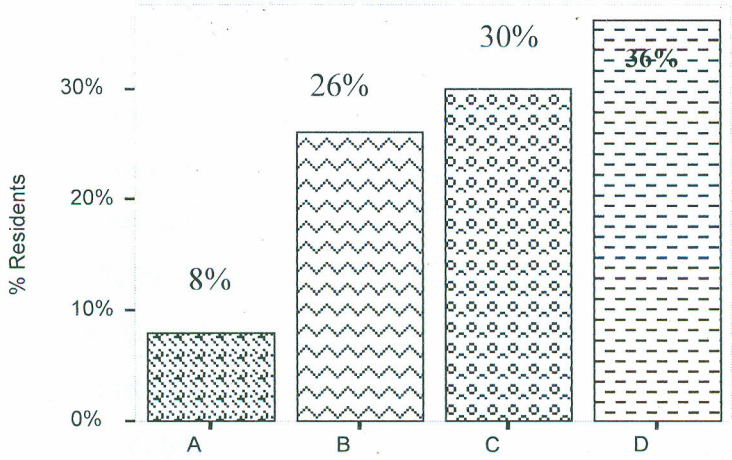

Figure 15: Distance of water wells from dumpsite according to residents; A=100-200m, B=50-100m, C=beyond 200m and D= within 50m

Source: Field data

Similarly, 54% of all the wells studied were situated within a distance of 50m from the pit latrines, down slope (Figure 16). Many plots are of small sizes of about 0.02 hectares (KCC, 2005) on black cotton soils; this makes it difficult to construct pit latrines at recommended distance of about 50m from the wells in accordance to Public Health Act, CAP 242, section 118 of the Acts of Parliament of Kenya.

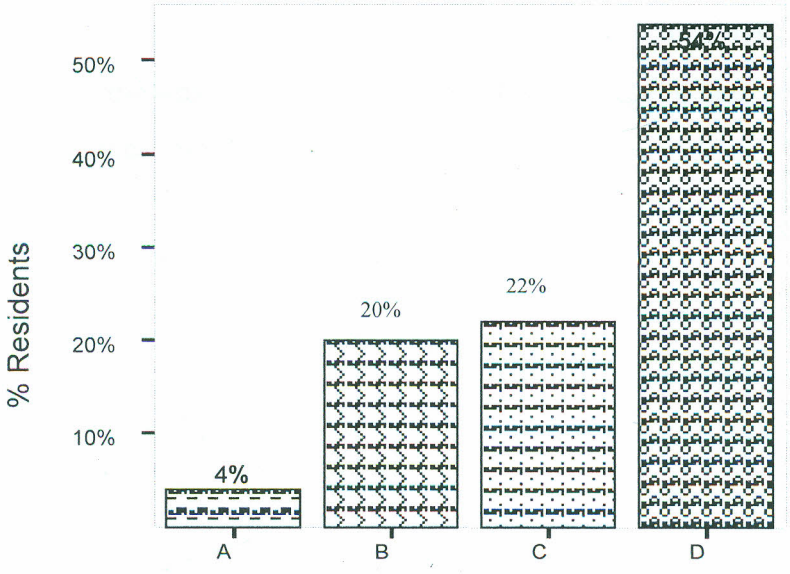

Figure 16: Distance of water wells from latrines according to residents; A=100-200m, B=50-100m, C=beyond 200m and D= within 50m

Source: Field data

The outcome indicates that 60% of wells sampled had semi-protection of concrete diverting surface run off and open sewage while the rest had no protection at all

(Appendix I). Only 12% of the wells had pumps for drawing water. The rest relied on containers to draw water from the depth using a piece of rope. The average depth of the wells sampled was 4.6m with a range of 4.0m to 5.2m. The average distance between the wells and nearest pit latrines, up slope, was 37.6m with a range of 5m to 60m. A proportion of 42.5% of the wells were within a distance of less than 50m from the pit latrine, down slope. Only 35% of wells sampled had a dumpsite nearby and upslope. The average distance of these wells to the dumpsite, upslope, was 27.7m with a range of 15m and above. Wigwa stream samples, as indicated earlier, were sampled at three different points i.e. just before the stream entered the informal settlement at Kasagam school (33.3%), as it joined Nyalenda 'A' sub-location (33.3%) and as it leaves Nyalenda 'B' sub-location to join Lake Victoria (33.3%). The range of distance between the stream and the nearest pit latrine was 30-50m, the closest distance being in Nyalenda "B". There were no dumpsites within site (Appendix I).

According to Public Health Act (CAP 242) of the Acts of Parliament of Kenya, pit latrines should be situated at least 50m down slope of any ground water source, especially for consumption or domestic use. Wastewater disposal among the residents of Nyalenda is also an issue. The study revealed, as in Figure 17, that 72% of the respondents splash the wastewater in the surrounding because of lack of proper drainage, as 18% have drainages into septic tanks.

