ASSOCIATION OF MORBIDITY OF CHILDREN LESS THAN 5 YEARS OF AGE WITH THE UTILIZATION OF VEGETABLES PRODUCED USING SEWAGE WATER. CASE STUDY OF DANDORA- NAIROBI

BY

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2015

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I, ILHAM MUTAWAKIL ABDALLA, hereby declare that this is my original work and to the best of my knowledge has not been submitted to any other institution for any degree award.

Signature…………………………………….. Date……………………………………………

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ACRONYMS/ABBREVIATIONS

ADHD	Attention-deficit/ hyperactivity disorder
As	Arsenic
Br	Bromine
Ca	Calcium
CFU	Colony Forming Units
Cr	Chromium
Cu	Copper
FAO	Food and Agriculture Organization
Fe	Iron
HH	Household
K	Potassium
KDHS	Kenya Demographic and Health Survey
KNH/UON ERC	Kenyatta Hospital/University of Nairobi Ethics Review Committee
Mn	Manganese
Ni	Nickel
NRR	Non-Response Rate
OBC	Original Broth Culture
Pb	Lead
rpm	Revolutions Per Minute
SIN	Subject Identification Number
SPSS	Statistical Package for Social Sciences
TXRF	Total X-ray Fluorescence Spectrophotometry
UA	Urban Agriculture
UNDP	United Nations Development Program
V	Vanadium
WHO	World Health Organization
Zn	Zinc
f	Frequency

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OPERATIONAL DEFINITIONS

Wastewater - This is water whose quality is compromised by anthropogenic influence, domestic liquid waste discharge, and waste from industries and/ or agriculture, and encompasses a wide range of potential contaminants and concentrations.

Sewage - This is wastewater that is contaminated with feces and urine. Sewage mainly refers to wastewater from sources including domestic, municipal, or industrial liquid waste products disposed of, usually via a pipe or sewer system.

Urban agriculture - is the practice of cultivating, processing, and distributing food in or around a village, town, or city. Urban agriculture can also involve animal husbandry, aquaculture, agroforestry, urban beekeeping, and horticulture. These activities occur in peri-urban areas as well.

Pathogenic microorganisms - Are agents that can produce disease. Typically the term is used to mean an infectious agent**.** A microorganism such as a virus, bacterium, prion, fungus or protozoan, which causes disease in its host, is widely known as a pathogenic microorganism.

Morbidity - This is a state of illness or disease.

ABSTRACT

Use of wastewater for growing vegetables has become a common practice among the Nairobi residents living in slum areas. Indeed, a good number of the city's residents ignorantly feed on these food crops grown in the sewer despite experts warning that they could have adverse effects on them. Farmers in Dandora have been seen to be using sewage water for irrigating vegetables especially within the slum area. This study aims at establishing the health risks paused by vegetables grown using sewage water, and nature of morbidity patterns among children less than 5 years of age. The study design was cross sectional and analytical in nature. Data collection was done through interviews and laboratory analysis. For the face-to-face interviews, questionnaires were administered among mothers who had children less than 5 years of age and consumed vegetables grown using sewage water. For laboratory analysis, sewage water, soil and vegetable samples were taken from gardens that irrigated with sewage water. These samples were analysed for the presence of bacteria, parasites and heavy metals. The study revealed that 78.8% of the households grew vegetables, while 85.3% sourced their water from sewerage and drainage systems for irrigation. 93.9% of these households did not treat the sewage water that was used for irrigation. The results on heavy metals, bacteria and parasites showed that although the water samples were not as heavily contaminated with metallic elements as the soil samples, both were contaminated with bacteria and parasites. The vegetables, the garden, the market and cooked ones at households presented no parasites and minimum exposure of metal elements in these leafy vegetables. Presence of bacteria was noted in fresh vegetables (from the garden and market) but the cooked vegetables showed no bacterial contamination. The study revealed that most common illness affecting the children less than five years of age was cough/ colds. There was an association between feeding children with vegetables grown using sewage water and diarrhea ($P= 0.575$; $\alpha= 0.01$) and cough/ cold ($P=0.360$; $\alpha= 0.01$). The study's conclusion was that there was a significant association between morbidity (Diarrhea and coughing/cold) of children less than five years of age and feeding of Sukuma wiki grown using sewage water in Dandora.

CHAPTER ONE: INTRODUCTION

1.1 Background

Wastewater is any water that has been adversely affected in quality by anthropogenic influence; and comprises liquid waste discharged from domestic residences, industries, commercial and/or agricultural activities (Tilley *et al*., 2011). It encompasses a wide range of potential contaminants and concentrations. Sewage is the part of wastewater that is contaminated with feces or urine, commonly referred to as wastewater (Metcalf & Eddy and McGraw 2003). Sewage then refers to wastewater from sources including domestic, municipal, or industrial liquid waste products disposed of usually via a pipe or sewer system. Wastewater or natural water supplies into which wastewater has been discharged, are likely to contain pathogenic organisms similar to those in the original human excreta. The four groups of pathogens potentially present in such wastes: include bacteria, viruses, protozoa and helminths (Feachem *et al.,* 1983, Rose 1986 and Shuval *et al.,* 1986).

The habit of using untreated wastewater for irrigation is widespread but has been largely ignored because the norm has always been that wastewater should be treated before use. Increasing water scarcity, lack of money for treatment and a clear willingness by farmers to use untreated wastewater have led to an uncontrolled development of wastewater use. The productive use of wastewater has also increased, with millions of small-scale farmers in urban and peri-urban areas of developing countries depending on wastewater or water sources polluted by wastewater to irrigate high-value edible crops for urban markets.

Urban agriculture (UA) is a common and increasingly important economic activity in many cities of the world. Closely linked with this type of production is the reuse of wastewater as an input for UA. Wastewater is used because it is a readily available resource in urban areas, has few costs associated with its use and can actually increase production, harvests and thus income (Mark Redwood 2004). Globally, urban farming is believed to produce roughly 20 per cent of the world's food supply, with half of this food being grown using waste water, according to a 2009 survey of 53 cities conducted by the International Water Management Institute. In sub-Saharan Africa, urban and peri-urban farmers who depend on wastewater to grow their crops produce 70–90 per cent of the perishable vegetables consumed in African cities.

The human waste and wastewater contains significant nutrients for crop production that not only reduce the need for chemical fertilisers, but also increase crop yields. Yet the health risks through microbial contamination, especially in foods consumed uncooked, are a reality. Concern for public health has been the most important constraint in the use of wastewater. Wastewater carries a wide spectrum of pathogenic organisms posing a risk to agricultural workers, crop handlers and consumers (Blumenthal *et al.,* 2001; Shuval *et al.,* 1989). High levels of nitrogen in wastewater may result in nitrate pollution of groundwater sources used for drinking, which could lead to adverse health effects. Accumulation of heavy metals in soils and their uptake by plants is another risk associated with wastewater irrigation (Khouri, Kalbermatten and Bartone 1994). Parasites and pathogens thrive in faeces, easily infecting those exposed through irrigation or consumption of unwashed produce. Among wastewater-related infections, diarrhoeal diseases are on top, causing deaths among children in the developing world. The problem is particularly acute in sub-Saharan Africa, where there are an estimated 1.2 billion incidence of diarrhoea a year, according to World Health Organisation, which lead to the deaths of some 770,000 among children less than five years old.

Domestic and industrial effluent together with domestic wastes in the urban watercourses of Nairobi are widely perceived as the causes of stench and disease, but not so for the thousands of urban farmers who have come to embrace the wastewater in urban farming. Such stocks of leafy vegetables, succulent oranges and large potatoes end up in grocery shops in the city. It is a blossoming market dominated by women from the informal settlements who take their produce to the city center to cash in on thousands of Nairobians who wish to buy groceries after leaving their place of work. Researchers analysed for microbial hazards in kales grown in Athi River, Ngong and Wangige, and those sold in markets in Kawangware, Kangemi and Githurai and the results from all these areas were the same. They indicated that vegetables on sale in the city are a major health hazard (The E.A. Medical Journal, 2011). The study however did not specify which pathogenic organisms are found at what specific stage of the supply chain for the vegetables. It does not matter whether one gets their daily fix of the vegetable from a roadside hawker or a supermarket or the high-end specialty stores, the risks are the same. The researchers tested the kales for coliforms, a broad class of bacteria found in the environment, including in human and animal waste, and returned positive results. Other organisms tested for were *E.coli*, a group of bacteria found in animal and human faeces, and implicated in causing stomach upsets, diarrhea, urinary and respiratory ailments, and associated with presence of salmonella bacterium, which can cause serious food poisoning. Faecal coliforms in water used on farms for irrigation and in the markets for washing the vegetables exceeded levels recommended by the World Health Organisation. Contamination by faeces or urine, originated from animals or human waste disposed into water sources used for irrigation and also from wrong use of manure. In some of Nairobi's vegetable-growing hubs, farmers were found to be using liquid slurry from sewers, which, apart from providing water to the crops, is also regarded to be "rich in nutrients". In Kibera, residents can be seen irrigating their Sukuma wiki planted in a soil-filled sack at their doorsteps, with water from the nearby sewers. Such planted vegetables, are usually ready in two weeks for harvesting, but their speedy growth and the lush inviting leaves are now the focus for scientific scrutiny.

1.2 Problem statement

Untreated sewage water contains organic and inorganic elements essential for plant growth but also contains pathogenic organisms and heavy metals, which maybe lethal for animals and humans if ingested at levels above permissible limits. In Dandora, there are reported health problems associated with bacteria, heavy metals and parasites suspected to be from sewage exposure. The actual implicated health hazards and their entry points in the food chain; whether in the farm postharvest or during transport till consumption, have not been demonstrated. Also the rate of such hazards as a source of morbidity for children less than 5 years of age has not been demonstrated.

1.3 Justification

Health risks have been reported in different communities, whose major etiologies are parasites, heavy metals and bacteria, associated with sewage water. Awareness of the health risks of using untreated sewage water for farming has not been created, and it is suspected that some farmers use the sewage unaware of the impact they cause. Despite the high content of nutrients in the sewer, research in other countries globally shows a high content of pathogenic organisms that pose a health hazard to the public. This study will determine at what stage in the food chain of vegetable production there are pathogenic organisms of health hazard to humans and whether they are related to the morbidity of children less than 5 years of age. The results of the study are expected to create awareness to the residents and health regulation agents.

1.4 Study Aim/ Purpose

To determine at what stage in the food chain are the health hazards present in vegetables grown using sewage water and determine their association to morbidities among children less than 5 years of age in Dandora, Nairobi.