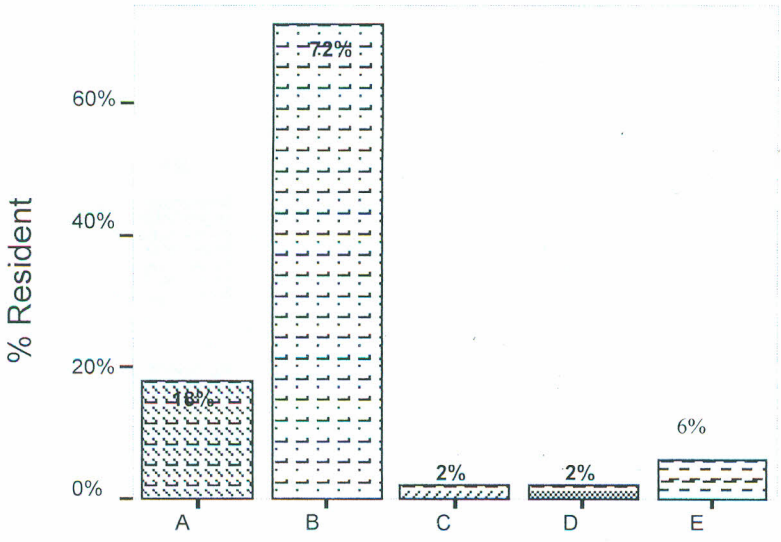

Figure 17: Disposal methods of wastewater; A= drainage, B= splashing in the surrounding, C= splashing & storage for use, D= Splashing & provision to livestock and E= re-use. Source: Field data

4.3.1 Sources of Water Pollution

According to Figure 18, most (58%) attributed the pollution of ground water to pit latrines as in Plate 3 which shows an overflowing latrine, as a total of 13% associated the pollution to garbage dumps, as shown in the background of Plate 1.

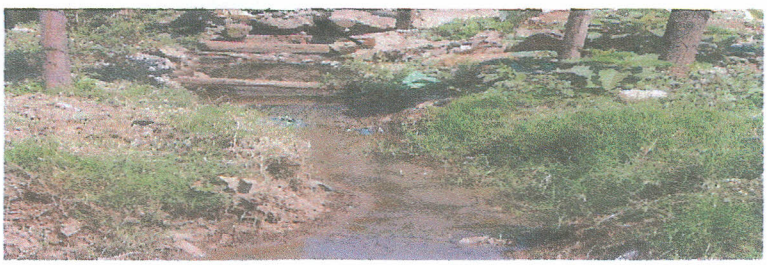

Plate3:Over flowing pit latrine (arrowed) in Nyalenda "A" informal settlement.
Source: Field photography.

Still some (23%) felt that both garbage dumps and latrines contributed to pollution of water bodies in the locality as a paltry 6% had no idea of what was the possible cause of water pollution.

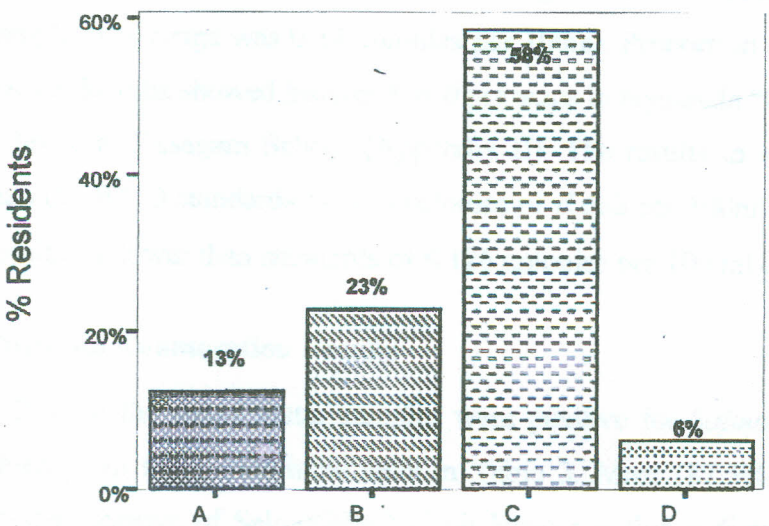

Figure 18: Sources of water pollution; A= garbage dumps, B= garbage dumps & latrines, C=; latrines and D= no idea. Source: Field data

4.3.2 *E-coli* Enumeration Results

On the analysis of the well water samples, the average *E.coli* count was 17 colonies per 100ml of sample with a range count of 0 to 68 colonies per 100 ml of sample (Plate 4).

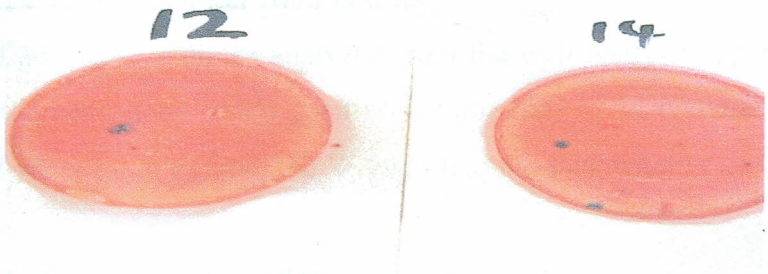

Plate 4: The dark blue bodies of *E. Coli* colonies in sample 12 and 14 of the well water samples. Source: Laboratory photography.

According to Appendix I, only 12.5% of the wells sampled had nil count of *E.coli* colonies. The owners attributed this to history of frequent chlorination of the wells and the fact that the nearest pit latrine, up slope, was situated more than 50m away. Wigwa stream water samples analysis showed that average count of *E.coli* was 6 colonies per 100ml sample. The range was 0-14 colonies per 100ml. Proportion of 88.9% of samples were positive. Results showed heavier *E.coli* presence in Nyalenda "B", downstream, and the least being at Kasagam School (Appendix II). The results in well water are much higher than the WHO standards of zero colonies of *E.coli* per 100ml of sample while the stream results are lower than standards of ≤ 126 colonies per 100 ml of sample (Table 2).

4.3.3 *Salmonella* Enumeration Results

In wells, 20% of the tested water samples were positive for *Salmonella* presence after being subjected to the biochemical tests in Table 3. Most (87.5%) of the well water samples tested positive of Salmonella had pit latrines within a distance of 50m, up the slope. Only 12.5% of the positive wells had semi protection. The positive, samples were 37.5% in Nyalenda "A" and 62.5% in "B", all had no hand pump. *E.coli* count of the samples that were positive of *Salmonella* ranged 18-68 colonies per 100ml sample (Appendix I). On analysis, 27.7% of the stream samples confirmed presence of *Salmonella*. All the samples collected on the upper section near Kasagam School, tested

negative and 33.3% of samples collected in Nyalenda "A" confirmed presence of *Salmonella* (Appendix II) on analysis. Coincidentally, all the stream samples that were positive of *Salmonella* spp had *E.coli* colonies counts of 6-14 per 100ml of sample, this lend credence to the use of *E. coli* as indicator organism.

4.3.4 *V. coli* Enumeration results

Of all the 40 samples analyzed from the well waters (Appendix I) in Nyalenda informal settlement, none tested positive for presence of V. cholerae organism. Likewise, all the 18 water samples from the Wigwa stream tested negative of the organism, V. cholerae.

4.4 Vegetation degradation over time

Due to high levels of unemployment (46%) revealed in this study (Figure 3), Nyalenda residents, generally, have low income. Low incomes compel the residents to use available resources in the environment. Majority (76%) of respondents unanimously indicated that vegetation cover have declined, tremendously, over time (Figure 19), some (4%) felt that the vegetation cover had increased, as 12% had no idea of the vegetation cover trend.

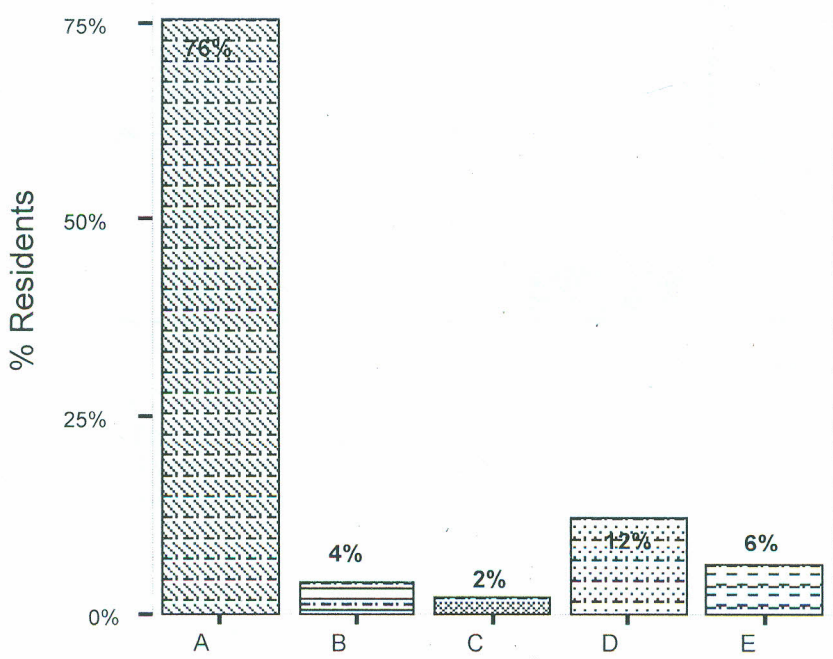

Figure 19: Residents views on vegetation changes; A= declined, B= increased, C= N/A, D= no idea and E= remain same. Source: Field data.