1.5 Main Objective

To determine the relationship between morbidity for children less than 5 years old and quality of vegetables produced using sewage water and human waste in Dandora, Nairobi.

1.5.1 Specific Objectives

(a) To determine the socio-demographic and economic characteristics of households utilizing vegetables produced for consumption using sewage water.

(b) To determine the production and agricultural practices for vegetables produced using sewage water.

(c) To analyze hazards in the supply chain for vegetable produced using sewage water from production to consumption.

(d) To determine the association between children's morbidity and hazards in the vegetable supply chain.

1.6 Research Questions

Is there a relationship between morbidity in children less than 5 years in Dandora, Nairobi and hazards in the supply chain for vegetables produced using sewage water and human waste?

What are the socio-economic and socio-demographic factors of households consuming vegetables produced using sewage water?

Are there bacteria, parasites and heavy metal load in these vegetables in the supply chain?

1.7 Hypotheses

Use of untreated sewage water in production of vegetables creates hazards in the vegetable supply chain in Dandora, Nairobi.

The hazards in the vegetable supply chain in Dandora are responsible for morbidity among children less than 5 years of age in Dandora, Nairobi.

1.8 Assumption and Limitations

Some farmers may not be willing to participate in the study.

Resistance of farmers to stepping into their farms and revealing their production practices.

Some vegetables not being ready for harvest at the time of sample collection.

Bad weather conditions like rain that may hinder movement during sample collection.

1.9 Benefits of the Research

(a) Creation of awareness of hazards and risks associated to the use of untreated sewage water for vegetable production in urban areas

(b) Lead to development of appropriate management systems for vegetables produced from sewage water in their utilization for food.

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview of Urban Farming

Urban farming in low-income countries has gained importance gradually over the years. Low-income households in particular turn to urban agriculture for the production of food for household consumption or for sale to generate income. Statistics show that most urban farming is done by the extremely poor and vulnerable people who live below the absolute poverty line of KES 2,648 per person in a month (Ayaga, 2004).

There are three distinct types of urban farming. The first one involves farming in backyards, whereby individuals grow food or rear livestock around their own homestead. The second one involves farming in open spaces of land not belonging to those who use it. Poor urban households typically carry out this type of farming. This type of urban farming has experienced tremendous growth during the last two decades. Lastly, there is farming in areas that were formerly rural areas but have become part of the city due to the extension of the city boundaries. In Nairobi, this was the case in 1964 when the city area increased more than tenfold from 65 square kilometres to the present 690 (Mbogaine, 1998). There is limited provision of extension services to the farmers participating in urban agriculture (Ayaga, 2004).

The farming activities that take place include; cultivation of crops, animal husbandry, forestry and horticulture (Olima, 2004). The most commonly cultivated crops are: sukuma wiki (kales), tomatoes, cabbage and spinach (Hide *et al.,* 2001). Others include; maize, beans, cow peas, arrowroots, sweet potatoes and bananas among other crops. It has been estimated that about 50,000 bags of maize and 15,000 bags of beans are harvested in Nairobi County alone annually (Ayaga, 2004). These farming activities take place; along rivers and river valleys, beside railway lines, in idle spaces and parks, within backyards of residential areas, along roads and sometimes in the middle of roundabouts (Ayaga, 2004).

Majority of urban farmers use a single plot with an average size of 0.5 ha. Land ownership is varied with most farmers being squatters on government or privately owned land (Hide *et al.,* 2001). In a study conducted by Hide et al. 2001, it was determined that a wide variety of water sources are used with 56% from rivers and streams, while 36% use raw sewage water for irrigation of farms. The study also demonstrated that irrigation techniques vary with 39% of the farmers using furrows and basins to apply water to their farms (Hide *et al.,* 2001).

By and large farmers consider water as the biggest constraint in urban farming. Other significant constraints include; inadequate farm inputs, production losses through crop damage, theft and inadequate labor (Hide *et al.,* 2001).

Most urban dwellers practising urban agriculture assume it is illegal, but the County Government and Public Health Act indicate that urban farming can be practised under specific restrictions.

2.2 Hazards found in sewagewater for irrigation

2.2.1 Pathogenic microorganisms

Microbial pathogens that can likely be found in wastewater are divided into; viruses, pathogenic helminths and bacteria. Most of these microorganisms are enteric (faecal – oral route). This means that they are shed through host faeces, spread and contaminate the environment then gain entry into a new host by ingestion.

2.2.1.1 Viruses

Untreated wastewater possibly contains many viruses that can cause disease in humans. Viral loads are present in concentrations exceeding 10^3 - 10^4 virus particles/litre of wastewater. Viruses are more difficult to detect in wastewater than other pathogens. In addition, they are more infectious and they need relatively smaller doses to generate infection in a host than other pathogens.

Most viruses, like most pathogenic microorganisms in wastewater, are enteric. That is, they are transmitted through the faecal-oral route. In addition, the most frequently detected pathogenic viruses are enteroviruses. These include; the poliovirus types 1 & 2, enterovirus, multiple strains of echovirus and coxsackievirus (International nomenclature of Diseases 1983). These enteroviruses are capable of causing many diseases in the human host that include; upper respiratory infections, poliomyelitis, aseptic meningitis, acute gastroenteritis, myocarditis and viral exanthema, pericarditis, hepatitis and conjunctivitis (International nomenclature of Diseases 1983).

In addition to the above viruses other viruses, which have been identified in wastewater, are; rotaviruses, astroviruses, adenoviruses, caliciviruses and reoviruses. These viruses may cause several infections including; diarrhoea, conjunctivitis, acute gastroenteritis and respiratory tract infections (Cruz, 1990). Of all the enteric viruses, the rotavirus is the most infectious and is therefore considered a major health concern group if identified to be present in water (Gerba, 1996).

Small children, immuno-compromised individuals and the elderly are considered to be the most vulnerable among the population to infections from these viruses.

2.2.1.2 Bacteria

Of all the microbial pathogens found in water, bacteria are the most commonly found in wastewater. Most of these pathogenic bacteria are enteric in nature although non-enteric pathogenic bacteria have also been detected in wastewater (Fliermans, 1996).

Infections of the gastrointestinal tract are the most common diseases caused by pathogenic bacteria in wastewater. Examples include; cholera caused by *Vibrio cholera,* dysentery caused by Shigella species, and salmonellosis caused by salmonella species. Typhoid (caused by Salmonella typhi and and other salmonella species) has been traced to food crops irrigated with wastewater (Bryan, 1977). *Helicobacter pylori,* has been implicated in causing stomach ulcers and some cancers. Helicobacter, Arcobacter and campylobacter have been identified as the major causes of human acute enteritis (Wesley, 1996)

Non-enteric pathogenic bacteria transmit diseases that include; legionellosis (caused by Legionella species), melioidosis (caused by *Pseudomonas pseudomallei*) and a zoonotic disease called leptospirosis (caused by *Leptospira interrogans).* Contamination of food crops irrigated with wastewater by toxin producing microorganisms such as some strains of *Escherichia. coli*, *Staphylococcus aureus, Clostridium perfringens* and *Salmonella spp*. can cause outbreaks of food poisoning that are sometimes severe and widespread. *Mycobacterium ulcerans*, a pathogen responsible for causing ulcerous lesions on body extremities has been traced to contact with wastewater (Johnson, 1996)

Some opportunistic pathogenic bacteria are also present in wastewater. Opportunistic pathogens are pathogens that cause infection and disease under optimal conditions particularly in young children, immune-compromised individuals and the elderly. Some of these opportunistic pathogens present in wastewater are; Streptococcus, Aeromonas, Flavobacterium and Pseudomonas (Ashbolt, 1995). Several opportunistic pathogens as a result of being members of the natural microbial population, can increase rapidly in number if given adequate nutrients. Wastewater due to its high nutrient load affords these opportunistic microogranisms with optimal conditions for rapid growth, creating large numbers of these microorganisms, which increase the risk of developing infection.

2.2.1.3 Helminths

Helminths are intestinal parasites that are commonly tramsitted through the faecal-oral route. Some of these parasites may need an intermediate host to mature before being infectious to human beings. Helminths that are usually found in wastewater are; *Trichuris trichiura* (whip worm), *Necator americanus* and *Ancylostoma duodenale* (hook worm), *Strongloides stercoralis* and *Ascaris lumbricoides* (round worm).

Ascaris lumbricoides is estimated to infect about 25% of the world's human population (Ellis, 1993). Infection with *Ascaris lumbricoides* is affected by education standards, dietary and cultural habits, population density, degree of agricultural development and sanitation levels (Khuroo, 1996). *Ascaris lumbricoides* is endemic in countries in Africa, Asia (especially India) and Latin America. The greatest health risk of using untreated wastewater for irrigation in agriculture according to the World Health Organization is the intestinal nematodes (WHO, 1989). Where human faeces are used as manure for vegetable growing, infection levels by intestinal nematodes are particularly endemic (Khuroo, 1996). People below the age of 19 years have the highest prevalence of nematode infection, while individuals aged 30 years old and above have the least infection levels (Udonsi, 1996). Helminth infection is especially a problem for children under the age of 5 years and chronic infections begin at a young age (Udonsi, 1996). The physical and mental development of children is affected by chronic helminth infections that cause malnutrition (Khuroo, 1996). After embyronation, helminth eggs can remain infectious in the environment for a period of not less than 10 years (Khuroo, 1996). This implies that soil that has been contaminated with wastewater water or faecal matter can serve potentially as a long-term of the helminth parasite infection (WHO, 1989).

2.2.2 Heavy Metals found in Sewage Water

Heavy metals are defined as metallic elements that have a high atomic weight and cause damage to living things even at low concentrations, by accumulating along the food chain (EPA, 2000). The heavy metals of highest public concern are arsenic, lead, cadmium, asbestos, thallium, arsenic and mercury (WHO, 2011).

2.2.2.1 Arsenic

Arsenic in its elemental form is a silver-gray solid metalloid that occurs naturally. The elemental form, is rarely a cause of toxicity in humans (Kosnett, 2005). Arsenic is mainly used in wood preservation, manufacture of glass and in manufacture of drugs particularly for leukaemia. In addition arsenic is used in silicon-based computer chips and as a feed additive for pigs and poultry (Ellenhorn and Barceloux, 1988). Table 1 shows the minimum exposure limits allowed for arsenic according to WHO 2001.