To get to the bottom of vegetation cover changes in Nyalenda, 79% of the respondents interviewed had lived in the area for over 6 years (Figure 20), 82% were over 41 years of age (Figure 2) and they provided very vital information on vegetation trend in the study area, including how the indigenous species of vegetation have been, gradually, replaced by the exotic varieties over time. The rest of the respondents had lived in the informal settlement for 1-5 years (14%) and below 1 year (6%).

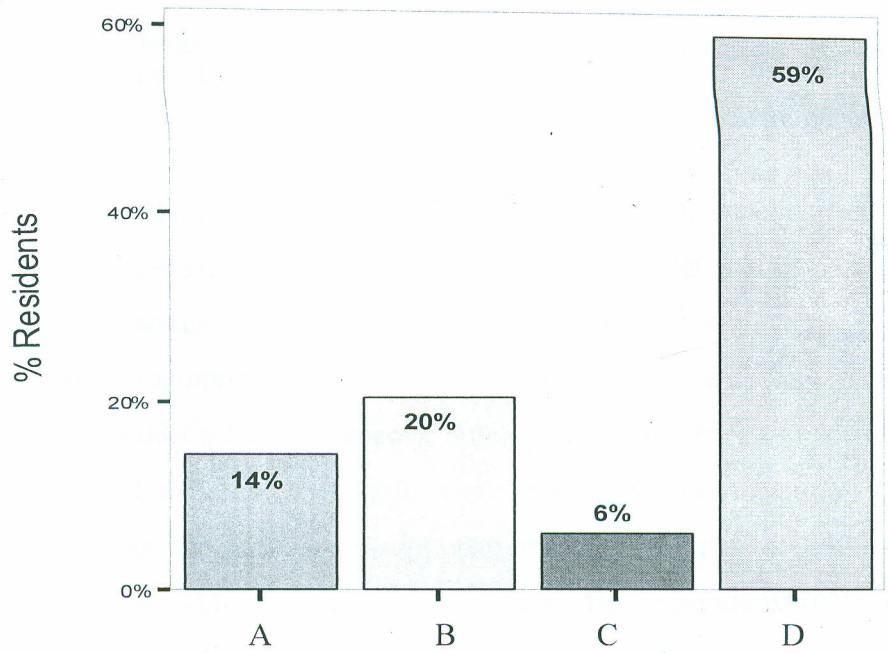

Figure 20: Duration lived in Nyalenda according to respondents. A=1-5 years, B=6-10 years, C=Less than 1 year and D=Over 10 years
Source: this study

In Figure 21, the respondents attributed the decline on vegetation cover to human settlement (80%), human settlement and tree felling (10%) and tree felling only (6%).

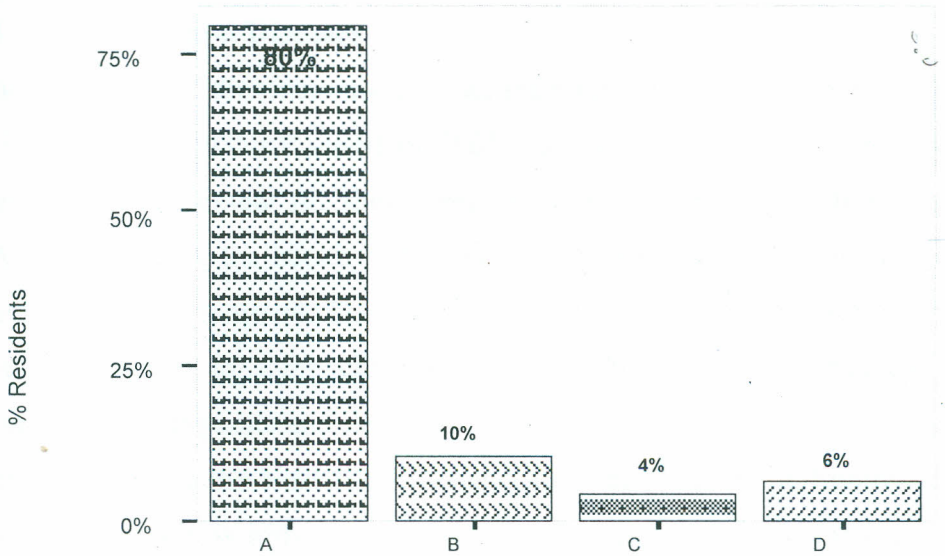

Figure 21: Reasons for change in vegetation cover; A= human settlement B= human settlement & tree felling, C= pollution and D= tree felling. Source: Field data

Respondents also indicated that before 1972, the area had indigenous tree species like, *Markhamia lutea* (siala), *Euphorbia* species (ojuok), *Cactus species* (abondo), *Carsia seamea* (bao), Balanites species (otho), *Tithonia diversifolia* (maua), *Acacia species* (kudho), *Solanum incanum* (ochok), *Albizia species* (ober) and lush natural pastures which supported wildlife like the impala, antelopes, hippos, hares, wild hogs, e.t.c; the study also revealed that many wetlands were drained for construction of houses and wetland plants like the reeds (*odundu*), papyrus (*togo*), elephant grass (*ogada*) and Siratro species (*bo dhok*) also disappeared over time. The respondents (6%) indicated that the immigrants, within their homesteads, planted exotic tree species. Such tree species, according to the respondents, included; *kei apple*, *calliandra, leuceana*, *cypress*, *Gravellea,* fruit trees (*olemo*) and *Eucalyptus*.

NB: all names in bracket are in Luo language.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Environmental Diseases

Since high rate of the unemployed is an indicator of low household income and as cited in UN HABITAT/UNEP report of 2005, the poor tend to exploit the resources in their immediate environment for short-term gains. In all unplanned informal settlement (UN HABITAT, 1996), the health of the inhabitants has always depended on their ability to manage their environment. This can either be done cooperatively or through delegation of this management to some city authority. As the size of a settlement grows and its economic base expands and demands increase on local resources, so does the need for a system to manage the basic resources and waste disposal. As in Figure 4, an individual's level of education is important not only because it affects their income earning capacity but also because it improves knowledge about how to promote health, prevent diseases and rapidly treat illness or injury and encourage greater use of health services. Infant and child mortality rates tend to be lower, the better educated the mother.

The outcome on common diseases in the study area is further supported by the comments of the Deputy Chief Public Health Officer (DPHO), Kisumu Municipal Council, who, in his interview, said that the most common environmental diseases in Nyalenda informal settlement are malaria, diarrhea, typhoid and pneumonia in that order (Figure 8). UN HABITAT (1996) indicated that the most common environmental diseases in the informal settlements across the world include: tuberculosis, diarrhoea, malaria, trachoma, worm infections, pneumonia and other respiratory diseases. This report is in agreement with the results in this research probably because the nature of target population was similar. In this study malaria was given more prominence as the most prevalent in average cases (369 per month) handled at the local health clinics and corresponding average doses (450 per month) of drugs sold by the local pharmacies (Table 5), while UN HABITAT report gives tuberculosis highest rating of occurrence in a similar setting. For diarrheal diseases, ranked second to malaria in terms of occurrence in this study, the links with built environment are particularly strong as risk factors include overcrowding, poor

sanitation, contaminated water and inadequate food hygiene. Figure 9 of this study clearly shows this linkage where the respondents clearly indicate that sanitation (56%) and pollution of water and sanitation (30%) are the main causes of diseases. According to UNEP (2007), a study done in the city of Khartoum, Sudan, significant environmental problems were seen in informal settlements, which offered negligible facilities for water, sanitation and solid waste management. The results were poor sanitation, high disease rates and difficulty in accessing basic services. The study found out that sanitation problem was directly reflected in incidences of water borne diseases, which make up 80% of the reported diseases in the informal area, a figure that is in tandem with the findings in this study (Figure 10). Similarity could be traced back to the type of study area, target population and methodology.

Kisumu City Council (2004) states that other diseases, apart from AIDS, that are common in Nyalenda and other parts of the town include; malaria, upper respiratory tract infections (URTI) and water borne diseases such as typhoid and diarrhea. The report further says that malaria is common amongst the children, in the study area, during the rainy season when the blocked drains and stagnant ponds of water provide rich breeding grounds for mosquitoes. In this study this information is corroborated in the findings in Figure 8 and Table 5, which clearly rate the said diseases very highly in their occurrence. About 80% of the informal settlement dwellers in Lake Victoria South Catchments have no access to safe drinking water as was reported by NEMA (2008). This figure of 80% is in agreement with the outcome of this research on mode of disease spread attributed to contaminated water (Figure 10). In the same report it was indicated that local authorities in Lake Victoria region lack essential sanitary services and many residents in informal settlements do not have access to safe drinking water. To reiterate the point of water being the most common mode of spread of diseases, KENSUP (2005) reported that septic tanks in Nyalenda are the major contaminants of ground water, a situation that was reiterated in the focus group discussion during this study (Appendix IX).

According to KENSUP (2005), the main type of toilet facility in Nyalenda informal settlement is pit latrine, some of which overflow when it rains (Plate 3) and according to