Table 1: Minimum exposure limits for Arsenic

Source of exposure	Recommended exposure amount
Food and water	20 ug/day
Background air	< 0.1 ug/m3
Drinking water	< 5 ug/L
Food	< 10 ug/day
Arsenic in water	0.01mg/L or 10 ppb

(WHO, 2001)

There are several ways in which arsenic is absorbed into the body, including:

- Inorganic arsenic (As^{3+}) of which 80-90% is absorbed from the Intestine
- Organic arsenic mostly found in seafood and not well absorbed from the Intestine, and therefore not considered toxic in children
- Arsenic gas – by inhalation
- By skin absorption particularly because it is lipid soluble (Etzel, 2003)

Arsenic in the human body undergoes transformation from the pentavalent (As^{5+}), which is less toxic and absorbed well to the trivalent (As^{3+}) form, which is much, more toxic. Once absorbed in the body the distribution of arsenic in the tissues is uneven, with some tissues having higher affinity and higher concentrations (Ellenhorn, 1988).

The mechanism of toxicity of arsenic is that it induces Reactive Oxygen Species (ROS) and oxidative stress, binds to thiols, alters signal cascade, results in imbalance in antioxidant levels and triggers apoptosis and eventually cell death (Flora, 2008). Arsenic is excreted mainly through the kidneys.

70-180 mg of inorganic arsenic (2 mg/kg in children) can be fatal. Acute toxicity of arsenic is manifested through; constriction of the throat, difficulty in swallowing, garlic taste in the mouth, excessive thirst, severe intestinal pain, diarrhoea, vomiting, muscle cramps, cardiac arrhythmias, coma and/or death. Chronic toxicity of arsenic is manifested through; garlic breath, excessive perspiration, muscle weakness and tenderness, paraesthesia in both hands and feet, deviations in skin pigmentation, peripheral vascular disease, foot gangrene and/or skin, kidney, bladder cancer (Smith, 2000).

Nutritional aspects greatly influence arsenic metabolism in adults. Poor nutritional status is believed to result in greater susceptibility to arsenic toxicity. Scientists in Bangladesh stated that deficits in folate and cysteine might adversely impact arsenic metabolism in children (Hall, 2009). Results from research imply that better nutritional status could institute a vital approach for lowering the risk of arsenic-related disease in Bangladeshi children (Freeman, 2009).

2.2.2.2 Cadmium

This is a silvery crystalline metal. It is soft, bluish-white in colour and metallic. It occurs primarily in lead, zinc and copper ores. Its atomic number is 48 and it is insoluble in alkalis but soluble in acids. Cadmium wields a toxic effect on the kidney, the skeletal as well as the respiratory systems. It is known as a human carcinogen. Usually it exists in the environment at low levels.

Human activities have however greatly amplified those levels. Cadmium is capable of traveling extensive distances from the origin of emission by atmospheric transfer. Cadmium readily accumulates in several organisms, conspicuously molluscs and crustaceans. Lower concentrations are found in vegetables, cereals and starchy root tubers. Human exposure happens mostly from eating contaminated food, inhalation of tobacco smoke actively or passively plus inhalation by personnel in the non-ferrous metal manufacturing (WHO, 2011). However, only 5% of the cadmium in foods particularly grains, cereals and leafy vegetables is absorbed in the body (WHO, 2011). Cadmium has no known beneficial function in the human body. It is ferried in the blood bound to metallothionein. The highest concentrations of cadmium are found in the kidneys & liver. The biologic half-life of the element lasts between 25-30 years and the excretion from urine is slow (Waalkes, 2001).

The mechanism of cadmium intoxication is that it interacts with essential nutrients. It competes with absorption of zinc in the gastrointestinal tract through inhibiting zinc enzymes. Cadmium also reduces copper in liver & plasma. It binds to ferritin, and reduces haemoglobin-causing anaemia. Cadmium eventually deposits on bones and doesn't generate free oxygen radicals (Flora, 2008). Acute cadmium toxicity through ingestion exhibits some specific symptoms such as nausea, vomiting, abdominal pain, diarrhoea, salivation, tenesmus, and hemorrhagic gastroenteritis in the gastrointestinal tract. Other manifestations of acute toxicity include; hepatic necrosis, renal necrosis and/or cardiomyopathy (Waalkes, 2001). Chronic toxicity of cadmium is manifested as; Chronic obstructive lung disease (COPD), lung fibrosis (restrictive), proximal tubular necrosis, proteinuria, secretion of beta 2 microglobulin, osteomalacia & osteoporosis and hypertension. It can also cause lung, kidney, prostate and stomach cancers (Waalkes, 2001).

2.2.2.3 Thallium

Thallium is a chemical element with the atomic number 81. This soft, white-blue element is not found free in nature. Some of its most distinct properties are that it's colourless, tasteless and odourless. When thallium is exposed to air it is oxidized to form thallium oxide (Sullivan, 2001). The bioavailability of thallium in the body is almost 100%, which means the entire administered dose of thallium reaches the circulatory system unchanged. Its distribution in the body is mainly intracellularly through the renal system but smaller proportions also go through the heart and the liver. The half-life of thallium is 10-30 days (Sullivan, 2001).

The lethal oral dose for thallium is 6 – 40 mg/kg of body weight. It is therefore highly toxic. Gastrointestinal symptoms of thallium poisoning include; anorexia, vomiting, gastrointestinal bleeding and abdominal pain. Later symptoms of poisoning include; lens opacities, emotional changes, autonomic dysfunction, coma, renal failure, psychosis, fatigue, seizures, skin erythema, hallucinations, delirium, cardiotoxicity with arrhythmias, which is potentially fatal (Sullivan, 2001).

2.4 Health risks posed by the use of wastewater for irrigation

There are many benefits of wastewater use in agriculture. These include both economic and agronomic benefits. Water supply is increased when irrigating with wastewater, thus providing an alternative supply of water. In addition to conserving the natural resources, the fertilizer value of many wastewaters is also important (FAO 1992). It has been estimated that domestic sources of wastewater effluent could supply most if not all of the nitrogen and much of the phosphorus and potassium that are normally required for crop production. In addition, micronutrients and organic matter also provide additional benefits (FAO 1992).

In many schemes around the world, the major constraint to many of these wastewater project schemes is the public health concern. Wastewater, specially domestic wastewater, contains pathogens that can cause disease spread if not properly managed. Therefore, the prime objective of any wastewater project scheme is to either minimize or eliminate potential health risks (Pescod and Arar, 1988). The health hazards associated with the use of wastewater are mainly a health and safety problem for those working on the land or living nearby, where the water is in use. This may subsequently pose a risk of infecting humans or animals through consumption or handling of the foodstuff or through secondary human contamination by consuming foodstuffs from animals that use the area (WHO 1989).

The survival of pathogens in the soil and the crop surfaces presented by (WHO 1989) indicates that, all excreted pathogens can survive in the soil for sufficient length of time to pose potential risks to the farm workers. The survival for the pathogens on crop surfaces is for a shorter time than in the soil as they are less well protected from the harsh effects of sunlight and desiccation. Nevertheless, survival times can be long enough in some cases to pose potential risks to crop handlers and consumers, especially when survival times are longer than crop growing cycles as is often the case with vegetables. WHO, 1989 has also pointed out that when excreted pathogens enter an irrigated area within the irrigation water, and have the potential to remain infectious for a considerable period of time unless steps are taken to interrupt this infectious cycle.

2.5 The Agricultural Sanitation Gap

53% of sub-Saharan population is served with sanitation services while in South Central Asia, only 38% of the population is served with sanitation services. Access to sanitation in rural areas is much worse than in urban areas. 930 million people already live in slums, and the most population growth is expected to occur in urban areas (Glickman *et al.,* 2009).

Water and soil pollution from heavy metals in urban areas particularly those in the developing regions are as a consequence of poor disposal of industrial and urban wastes. This leads to the risk of contaminating food crops that may absorb heavy metals from the soil and polluted water. Studies indicate that different plant species have varied capacities to uptake and accumulate certain heavy metals (Carr *et al*., 2004; Emongor, 2007). In China, the use of contaminated industrial wastewater for crop production was associated with a 36% increase in hepatomegaly (enlarged liver), and a 100% increase in both cancer and congenital malformation. In Japan, Itai-itai disease, a bone and kidney disorder, which was associated with chronic cadmium pollution of paddy water coming from the Jizu River (Kakar *et al.,* 2006).

A study conducted in 2001 at Pension farm (near Harare)-Zimbabwe to determine the effect of long term (>30 yrs) application of sewage sludge and effluent on Zn and Cu accumulation in top soil, uptake of these metals by lettuce and mustard rape and dry matter yield. Application of sewage sludge/effluent significantly ($p<0.001$) increased total Zn (13.7-1563.9 mg kg^{-1}) and Cu (2.5-133.3 mg kg^{-1}) in the topsoil, compared to the control. Sewage sludge addition significantly ($p<0.001$) increased Zn uptake by both test crops, while Cu uptake was significant in the first crop of lettuce and the second crop of mustard rape. It was concluded that long-term addition of sewage sludge to soil at Pension farm had increased the concentration of Zn and Cu in topsoil to levels that posed environmental concern. The consumption of leafy vegetables produced on these soils posed a health risk to poor communities that resided around the study site, especially children, through possible Zn toxicity (Bangira C.*et al.,* 2004).

A study on the health impact of utilization of raw domestic sewage for vegetable farming in the suburbs of Asmara, Eritrea, (Srikanth R and Naik D 2004) showed heavy contamination of vegetables by fecal coliforms and Giardia cysts as well as other pathogenic bacteria such as Shigella and Salmonella. Dietary intake of raw greens (lettuce, cabbage) grown on the raw sewage appeared to cause giardiasis, amebiasis, and diarrhea in the farming community, as well as in the surrounding area. Comparison of hospital data from the affected area with data from other areas of Eritrea indicated that agriculture use of untreated wastewater was the major cause of the increase in giardiasis and other gastrointestinal diseases especially in children.

2.6 Gaps in Knowledge

A lot of research has been done to prove that YES there are health hazards in utilizing vegetables grown using sewage water and human waste, but there is still no information regarding at what particular stages (pre-harvest, post-harvest and consumption) the hazards are carried along.

There is also no information relating whether these health hazards may contribute to the morbidity of children less than 5 years of age.

CHAPTER THREE: STUDY DESIGN AND METHODOLOGY

3.1 Study Setting and Population

3.1.1 Study Area

Dandora is an Eastern suburb in Nairobi Kenya. It is part of the Embakasi division. Dandora has an estimated population of 110,164 and has a land area of 4square kilometers with approximately 27,541 persons per square kilometre. Dandora is located east of the city in Embakasi Division and borders Kasarani Division to the North, a division that comprises poor neighbourhood such as Korogocho and Kariobangi. The three neighbourhoods of Dandora, Kairobangi and Korogocho are estimated to host over a quarter of a million residents. The Dandora dumpsite is an unrestricted dumpsite and is located 7.5 kilometres from Nairobi Central Business District, in an area surrounded by low-income residential estates. In particular, the dumpsite is adjacent to Korogocho, Dandora and Kariobangi estates, which together form a network of residential housing units for over 750 000 people. However, the study was restricted to Dandora phase two due to its high population density, proximity to the dumpsite and the channeling of the sewage system around the area as seen in the Appendix III.

3.2 Study Population and Sampling Frame

With the new constitution, Dandora has been divided into four wards with a total population of approximately 150,000 people. Respondents, who were mothers with a child or children less than 5 years of age, from a section of Dandora Phase II were subjected with the questionnaires. A street map was used as a frame for a door-to-door survey. Although it did not show individual houses, streets were selected from the map, followed by purposive selection of houses for questioning. Purposive sampling was also used to select kitchen gardens that grew vegetables using sewage water. Two kitchen gardens were randomly selected from such gardens.

3.3 Study Design

The study was both cross-sectional and descriptive; with analytical components that were experimental in design. The descriptive component, involved use of questionnaires administered to respondents who were both consumers and producers of the vegetables produced by sewage water, and those who did not consume the vegetables produced by sewage water. The study also involved analysis of vegetable samples from different stages of the vegetable supply chain. The different stages at which the vegetables were acquired for analysis were the gardens in which these vegetables were grown, the nearby market where the vegetables were sold and at households where the vegetables were prepared for consumption. Finally sewage water used for irrigation and the soil samples were taken to the laboratory for analysis. The samples were analysed for bacteria, parasites and heavy metals as hazards and risk factors in the vegetable supply chain. An association between morbidity and hazards and the risk factors was then computed.

3.3.1 Sample Size Calculation

In this study, the sample units included households and children less than 5 years of age. For estimation of the sample size, a 45.3% prevalence of diarrheal disease in Nairobi for children less than 5 years of age (KDHS 2008-09) was used as an indicator for morbidity. The minimum number of study subjects was estimated using minimum sample size determination using Fischer's formula (Fischer, 1948).

$$n = \frac{z^2 . pq}{d^2}$$

Where;

n is the desired population

z is the critical value based on the desired confidence level (e.g., z = 1.96 for 95% confidence level)

q is the estimated value of proportion of households not affected by sewage water. **(1-p)**

p is the estimated value of the proportion. In this study, p is the proportion of households with children less than 5years of age affected by diarrheal diseases, which is 45.3%.

d is the expected observed difference at 0.11 significance

Hence;

$$n = \frac{(1.96)^2 \times 0.453 \times 0.547}{0.11^2} = \mathbf{78.6}$$

Considering a non-response rate (NRR) of 5%

Total sample size (factoring NNR) = the obtained sample size

(1-non-response)

Therefore;

N = **n / (1-0.05)**

N = 78.6/0.95

N = 82.7 (approx. 83)

Accordingly, 83 households in Dandora with children less than 5 years were used in this study.

3.3.2 Sampling Procedure

Purposive sampling was used to select respondent's houses. A street map was used for the door-to-door survey of the selected study area of Dandora Phase II. For the kitchen gardens, purposive sampling was also used to choose gardens that used sewage water for irrigation of the vegetables.

3.3.2.1 Inclusion Criteria

All selected households were identified on the street map in the area of study. Only samples from vegetables produced using sewage water were taken to the laboratory for analysis. Households with children less than 5 years of age and those that accept to sign the consent form were also included in the study.

3.3.2.2 Exclusion Criteria

Households that had children less than 5 years with chronic illnesses such as asthma were excluded in the study. Vegetables not grown using sewage water were also excluded in the study. Households that refused to sign the consent form were also excluded from the study.

3.4 Research Tools and Equipment

3.4.1 Questionnaires

Questionnaires were subjected to mothers who had children less than 5 years of age. These were used to collect data from households to measure the socio-economic and socio-demographic status for those who consumed the vegetables, and document how they prepared these vegetables. Morbidity factors experienced by children less than five years old from these households were also measured. The questionnaire tool is as in Appendix II.

3.4.2 Laboratory analysis

The vegetable, soil and sewage water samples taken from the field were analysed for total viable counts of bacterial pathogens including *Escherichia coli* and *Salmonella* species.

The samples were also examined for the presence of parasites with the help of the microscope using the Kato-Katz procedure.

Presence of heavy metals was analysed in the samples using the solid digested TXRF analysis procedure with the use of a atomic spectrophotometer.

3.5 Recruitment and Training of Research Assistants

3.5.1 Recruitment of Research Assistant

Two research assistants were recruited, one of them meeting the following requirements: Over 18 years of age, a resident of the Dandora area for at least five years and understood the area well. Must have taken part in vegetable farming using sewage water or sells vegetables from the sewer farms, and was willing to be a research assistant in the study.

The second research assistant met the following requirements: At least had medical or environmental background in his/her education, had good writing and communication skills to help through the questionnaires with talking to the residents, and was willing to take part in the study.

3.5.2 Training of Research Assistant

This was done one month before start of the project. The research assistants were trained on ethical issues pertaining to research, such as consent from the participants which was key to obtaining data, courtesy while talking to participants, the language to use, how to react from unwilling members of the community, integrity and confidentiality. They were also trained on how to aseptically collect data from the vegetables farms, the market places, at the homes, and their transportation to the laboratory for analysis.

3.6 Pretesting of Research Tools

A pilot test was done three weeks prior to commencing the research. A section of the area of study in Dandora was used for pretesting of the questionnaire as a research tool. The research assistants pretested the questionnaire with a few residents in the area. The laboratory equipment, including the microscope, the incubator and spectrophotometer were calibrated prior to commencement of the laboratory analysis.

3.7 Research methodologies

3.7.1 Sample Collection

Samples were collected in form of sewage water samples, soil sample,s and also vegetable samples at the garden, at the market and cooked vegetables for laboratory analysis. Sewage water was collected where the water was directly irrigated to the farms. The soil samples were also representatively collected from different parts of the same garden to ensure the sample was representative. Both the sewage water sample and the soil samples were transported in sterile plastic bottles. The leafy vegetables were collected from the gardens, from the market and also obtained cooked from one of the households. These vegetables were carried in individual zip log bags. Each of the samples was collected in duplicates. All these samples were then transported to the laboratory for analysis.

3.7.2 Laboratory Analysis

3.7.2.1 Detection of parasites

Samples for analysis were put in clean containers and zip logs, and transported to University of Nairobi College of Agriculture and Veterinary Science for Laboratory analysis. All the samples were processed in duplicates and examined microscopically for any developmental stages of parasites. For the sewerage water samples, each container had about 40ml and was divided into equal volumes of 20ml, and put into 2 centrifuge tubes. These were centrifuged at 2000 rpm for 3 minutes. After centrifugation, the supernatant was poured out and the deposits collected. The sediment was then again re-suspended and a drop of the sediment was put on a clean microscope slide, covered with a cover slip and examined under the microscope starting with low power then high power objective lenses. The sewage water was checked for larvae, trophozoites and parasite eggs.

The soil samples were processed just like the stool samples. The soil samples were mixed with about 10 ml of 0.85% normal saline using the motor and pestle, and then strained through four layered wet gauze roll onto 2 centrifuged tubes and then centrifuged at 2000 rpm for 3 minutes. The supernatant was then discarded and the deposit re-suspended in saline and examined under the microscope.

For the vegetable samples, all three samples namely: the raw vegetables from the farms, from the market and the cooked vegetables were subjected to the same procedure as for the soil samples above. The samples were first mixed with about 10ml of 0.85% normal saline using a pestle and motor and then strained through wet gauze onto the centrifuge tubes. These were then centrifuged at 2000 rpm for 3 minute. The supernatant was discarded and the deposit re-suspended in saline and examined under a microscope.

In all samples 50-100 fields were examined.

3.7.2.2 Quantitative identification of Bacteria

The specimens were collected in sterile containers and zip logs, and taken to the laboratory for assessment in less than 6 hours of collection. At the laboratory, the specimens were analyzed according to Monica Cheesbrough Lab Practice in Tropical countries. The sewage water samples were used as received in the laboratory. The soil and all the vegetable samples were emulsified with 10 ml of 0.85% normal saline using a pestle and mortar. Then 10mls of all the samples of the original fluid, containing bacteria, were placed in tubes and labeled OBC. A series of 9ml dilution tubes of saline solution were placed in 5 tubes, and labeled 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5}. The OBC tube was shaken and swirled to allow the contents in the tube to mix thoroughly. A tenth of the OBC dilution was transferred to the 10^{-1} tube. The 10^{-1} tube was shaken and a tenth of the dilution transferred to the next tube. This transfer was done from tube to tube until the tube labeled 10^{-5}. From the ranges of dilutions, an inoculum of 0.1ml from each dilution was placed on the surface of an agar plate. The inoculum was spread rapidly over the entire agar surface using a flame-sterilized nichrome wire bent in a L-shape. Nutrient agar was used for viable counting method. The plates were labeled similar to the dilution factors on the tubes to minimize confusion. The plates were incubated for up to 48 hours at 37^0C. After incubation, the plates were removed from the incubator and the colonies read. The colony counting was an average of two plates inoculated with the selected dilution for greater accuracy. The colonies were counted using a manual counter.

3.7.2.3 Heavy Metals

Samples were collected from both sewage water, soil sediments and vegetable leaves. The sewage water samples and the soil samples were collected in clean containers. The vegetable samples were collected in clean zip log bags. All the individual samples were collected in duplicates and from different localities of the same area to ensure that they are representative of the study area. The samples were transported to the laboratory within 6 hours of sample collection time in order to ensure viability, where they underwent analysis using the sample analysis for solid digested TXRF analysis. The procedure undertook 3 steps in order to analyse the samples, including:

Step1: Sample digestion

About 10g of the sample was weighed in to a digestion vessel and 2.5mLs and 7.5mLs of concentrated HNO_3& HCL added respectively. The instrument was set at the temperature of 200^o and sample was left to digest for 30 minutes. The digest was transferred into a clean container and toped up to 50mLs with double distilled water.

Step2: Adding internal standard and spiking on the carrier

10mL of each sample was pipetted into a clean vial. 10µL of 1000ppm Gallium (or any std) stock solution (as internal standard) was added resulting into a concentration of 1ppm Ga in sample (Concentration of internal standard varies with concentration of samples). The specimen was homogenized by use of a vortex mixer for a minute. 10µL of sample specimen was pipetted using a micro-pipette onto a clean quartz carrier. The carrier was then dried in an oven or hot plate to evaporate the liquid.