the residents (54%) most are within 50m of the watering wells (Figure 16) and that solid waste disposal (Figure 18), which 38% of respondents say is a source of water pollution, is a major problem in the area as the Municipal services do not cover the area for several reasons including; poor accessibility, inadequate refuse transport and bins, and household's casual attitude to waste disposal. According to the research done by UNEP (2007) in Khartoum, informal settlement population relies on basic latrines or septic tanks, as is the situation in Nyalenda. UN HABITAT, in its report in 1996 emphasized that provision of safe water; sanitation, drainage and safe disposal of wastes are, obviously, central to good health. In the same report, it was reported that in Dar-es-salaam, 89% of population in the informal settlement have simple latrines that over flow in the rainy season, a state that is common in the study area (Plate 3). Majority (83%) of residents in informal settlement in Kampala use pit latrines and 2% have no toilets according to Nyakaana, et al (2007), a case similar to Nyalenda situation. The Kisumu Municipal Physical Planner, when interviewed added that Nyalenda lacks drainage, save for along the Ring Road, which separates the informal settlement from Millimani area. These sentiments were in coincidence with the outcome of this study in Figure 17 that states that only 18% of the respondents have access to drainage, which is just along the ring road and majority (72%) splash the waste water to the surrounding. The outcome was similar because the study was done in the same locality. Kisumu City Council (2005) report on environmental profile on sustainable urban mobility also noted that many water sources within the Nyalenda, including the stream, shallow wells and springs contain water whose quality is unacceptable for drinking. This argument came out very clearly in the results of analyzed water samples from the wells and the Wigwa stream in Appendices II and I where 87.5% of well water samples 89.9% of stream water were positive of *E.coli*.

UN HABITAT (1996) stresses that access to piped water supply does not necessarily mean adequate or safe supplies. Plate 2 shows how a pool of sewage water can easily contaminate piped water, especially if there is a pipe burst in the system. The quantity of water available to a household and the price that has to be paid can be as important to a household's health as its quality. Thus, those served by formal public water supply may

have access to uncontaminated water in Nyalenda but difficulties in getting access to it in terms of cost may often limit its use to full health benefits in low-income households. Samira (2006) indicated that dug well cannot be considered any more as a source of drinking water without treatment, as two consecutive bacteriological analyses reveal presence of more than 10 coliform colonies per 100 ml. Appendices I and II shows that well water samples had between 0 - 68 *E. coli* colonies (12.5% had nil) per 100 ml of the well water samples and 0-14 colonies (11.1% had nil) per 100 ml of stream water samples. According to NEMA (2005a) report, contributing factors to poor sanitation in the study area are: lack of sewer system, unexplored ecological sanitation, lack of awareness on proper disposal of human waste (children), use of pit latrines and lack of enforcement of public health regulations especially open bathing and domestic use of water from Wigwa stream. Figure 11, in this study, shows how the findings are in tandem with the NEMA report, as the respondents mention sanitation (34%), drainage and sanitation (26%), improved drainage (12%), among others as being the main issues to tackle for the incidences of environmental diseases to reduce. The Physical Planning Department, Kisumu Municipal Council also conceded that drainage in Nyalenda is poor as there is only one drainage system running along the Ring road, between the settlement and the up market, Millimani estate and is confirmed by findings in this study (Figure17) which also shows that 6% of respondents re-use water. Even Santosa (2003) supported this view that the people living in informal settlement frequently fall ill due to poor quality of their environment as the case in Nyalenda.

The Deputy Chief Public Health Officer (DCPHO) concurred with the findings by saying that disease incidences in Nyalenda were as a result of unplanned settlement without infrastructures. In another interview session with Municipal Physical Planning Assistant, he said, "the degradation of Nyalenda environment is as a result of lack of awareness of environmental conservation and lack of proper enforcement of municipal by-laws on building code and physical planning." He further said, "most of Nyalenda scheme was an intact land inhabited by farmers and fishermen until 1972 when the boundaries were expanded to accommodate increasing Municipality population." According to NEMA (2005b) domestic waste, for a long time, has been a cause of nuisance, accidents and

diseases in neighbourhood with poor or no waste collection services. The Nyalenda case (Figures 15 and 18) is comparable to a study done by UNEP (2005, 2006), as quoted in UNEP (2007), which confirmed that informal settlements in Khartoum and Juba, Sudan, solid waste was not being collected by the authorities. According to study in the website: www.nied.edu.na (2007) environmental diseases spread most in dirty and overcrowded environments lacking in sanitation and have poor waste disposal. In Figure 10 of this study the respondents (80%) associated the spread of diseases in Nyalenda to polluted water due to poor sanitation.

5.2 Bacteriological Water Pollution

According to the Deputy Chief Public Health Officer for Kisumu Municipality, the behavior of splashing wastewater in the surrounding areas is enhanced by the fact that there is lack of essential sanitational facilities like sewer system and drainage. He also attributed this, to poor attitude of the residents towards sensitive matters of health. Figure 17 gives a clear picture of what the above mentioned Municipal official said; 72% of the respondents splash waste water in the surrounding environment as only 10% have access to drainage. The Municipal Planning assistant commented that the only drainage system in Nyalenda is along the Ring Road and the rest of the areas have no drainage at all. According to Situma (1992) dumping leads to production of methane, an air pollutant and a green house gas when the wastes decompose and to pollution of ground water through leaching besides creating breeding grounds for flies, cockroaches, rats and other vermin. Figure 15 and Appendix I indicate that 36% of the wells studied were within 50 m of the nearest communal dumpsites on the higher side of the slope, hence higher chances of contamination from leachates. Solid waste disposal is a major problem in Nyalenda informal settlement (KENSUP, 2005) and in a UNHABITAT (1996) study on poor urban population living in South of Sahara, it was found that most lack hygienic means of disposing solid, liquid and human waste leading to poor sanitation as was found in Nyalenda informal settlement. Figure 9 shows that 56% of respondents believe that poor sanitation is a major cause of diseases, while Figure 11, 34% of respondents say that improved sanitation would reduce diseases incidences.