Step 3: Sample spectrum acquisition and quantitative analysis

A **S2 PICOFOX TXRF Spectrometer** was used to acquire sample spectrum (sample irradiated for between 300 - 1000 seconds using a 50kV and a current of 1000µA). The measured spectrum was then evaluated using S2 PICOFOX software on the basis of the chosen elements. The same software (S2 PICOFOX) was used to determine concentration of elements. The calculation of element concentrations was based on the net intensities of the element peaks as per the following formula;

$$Cis = \frac{Nx / Sx}{Nis / Sis} xCis$$

Where,

Cx ---- Concentration of the analyte

Cis ---- Concentration of the internal standard

Nx----- Net intensity of the analyte

Nis----- Net intensity of the internal standard

Sx------ Relative sensitivity of analyte

Sis------Relative sensitivity of internal standard

3.8 Data Quality

All analysed samples and households with children less than 5 years of age were assigned a subject identification number (SID). All data entered into the study databases were identified and only associated with a SID in password-protected files. The study maintained a double entry system for the data. Sample collection was done in duplicates and transported to the laboratory in sterile containers in an icebox to ensure viability of the samples. Data was analysed using SPSS package to analyse the quantitative data of the study.

3.9 Ethical Considerations

Before commencement of the study, ethical clearance was sought from both the Board of Post Graduate studies here at the University of Nairobi and also from the KNH/UON ERC Board which reviewed biomedical research in order to help safeguard the dignity, rights, safety and well being of all actual or potential research participants. The Board also gave comments on how to go about with the study and allowed the study to continue as per their guidance. Consent was also obtained from the Area Chief. A consent form was provided to each of the respondents of the study, namely the mothers on the day of data collection.

3.10 Data Entry, Cleaning and Analysis

Data editing was done during and after data collection exercise. The primary data was entered into the Statistical Package for Social Sciences (SPSS). Data was then cleaned in order to remove any outliers so that the data lied in a normal distribution curve. Data was then analysed using Kendall tau-b correlation to correlate morbidity and contaminated vegetable consumption. Frequency distributions were used to determine the socio-economic and socio-demographic characteristics of individuals utilizing vegetables produced using sewage water. Student's t distribution at 95% confidence interval was used for agricultural practices characterization. The regression equation was to correlate hazards found in the vegetable produced using sewage water at the garden, at the markets and during consumption with morbidity of children less than 5 years of age.

Graphs were drawn using the Microsoft Excel 2010.

3.11 Data Dissemination Plan

After the data was analysed, it was presented in a simplified format in form of simple bar graphs and pie charts on flip charts. These flip charts were presented to the local community in a public baraza organized on a specified date and venue, in consultation with the local community leaders.

CHAPTER FOUR: RESULTS

4.1 Introduction

The chapter presents results from the study. The results are based on the specific objectives of the study and are founded on analysis of data from the total of 83 respondents, who are mothers with a child or children less than 5 years of age. The results also present findings from the kitchen gardens that were taken to the respective laboratories for analysis.

4.2 Socio demographic and economic data

4.2.1 Parents'/Respondents' characteristics

Table 2 shows the socio- demographic and socio economic characteristics of the parents and children less than 5 years of age from the family interviewed. The table gives a summary of the 83 respondents/households that were interviewed; most respondents (62.4%) were aged between 21-30 years, 59.0% of them were married with (45.8%) indicating completion of primary school level of education and 72.3% recorded had a form of employment. consequently the study examined demographic characteristics of children under 5 years from studied households, 54.2% of these children were male, while 45.8% on the other hand were female. 33.7% of these children were aged less than one year (12 months), 24.1% under the age group 12 – 24 years, and 10.8% under the age group 25 – 36 months, while the eldest group of children more than 36 months old, represented 31.4% of the study children.

Table 2: Socio demographic and socio economic characteristics of the respondents

Socio-demographic characteristics	n	%
Age (Years)		
< 21yrs	8	9.8
21-30yrs	52	62.4
31-40yrs	21	25.7
>40yrs	2	2.1
Marital status		
Single	18	21.7
Married	49	59.0
Separated	3	3.6
Divorced	4	4.8
Widowed	9	10.9

Table 2 continued

Socio-demographic characteristics	n	%
Child's Gender		
Male	45	54.2
Female	38	45.8
Child's Age		
less than 1 year	28	33.7
12 - 24 months	20	24.1
25 - 36 months	9	10.8
More than 36 months	26	31.4
Education levels		
Completed primary	38	45.8
Dropped out from primary	25	30.1
Completed secondary	12	14.5
Dropped out from secondary	8	9.6
Sources of income		
Employment	60	72.3
Labour	17	20.5
Child care	6	7.2

4.3 Production and Agricultural Practices

4.3.1 Growing of Vegetables by the Respondents

As shown in Table 3, majority of the households 90.4% participating in the study were small-scale farmers with small vegetable gardens. 45.8% grew the vegetables for both domestic use and selling purposes. 34.9% of these were purposely growing the vegetables for their domestic use only, while 9.6% of the women grew the vegetables for selling purposes. However, some of the women who were involved in the study did not practice vegetable growing, representing 9.6% of the respondents.

Table 3: Household's involved in growing vegetables

Respondents' practice in growing of vegetables			Purpose of growing			Total
			Home consumption	Sale	Both	
Growing of vegetables	Yes	n	29	8	38	75
		%	34.9%	9.6%	45.8%	90.4%
	No	n	0	0	0	8
		%	0%	0%	0%	9.6%
Total		n	29	8	38	83
		%	34.9%	9.6%	45.8%	100.0%

4.3.2 Sources of water for vegetables

Findings as presented in Table 4 reveal that out of the 75 respondents who grew vegetables in their farms/garden, 85.3% used water from sewers and drainage systems. 14.7% of the women on the other hand used rainwater and gutters for watering the vegetables. Table 5 also revealed that, majority of the women (93.3%) with vegetable gardens did not treat the water before using it for watering the vegetables whereas only 6.7% of the women who grew vegetables were found to have been treating the water for irrigation. The findings as well illustrated that all the respondents who used rainwater and gutters did not treat the water before the use, whereas only 5 out of the 59 who used water from sewers and drainage systems treated the water before use.

Table 4: Irrigation water sources and treatment

			Water treatment		Total
			Yes	No	
Source of Water	Rain water and gutters	n	0	11	11
		%	0%	14.7%	14.7%
	Water from sewers and drainage systems	n	5	59	64
		%	6.7%	78.6%	85.3%

Total	n	5	70	75
	%	6.7%	93.3%	100.0%

4.3.3 Reasons for not treating water

This Research also sought to establish the factors contributing to the poor hygiene in handling water for irrigation. This was necessary as the majority of the respondents (93.3%, n=70) reported not treating wastewater for irrigation. The major reason reported for not treating wastewater was lack of information, where the respondents reported that they did not see the importance of treating the water. The respondents also reported that they were not informed on the water treatment/ purification procedures, and could not undertake the activity. Further investigation was undertaken seeking to establish the reason as to why they never treated the water. Figure 1 indicates the documented responses. From the figure, it is clear that, the majority (70.4%) of those who never treated wastewater reported that it is expensive and costly for them to treat wastewater for irrigating the small vegetable gardens they had for their vegetables. They also reported that they had no funds for treating the wastewater alongside other household requirements. 48.1% also reported that they used sewage water, which had nutrients and fertilizers, for their vegetables, and thus did not need to treat the wastewater. From the Figure as well, 25.9% of those who never treated water for irrigation reported that they did not treat the wastewater since the vegetables would be washed and cooked to kill the germs and bacteria that would be present in the vegetables as a result of wastewater. 11.1% of the respondents felt that the process takes a lot of time, which they never had, as they had some other duties to be undertaken ahead of the days after watering their vegetables.

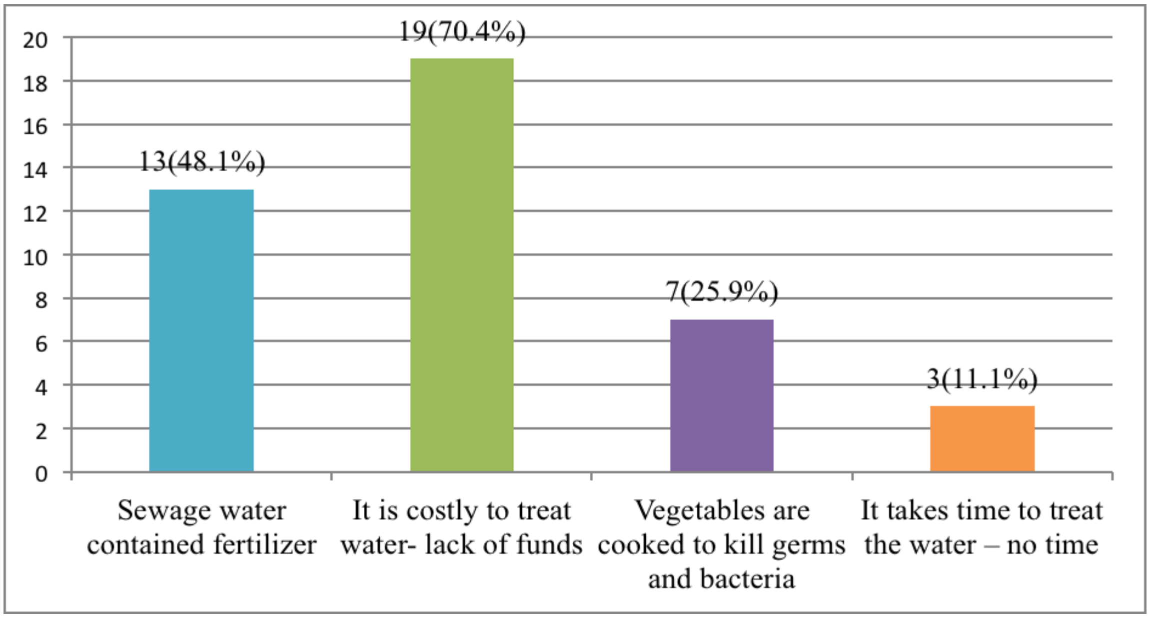

Figure 1: Reasons for not treating sewage water

Association between source of water and water treatment

The study also tested the association between the sources of water used for irrigation and the treatment of the wastewater. The study found no association between the sources of water and wastewater treatment before irrigating the vegetables with a correlation coefficient of -0.187 with p_value= 0.061 indicating no significant association.

4.4. Hazards in the supply chain for vegetables produced using sewage water

4.4.1 Washing vegetables before cooking

As shown in Table 5 below, the consumption of the vegetables in all the households was after the washing of the vegetables with clean water. However, only 4 respondents reported that they used the running water to wash the vegetables before cooking. This shows that, majority (95.2%) of the women studied washed their vegetables with stand still water that left the germs in the vegetables even after washing.

Table 5: Washing vegetables before cooking

	Yes	No	Total
Washing the vegetables before cooking	83(100%)	0(0%)	83(100%)
Washing under running water	4(4.8%)	79(95.2%)	83(100%)

4.4.2 Cooking methods used for Sukuma wiki

Findings as presented in Table 6 show that majority of the women, 73.4% used stewing method to prepare their vegetables. About 26.5% of the women studied used boiling method to prepare the vegetables. This shows that, only a few of the women used the boiling method in preparing the vegetables for their families. Majority (86.7%) of the respondents reported that they cooked the vegetables for less than 20 minutes while only about 13.3% of the respondents reported that they cooked the vegetables for a period of 20 to 30 minutes. This revealed that, despite them using poor cooking methods to prepare the vegetables, the preparation time was also minimal for cooking these vegetables. As for the 26.5% households that boiled their vegetables, only 10.8% cooked for more than 20 minutes, while the rest cooked for less than 20 minutes.

Table 6: Cooking method used to prepare Sukuma wiki

		Cooking period		Total
		< 20 min	20 – 30 min	
Cooking method	Boiling	13(15.7%)	9(10.8%)	22(26.5%)
	Stewing	59 (71.0%)	2(2.4%)	61(73.4%)
Total		72(86.7%)	11(13.3%)	83(100.0%)

4.4.3 Heavy metals in Sukuma wiki

Table 7 shows the distribution of the concentrations of the heavy metals in the samples in mg/kg (Wet Weight for vegetables and dry weight for soil samples) and mg / L for the water samples respectively.

The highest concentrated element in cooked Sukuma wiki was Potassium with 2992 mg/kg followed by Calcium with 1673mg/kg. Heavy metals like Lead and Arsenic had very low concentrations of less than 0.02mg/kg each. Nickel was also found to have concentrations of less than 0.02mg/kg. Other metals that presented low concentration included Valium and Chromium, with concentrations of less than 0.03 mg/kg each. Metals like Cadmium, Asbestos, Thallium and Mercury were undetectable. Accordingly, the analyzed samples had very low levels of Ca, Fe, Ni, Br and Pb and high levels of Cu, Zn and Ar.

Growing vegetables showed high concentrations of calcium (5043 mg/kg) followed by potassium (4072 mg/kg). Concentrations of Lead, Arsenic, Nickel and Copper were less than 0.02mg/kg each. Metals like Valium and Chromium had concentrations of less than 0.03 mg/kg each. Heavy metals like Cadmium, Asbestos, Thallium and Mercury also undetected. Accordingly growing vegetable samples exhibited very low concentrations.

The vegetable samples from the market were found to have high concentrations of calcium at 3384 mg/kg followed by potassium at 2475 mg/kg. The heavy metals like Lead and Arsenic had low concentrations of less than 0.02mg/kg each, and the same for Nickel and Bromine. Other metals found in low concentrations included Valium and Chromium, with concentrations of less than 0.03 mg/kg each.

The soil samples contained high concentrations of Iron at 74161 mg/kg followed by Manganese at 10505 mg/kg. Both Calcium and Potassium were also found in high concentrations of 3429mg/kg and 1572 mg/kg respectively. Lead was found in high levels of 78.8 mg/kg but Arsenic was less than 0.02 mg/kg. Metals like Cadmium, Asbestos, Thallium and Mercury were undetectable. Bromine was present in soil samples at less than 0.02 mg/kg.

The analysed water samples revealed high concentrations of Iron at 53.2 mg/L, followed by Calcium at 25.5mg/L and Potassium at 16.2 mg/L. Lead levels were very low at 0.076 mg/L and so was Arsenic at less than 0.02 mg/L. Metals like Cadmium, Asbestos, Thallium and Mercury were undetectable.

Table 7: Results of the analysis of Metal Elements

Element	Tolerable Upper Intake Levels, Elements	Cooked Vegetables	Growing Vegetables	Vegetables From the Market	Soil Samples	Water Samples
K	ND	2992 ± 136	4072 ± 229	2475 ± 121	1572 ± 105	16.2 ± 0.32
Ca	2500	1673 ± 122	5043 ± 232	3384 ± 123	3429 ± 172	25.5 ± 0.33
V	0.01	<0.03	<0.03	<0.03	794 ± 21	0.376 ± 0.024
Cr	0.011	<0.03	<0.03	<0.03	573 ± 16	0.290 ± 0.026
Mn	2	13.0 ± 0.8	18.8 ± 0.5	49.3 ± 1.0	10505 ± 655	6.84 ± 0.09
Fe	40	22.2 ± 1.7	106 ± 2	54.4 ± 1.6	74161 ± 990	53.2 ± 0.26
Ni	0.2	<0.02	<0.02	<0.02	19.5 ± 1.7	<0.02
Cu	1	1.39 ± 0.18	<0.02	1.08 ± 0.12	12.2 ± 1.1	0.092 ± 0.012
Zn	7	10.5 ± 0.5	8.41 ± 0.23	17.6 ± 0.9	300 ± 16	0.662 ± 0.016
As	0.0003	<0.02	<0.02	<0.02	<0.02	<0.02
Br	3	1.76 ± 0.17	0.656 ± 0.077	<0.02	<0.02	<0.02
Pb	0.24	<0.02	<0.02	<0.02	78.8 ± 2.3	0.076 ± 0.008

Concentration values in mg/kg [Wet Weight for vegetables and dry weight for soil samples] and mg/L for water samples.

4.4.4 Microbial content in Sukuma wiki

The study analysed coliforms counts per unit along vegetable production chain. The study found sewage water used for growing Sukuma week had 90 CFU/ml, soil had 125 CFU/g, and fresh Sukuma wiki from the samba recorded 12 CFU/g while those obtained from the market recorded 2 CFU/g. There was no bacterial colony forming units found in cooked Sukuma wiki.

Table 8: Microbial load in production chain.

Production chain	Water	Soil	Fresh produce from the farm	Fresh Sukuma wiki from the market	Cooked Sukuma week
Coliforms units/g		125	12	2	-
Coliform units/ml	90				

4.4.5 Presence of parasites in Sukuma wiki

Table 9 below shows the analyzed results for parasites from the vegetable samples. Both sewage water and soil samples analysed for parasites and bacteria showed no presence of trophozoites, cyst and adult worms. However, small amounts of larvae and ova were detected, whereas high microscopic counts of bacteria were also detected. Vegetable samples gotten from the gardens, market and the cooked samples showed no presence of both parasite and bacteria. The trophoziotes, cyst, larvae and ova were also absent.

Table 9: Parasites in sewage water, soil and the Sukuma wiki samples

Name of sample	Trophozoites	Cyst	Larvae	Ova	Adult worm	Bacteria
Sewerage water sample	0	0	+	+	0	+++
Soil sample	0	0	+	+	0	+++
Fresh Sukuma from garden	0	0	0	0	0	--
Fresh Sukuma from market	0	0	0	0	0	--
Cooked Sukuma	0	0	0		0	--

Footnote;

0 = none detected -- = none detected += Few detected +++ = Detected in high amounts

4.5 Morbidity among children consuming vegetables grown using sewage water

4.5.1 Children's illnesses in the last two weeks

The findings in Table 10 below indicate that, out of 83 households studied, 55.4% of them had a child who had been sick for the previous two weeks during the study period. The illness cases were usually referred to hospital for medication services, as reported by all families that had affected children.

Table 10: Children's illnesses in the last two weeks

Did the child fall sick in the last 2 weeks?	Frequency	Percent
Yes	46	55.4
No	37	44.6
Total	83	100

4.5.2 Most common illnesses suffered by children

Figure 2 shows the most commonly reported illness that children suffered from is coughing/cold. This was reported in 83.1% of the families studied. Malaria/ fever was second, reported by 43.4% of the families studied, followed by diarrhea which was reported by 41% of the families. The least was the intestinal warms illness reported to have been experienced in 13.3% of the families studied.

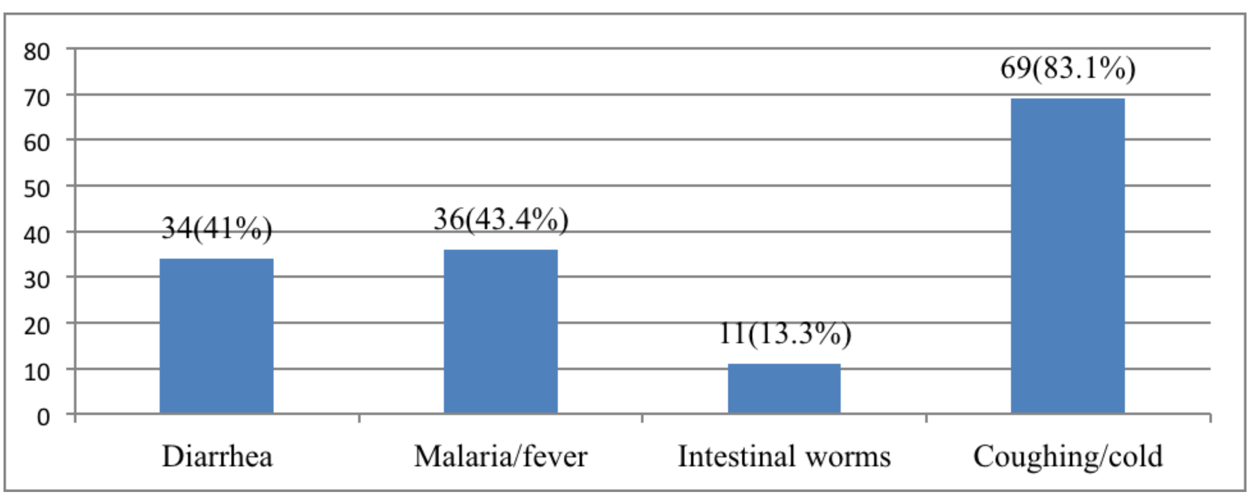

Figure 2: Most common illnesses among children

4.5.3 Diarrhoea episodes among children

Diarrhea episodes among children were measured according to measured stool frequency per day, reported by families. From figure 3, 47% of the respondents reported that whenever their children had greater than 3 lose stool per day, they would conclude presence of diarrhea in the children. On the other hand, 43% of the respondents reported cases of more than 4 stools as diarrhea per day. Only 10% of studied households considered cases of more than 5 stools per day as diarrhea in their children.