Pit latrines are a source of biological organisms that are a threat to ground water quality and the agents, currently, are responsible for most water borne diseases. Such organisms include; *Escherichia coli*, *Salmonella species*, *Vibro cholerae* among others. Well water in Nyalenda is highly contaminated leading to high morbidity levels (KENSUP, 2005). The bacteriological analysis of both well and Wigwa stream water samples confirmed presence of *E.coli* and *Salmonella* species. In Appendix I, where 87.5% of the sampled wells tested positive of *E.coli* and 20% positive of *Salmonella species* and Appendix II shows that 88.9% of the stream samples were positive of *E. coli* and 27.7% of *Salmonella species*. No sample was *V.cholerae* positive as this organism is seasonal and only, easily, detectable during an outbreak (at the time of carrying out this study, there were no reported cases of cholera). A study done by Mara and Oragui (1985) in informal settlements in Nigeria and Zimbabwe indicated that surface water sources are feacal contaminated by both human and animal waste. The stream waters on examination had a range of 102-104 colonies of *E. coli* per 100 ml of water, a range that was too high compared to Wigwa stream, which had 0-14 colonies of the organism per 100 ml of sample (Appendix I) or the well water samples (Appendix II) which had 0-68 colonies per 100 ml. The variation in the figures could have been due sampling and analysis procedures or level of exposure of the water body to the contaminant.

According to study done by Lund (1998) on Kaunas River in Lithuania, bacteriological pollution increased downstream. *E. coli* index upstream did not exceed Highest Allowable Concentration (HAC) but downstream of the river the index reached unacceptable level per litre of sample. The findings in the analysis of Wigwa stream water samples, in this study, conforms to the Lund findings as *E.coli* count increased downstream from Kasagam school (average 3 colonies per 100 ml) on the higher gradient to Nyalenda 'B' (11 colonies per 100 ml), downstream. Even for *Salmonella* species, Nyalenda 'A', upstream, 37.5% of the samples were positive while Nyalenda 'B', downstream, 62.5% confirmed presence. In a case study done by Mara and Oragui (1985) in an informal settlement in Nigeria, water from a well showed heavy bacteriological contamination on analysis. When the site was visited, the source of contamination was obvious; the well was badly protected, there was no hand pump, a bucket and rope that

were used to draw the water were left on muddy ground and spilt water escaped back into the well taking with it surface contamination. There was no concrete slab around the well, sloping away from it. This, typically, describe the situation in Nyalenda informal settlement where 60% of the wells are semi-protected and a paltry 12.5% have hand pump (Appendix I). This is illustrated very clearly in Plate 1, showing half open well with containers left on the ground, pit latrine and dumpsite in the background and further confirmed in the focus group discussion (Appendix VIII). *E. coli* is easily measured (Plate 4) hence commonly used as indicator for presence of other pathogenic organisms. A study in the website: www.wvic.uwaterloo.ca (1991) indicated that survival characteristics, in water and susceptibility to disinfections, of *Salmonella spp* have been demonstrated to be similar to that of *E.coli.* This theory was confirmed in this study as all the well water samples that were positive of *Salmonella spp* also tested *E.coli* positive of 18-68 colonies per 100 ml of sample (Appendix I), likewise, all the Wigwa stream samples that confirmed presence of *Salmonella spp*, had indicated 6-14 colonies per 100 ml of *E. coli.*

5.3 Vegetation Degradation

The study revealed many cases of vegetation destruction associated with poverty. NEMA (2005c) indicated that such cases, in Nyalenda, included use of firewood and charcoal to the detriment of the environment. According to the report, low incomes result into over exploitation of natural resources and the use of detrimental means of extraction leading to environmental degradations or an environment, which is unable to renew itself. Poor residents encroach into fragile and conservation areas to cause deforestation as were confirmed in the focus group discussion (Appendix VIII). According to this study, 40% of the respondents were over 50 years old (Figure 2), 79% had lived in Nyalenda for over 6 years (Figure 20) and 76% affirmed that vegetation cover had declined over time (Figure19). The respondents attributed the decline to; human settlement (80%), human settlement and tree felling (10%), tree felling (6%) which could have been for firewood or charcoal as defined in the NEMA (2005c) report and pollution (4%). UN HABITAT (2004) quotes Deneiger and Minten (1996) that in their study of informal settlement in Mexico City, they stated that there was empirical evidence that urban poor are related to

high levels of devegetation. This is what has been happening in Nyalenda since 1972, when rapid expansion started taking place (Figure 21). As a result, many indigenous vegetation species like *Markhamia, Euphorbia, Cactus, Balanitie, Albizia* and many other species have disappeared through harvesting for domestic use, construction or over grazing. Wetlands were also invaded, drained and vegetation like reeds, papyrus and elephant grass harvested for immediate needs.