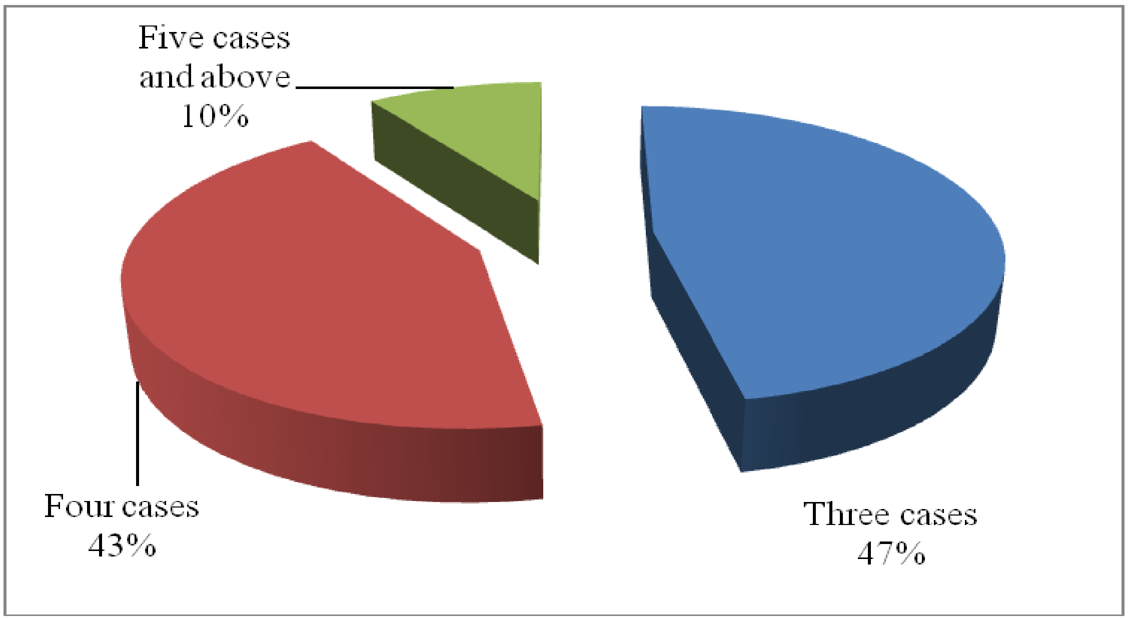

Figure 3: Stool frequencies as reported by respondents

4.6 Association between diarrhea episodes among children and feeding on sewage water vegetables

4.6.1 Association between diarrhea episodes and consumption of vegetables

From Table 11, there was an association between diarrhea episode and the feeding of vegetables grown using sewage water. The correlation value was found to be 0.575 with significance of 0.000 indicating that the association is statistically significance at α=0.01 between diarrhea episode and the feeding of vegetables grown using sewage water.

Coughing/cold was found to be associated to feeding of vegetables grown using sewage water. The correlation value was found to be 0.360 with significance of 0.0011 indicating that the association was statistically significance at α=0.01 between coughing/cold and the feeding of vegetables grown using sewage water.

Consequently, microbial hazards in vegetables and diarrhea episode were found to be associated. The correlation value was found to be 0.261 with significance of 0.000 indicating that the association is statistically significance at α=0.01 between microbial hazards in vegetables and diarrhea episode.

Table 11: Association between diarrhea episodes and consumption of vegetables

Associations	n	Kendall's tau_b correlation Coefficient	Sig. (2-tailed)
Feeding of vegetables grown using sewage water and Diarrhea episode	83	0.575	0.000
Feeding of vegetables grown using sewage water and coughing/ colds	83	0.36	0.001
Microbial hazards Diarrhea episode	83	0.261	0.005
Correlation is significant at the 0.01 level (2-tailed).			

4.6.4 Association between Coughing/ cold and Non-microbial hazards

From Table 12, there were slight associations between non-microbial hazards in vegetables and coughing/colds. The correlation values were found to be 0.077416 for potassium, -0.05178 for Calcium, 0.144459 for vanadium, -0.10076 for Manganese, 0.099055 for chromium, -0.09735 for iron, 0.144312 for nickel, 0.03928 for copper, 0.044404 for arsenic, -0.03416 for baron and 0.138335 for lead respectively. However, none of these correlations were found significant at α=0.05 for non-microbial hazards tested against coughing/cold.

Table 12: Association between Coughing/ cold and Non-microbial hazards

Correlations				
			Coughing/colds	Sig. (2-tailed)
Kendall's tau_b	Coughing/colds	n	correlations	.
	Non-microbial hazards	83	1	
	K	83	0.0774	0.3942
	Ca	83	-0.0518	0.5690
	V	83	0.1445	0.1277
	Mn	83	-0.1008	0.2666
	Cr	83	0.0991	0.2748
	Fe	83	-0.0974	0.2832
	Ni	83	0.1443	0.1116
	Cu	83	0.0393	0.6650
	Zn	83	0.0393	0.6650
	As	83	0.0444	0.6245
	Br	83	-0.0342	0.7065
	Pb	83	0.1383	0.1272
*	Correlation is significant at the 0.05 level (2-tailed).			

4.6.5 Association between children's morbidity and hazards in the vegetable supply chain

To determine the association between children morbidity and hazards in the vegetable supply chain, the researcher carried out binary logistic linear regression. The researcher considered the hazards present in cooked vegetables. These hazards included heavy metals, bacteria and parasites. Some scholars have argued that heavy metals such as manganese, copper, Zinc, iron, lead and chromium have adverse effects when consumed in excess in human body. Parasite was found not to exist in all samples and examined including cooked vegetables. According to the findings of this study, increased content of Ca, Cr, Mn, Fe, Ni, Zn, Br and Pb showed a potential increase in morbidity among the children of less than 5 years of age in Dandora. Increased concentration of K, V, Cu, and Ar were found to potentially reduce chances of disease among the children less than 5 years of age as shown in Table 13 below.

Increase in concentration of bacteria in vegetables was found to increase the chances of disease among the children less than 5 years of age in Dandora.

Parasites were not found to exist in all examined samples of cooked vegetables.

Table 13: Relative contribution of hazards to morbidity among children

	B	S.E.	Wald	df	Sig.	Exp(B)
K	-0.00339	0.003581565	0.89486351	1	0.344162737	0.996617672
Ca	0.004049	0.003933238	1.059749862	1	0.303272242	1.004057247
V	-32.4054	25.62276887	1.599497293	1	0.205974466	8.44306E-15
Mn	1.15629	0.535045143	4.670385756	1	0.030687034	3.178120829
Cr	13.16882	33.57907912	0.153799854	1	0.694930211	523774.4507
Fe	0.013529	0.268411327	0.002540397	1	0.959801762	1.013620487
Ni	57.68018	55.5002308	1.080099278	1	0.298675348	1.1225E+25
Cu	-4.42554	2.93769831	2.269434467	1	0.131948044	0.011967778
Zn	1.149173	0.964528141	1.419517247	1	0.233482878	3.155580714
Ar	-99.496	45.00423607	4.887701516	1	0.027048673	6.15779E-44
Br	1.498326	2.686728261	0.31100335	1	0.577065142	4.474192397

Pb	41.70398	52.34567105	0.634736359	1	0.42562329	1.29362E+18
Bacteria	0.177026	0.12798484	1.913193154	1	0.166608989	1.193662557
Constant	-21.9561	20.79536624	1.114744854	1	0.291052844	2.91E-10

Coefficient of determination

The contribution of bacteria and heavy metals to morbidity among the children of less than 5 years of age was found to be 0.183 (Obtained using binary logistic regression). Which means that the hazards could only explain 18.3% of possible variations of morbidity among the children of less than 5 years of age in Dandora?

CHAPTER FIVE: DISCUSSION

5.1 Introduction

This cross-sectional study reveals certain issues related to children less than 5 years of age with their consumption of vegetables grown using sewage water. The study aimed at generating data on the two principles in order to relate if there is an association.

5.2 Socio demographic and economic characteristics

Age and sex composition in a household are important demographic factors. According to KDHS survey (2008-09), the factors are vital in that, they are associated with welfare of the household. Households where women are the heads are poorer than households that are headed by men. This study is consistent with Ndunda et al (2012) findings, which showed a negative, and no insignificant impact between age and the adoption of risk-reduction measures in wastewater irrigation.

Education is a strong determinant of one's health practices and attitude (KDHS 2008-09). A study by Ndunda et al (2012), purport that education of the household head had a significant and positive impact on the adoption of the considered risk-reduction measures in wastewater irrigation. Consequently we may attribute the high level of lack of water treatment to low education qualification in the area.

5.3 Production and Agricultural practices for the vegetables grown using sewage water

Food safety is vital; farmers' bear responsibility to produce both nutritious and safe food. According to center for disease control and prevention, 1/3 of all significant multistate outbreaks of foodborne disease in the year 2011 were associated to fresh produce such as vegetables. This has health and economic implication to the individual households and the government. According to Hà Nội, (2008), there is need to assess the risk of chemical and biological contamination of water used for irrigation.

Several studies have attributed the use of wastewater to scarcity of fresh water and cost of treating water for irrigation especially in urban and peri-urban areas (Ndunda *et al*., 2012, Buechler and Devi, 2006; Drechsel et al., 2006). The findings of this study indicated that 78.6%

of the household studied grew vegetables in their small kitchen garden for domestic use and/or commercial purpose using water from sewerage and drainage systems with 93.3% of the household using untreated sewage water. This practice could be highly attributed to low education qualification, as most respondents were unaware of hazards associated with use of sewage water for irrigating vegetables.

5.4 Hazards present in the supply chain for the vegetables produced using sewage water

Hazards present in soil

Many studies have shown that sewage water irrigation has elevated the levels of heavy metals in receiving soils (Singh, K. *et al.,* 2004 and Mapanda, F. *et al.,* 2005). According to the findings of our study, several metals exceeded heavy metal limits in the soil as recommended by European standard union (EU, 2002), among the analyzed metallic content, Cr, Mn, Ni, and lead Cu exceed the limit while Zn and Pb were within the recommended quantities.