The Municipal Council of Kisumu, Director of Environment agreed with these findings by saying; "Most vegetation is cleared to get space to accommodate the ever increasing human population in Nyalenda, hence the interference with vegetation cover." Records in the office of Municipal Physical Planner indicate that farmers and fishermen formally inhabited Nyalenda informal settlement until 1972 when the settlement's boundaries were expanded due to increasing population, a view shared by Ali and Suleiman (2006) that expansion of informal settlements has been a major cause of loss of vegetation cover and catchment areas, a phenomenon that has led to serious environmental degradation. Reports from both authorities are in agreement with the findings of this study because of similar study area and target population. KENSUP, (2005) noted that the Nyalenda informal settlement is a typical rural setup caught up in urban expansion. This is supported by the revelations in this study that the Nyalenda residents were peasant farmers and fishermen. In relation to environmental conditions, Hurskainen (2004), while studying informal settlements in Voi, Kenya, stated that poor environmental conditions led to diminished vegetation cover and polluted water bodies, which connected to other issues, have caused bad sanitation and spread of diseases in Voi. In Nyalenda the depletion of vegetation cover led to increased run off carrying pollutants into the water bodies. In Figure 19, respondents (76%) confirmed the declining vegetation cover and in Figure 9, 30% of respondents stated that water pollution and poor sanitation are major causes of environmental related diseases.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The issues of poor sanitation and polluted water resources are the main problems in Nyalenda informal settlement as the increase in population and changing consumption patterns have now threatened the environment and natural resources through accumulation of solid wastes and lack of drainage for sewage generated. Majority of Nyalenda residents rely on unprotected wells that are subject to high chances of contamination due to frequent raptures of pit latrines and the high water table. As a direct consequence, a high prevalence of water and sanitation related diseases, like diarrhoea, typhoid and amoebiasis, just to mention a few, have become prevalent in the area. Sewage disposal remains a major problem and black cotton soil, in parts of Nyalenda, affect drainage and pit latrine construction. Hence, it is evident to conclude that the unplanned growth of Nyalenda informal settlement has, effectively, led to higher occurrence and morbidity of environmental related diseases as highlighted in the study.

Presence of feacal coliform (FC) or *E.coli* bacteria colonies (Plate 4), found in well and stream water samples is strong evidence that sewage is present, therefore, a greater potential for pathogenic organisms existing. Presence of *E.coli* is indicative that there is pollution, which can cause health problems. *E.coli* counts were above the recommended zero per 100ml of sample (0/100ml) in all water supplies; treated or untreated, piped or unpiped. This frequent occurrence of high *E.coli* counts in Nyalenda well waters, signify the need for an alternative water source or sanitary protection of the current sources. Growth of Nyalenda informal settlement has had a role to play in the bacteriological pollution of Wigwa stream as the *Salmonella* spp were detected, above recommended levels, in only those samples in Nyalenda "A" and "B". The well water, as well, is not safe for consumption as routine sample analysis may reveal that more wells have *Salmonella* Spp. Both samples from the wells and the stream tested negative of *V. cholerae*. Routine tests are still required to validate the outcome further. Despite the fact that there are several legislations that impact on the environment, like Environmental

Management Coordination Act (EMCA) 1999, there has not been proper land use planning in Nyalenda informal settlement. This has led to many indigenous vegetation species disappearing through domestic use, construction and drainage of the wetlands.

6.2 Recommendations

- To reduce the disease incidences in Nyalenda, wells have to be disinfected and flushed, the water must be tested again for *E.coli* and if none is detected, the "Boil water" order may be lifted.
- Mitigation should involve the lining of pit latrines and up grading the present ones into ventilated improved pits (VIP).
- Residents should avoid use of Wigwa stream water for domestic purposes and rely on the treated piped water from the Municipal water supply system..
- Since feacal coliform is excreted in feaces, enough and suitable toilet facilities should be provided to reduce chances of defecating in the open.
- High level of hygiene must be observed throughout since cholera disease is transmitted, primarily, by feacal-oral route through contaminated water.
- The Municipal Council of Kisumu (MCK) should manage the growth of Nyalenda informal settlement by undertaking elaborate planning to control human settlement activities. This will reduce rampant destruction of vegetation cover.
- Everybody is entitled to clean and healthy environment (EMCA, 1999) and the relevant authorities should enforce this piece of legislation to ensure there is no more destruction of biodiversity and provide proper sanitation in Nyalenda.

Suggestion for further Research

There is need to determine the level of bacteriological load in Nyalenda well waters, during both rainy and dry seasons, in relation to the studied organisms, herein, or otherwise. It would also be necessary to investigate the extent to which growth of Nyalenda informal settlement has impacted on quality of housing and indoor pollution.

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