Hazards present in water

According to Davies *et al.,* (2002), within crop production, many practices require the use of water including irrigation, pesticide application, produce washing and cooling systems. The main risk associated with wastewater irrigation is infection with intestinal helminthes (Mara and CainCross 1989), which poses a health risk to the individuals and can be affected by diarrheal diseases. Non-microbial hazards such as Cr, Mn, Cu and Pb were found to exceed the limits while Ni and Zn were found to be within the limit according to Guideline for safe limits of heavy metals (FAO, 1985) and Indian standards (Awashthi 2000)

Hazards present in fresh Sukuma wiki

Hazards present in water and soil such as bacteria are sometimes acquired during harvesting period. According to Zander, A and Bunning, M. (2010), washing vegetables under running water does not completely kill or remove the microorganisms but it is an effective way of reducing the number of microorganisms present in the vegetables. The findings of this study confirms as majority washed Sukuma wiki before cooking but still hazards were found in cooked Sukuma wiki; the fresh vegetables showed presence of bacteria and heavy metals.

Accumulation of the bacteria and the parasites in the vegetable samples was either absent or below the levels provided by WHO 2006 and this rendered the Sukuma wiki safe for consumption.

Hazards present in cooked Sukuma wiki

Studies have shown, long term use of waste water, in cultivation of leafy and other vegetables, has resulted in accumulation of heavy metals in the soil and their transfer to the various vegetables under cultivation (Singh et al., 2004; Sharma et al., 2007; Marshall et al., 2007). This is consistent with reports of higher concentrations of heavy metals in vegetables from wastewater irrigated areas of Ludhiana city of Punjab by Kawatra and Bakhetia (2008). The analysed vegetables reviewed that Ca, V, Cr, Fe, Zn, As, Br, Pb & Mn concentration did not exceed the permissible limit except for Cu. These heavy metal concentrations are well below hazardous levels (Aljaloud, A. A. 2010 and Ramesh, M. 2003).

The vegetables when brought to the household and ready for consumption are to be thoroughly washed and cooked to the right temperatures to increase the chances of reducing the bacterial and parasite content if present in the vegetables.

5.5 Association between children's morbidity and hazards in the vegetables

Mara and Cain Cross (1989) noted that intestinal worms pose a major health concern for families that irrigate their farms using sewage water. Consequently intake of heavy metals has been observed to cause health threat especially when daily intake limit is exceeded (Guerra *et al*., 2011), European standards union (2002), and FAO (1985)). The finding of this study found that most heavy metals were below acceptable limit.

The study also found feeding on vegetables grown using sewage water was a significant cause of diarrhea and coughing/cold among children below 5 years of age. Further analysis reviewed that microbial organisms in Sukuma wiki analyzed were significant cause of diarrhea. Heavy metal were found to be associated with coughing/cold, however, this association was not statistically significant.

CHAPTER SIX: CONCLUSION AND RECOMENDATIONS

6.1 Conclusion

From the results of the study, we conclude that socio-economic characteristics of household especially education and income greatly impacted on production and utilization.

The study noted high association between education and economic status and Sukuma wiki production in Dandora. High number response perceived sewage water used for irrigation to contain fertilizers, consequently there was notion that bacteria and germs that were easily destroyed once the vegetables are cooked, treating waste water was termed as costly and time consuming.

We further conclude that supply chain is not independent of hazards causing morbidity in Dandora. However, there was variation from samples collected from soil, sewage water, fresh and cooked vegetables. The microbial organism reduced from soil to cooked Sukuma wiki; Bacterial and parasite were absent in properly prepared/cooked vegetables. However, this is dependent on cooking method applied by the household. Metallic elements were present at minimal concentrations in sewage water and the Sukuma wiki at all levels of production and high concentrations in soil samples.

Finally, we conclude that there is a significant association between morbidity of disease (Diarrhea and coughing/cold) and feeding of Sukuma wiki grown using sewage water in Dandora. Consequently, association between diarrhea and bacteria presence is significant. However the association between coughing/cold was slightly low and insignificant.

6.2 Recommendations

Based on the study findings and discussions, the study makes recommendations that;

1. An effort should be made through health facilities and community health workers to enlighten local vegetables producers on dangers and long-term effects of using untreated sewage water in vegetable production.
2. The government through ministry of water and sanitation to enhance sewage lines to avoid outburst of sewerage that acts as source of water to local vegetable farmers.

3. There is need to embrace and recognize urban farming by County Government where local farmers can practice safe crop production thus reducing risk associated with unhealthy production.

4. This study assessed vegetable intake based on one meal and one farm produce, another study could be carried to examine number of exact times and quantity consumed by household for effective comparison with recommended daily intake as well as hazards in other crops such as roots and stem tubes whose absorption of heavy metals is high.

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APPENDICES

Appendix I

Consent Information Sheet and Consent form

INFORMATION SHEET

Association of morbidity of children less than 5 years of age with the utilization of vegetables produced using sewage water. Case study of Dandora, Nairobi.

You are being invited to take part in a research study assessing the association of morbidity of children less than 5 years of age with the utilization of vegetables produced using sewage water.

The study aims to determine the health hazards that cause diarrheal related morbidities in children less than 5 years when utilizing vegetables grown using sewage water for farming. I am Ilham Mutawakil, the primary investigator from the University of Nairobi and my supervisors are Prof. S. K. Mbugua and Prof. E. G. Karuri both from the University of Nairobi.

In this study, you will be required to provide information on the source of vegetables you use and the method of preparation. You will also be required to make available information on your child's medical history.

The study will take between 10 to 12 minutes to complete. You may decide to stop participating in the study at any time. You have the right to demand that any data provided until that point be withdrawn/destroyed. Feel free to ask questions at any point. If you have any questions as a result of reading this information sheet, you should ask the investigator before the study begins.

This study poses no known risks to you. The study will benefit your community by creating awareness of the harmful effects of using untreated sewage for vegetable farming among the farmers and the residents. This study will also help in making policies safeguarding use of wastewater for urban farming. Your participation in this study is purely voluntary. There will be no compensation for participation.

The data collected will only be seen by members of University of Nairobi affiliated with the study, and will not be linked to any identifying information such as name, address or other personal details that you supplied. The data collected will be presented at conferences, academic presentations and in academic publications, however; only data averaged over many participants will be presented. Your individual data will not be identifiable.

Respondent Number: ______________________

CONSENT FORM

Association of morbidity of children less than 5 years of age with the utilization of vegetables produced using sewage water. Case study of Dandora, Nairobi.

Principal Investigator: Ilham Mutawakil
Telephone Number: 0723 906913
Email address: ilham.albakry@hotmail.com

Kindly tick where appropriate

1. I confirm that I have read and understood the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had the questions answered satisfactorily ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. ☐

3. I understand that individuals may look at relevant sections of my personal information and data collected during the study from University of Nairobi where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. ☐

4. I agree to take part in the above study. ☐

Signature of Respondent ……………………… Date.....................................

Signature of witness …………………………... Date …………………………

APPENDIX II

Questionnaire

Hello, my name is ______________________________. I am a student at the University of Nairobi studying MSC Applied Human Nutrition. In order to acquire information about morbidity of children under 5years in relation to utilization of vegetables produced using sewage water and human waste in Dandora, Nairobi. We are conducting a survey in this area and your household has been selected by chance from all households in this area.

The information you provide will be useful in determining the safety of the vegetables produced with sewage water. A copy of this report will be submitted to your community leader who may use it for planning of development projects in this area.

All information you give will be confidential. The information will be used to prepare general report but will not include any specific names. We encourage you to participate in this study and your cooperation will be highly appreciated.

If it is okay with you may we proceed to ask some questions related to food security and health of children in your household?

Respondent agreed to be interviewed __________________ 1 = Yes 2 = No

IDENTIFICATION

Questionnaire No. ________

Location____________________ Sub location______________________ Household No._____

Name of interviewer___________ Date of interview ______/___/________

Section A: Social economic and demographic Characteristics (Sub Objective 1) Q1 – 7

S/No	Relationship to HH head -codes-	Sex M=1 F=2	Age (Years)	Marital status -codes-	Education -codes-	Contribution to HH
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

RHHH	Marital Status	Education	Contribution to HH
1=HHH 2=Spouse 3=Son 4=Daughter 5=Grandson 6=Granddaughter 7=Relative 8=Parent 9=House girl 10=Gardener	1=Married 2=Separated 3=Widowed 4=Single 5=Divorced 6=N/A	1=College/University 2=Completed secondary 3=Completed primary 4=Dropped from primary 5=In primary 6=In secondary 7=Adult education 8= Illiterate 9 = N/A (Preschool)	1=Nothing 2=Money 3=Labour 4=Childcare 5=Savings

Section 2: Production and agricultural practices of vegetables produced using sewage water. (Sub objective 2)

8. Do you grow your own vegetables for domestic use?

1=yes 2=No

9. If yes to Q8, what is your source of water for watering the vegetables?

1. Rain water and gutters
2. Tap water
3. Water from vendors and distributors
4. Water from sewers and drainage systems

10. Do you treat the water before using it for watering the vegetables?

1=yes 2=No

11. If yes, which method of water treatment do you use?

1=Boiling 2=Chlorine 3=Sun treatment 4= filtering 5=others (specify)

12. If no, what is the reason? ____

13. Do you feed your children with the vegetables that you grow?

1=yes 2=No

14. Do you wash the vegetables before cooking them?

1=yes 2=No

15. If yes, do you wash under running water?

1=yes 2=No

16. What cooking method do you use to prepare the vegetables?

1. Boiling
2. Stewing
3. Consumed raw
4. Others (specify)

17. For how long do you cook the vegetables?

1. Less than 20 minutes
2. Between 20 – 30 minutes
3. Between 30 – 45 minutes
4. More than 45 minutes

Section 3: Child information (sub objective 4)

(Q18 – 23)

S/No	Sex 1=M 2=F	Date of birth (Verify from Clinic Card)	Age (Months)

24. What are the most common illnesses your children suffer most?

A. Diarrhea.................. ☐

B. Malaria/fever............ ☐

C. Intestinal worms... ☐

D. Scabies...................... ☐

E. Coughing/cold........... ☐

F. Any others (Specify)... ☐

25. Has the child suffered from any illnesses in the last two weeks?

1 = Yes 2 = No

26. If yes, where did the child seek medical attention?

1= Hospital 2 = Traditional Healer 3 = Pharmacy 4 = Stayed home.

27. Does the child have a medical card?

1 = Yes 2 = No

28. What kind of stools would cause you to think your child has diarrhea?

a. Becomes more watery ________

b. Consecutively more watery ______

c. Stool smells bad _______

d. Stool has blood ________

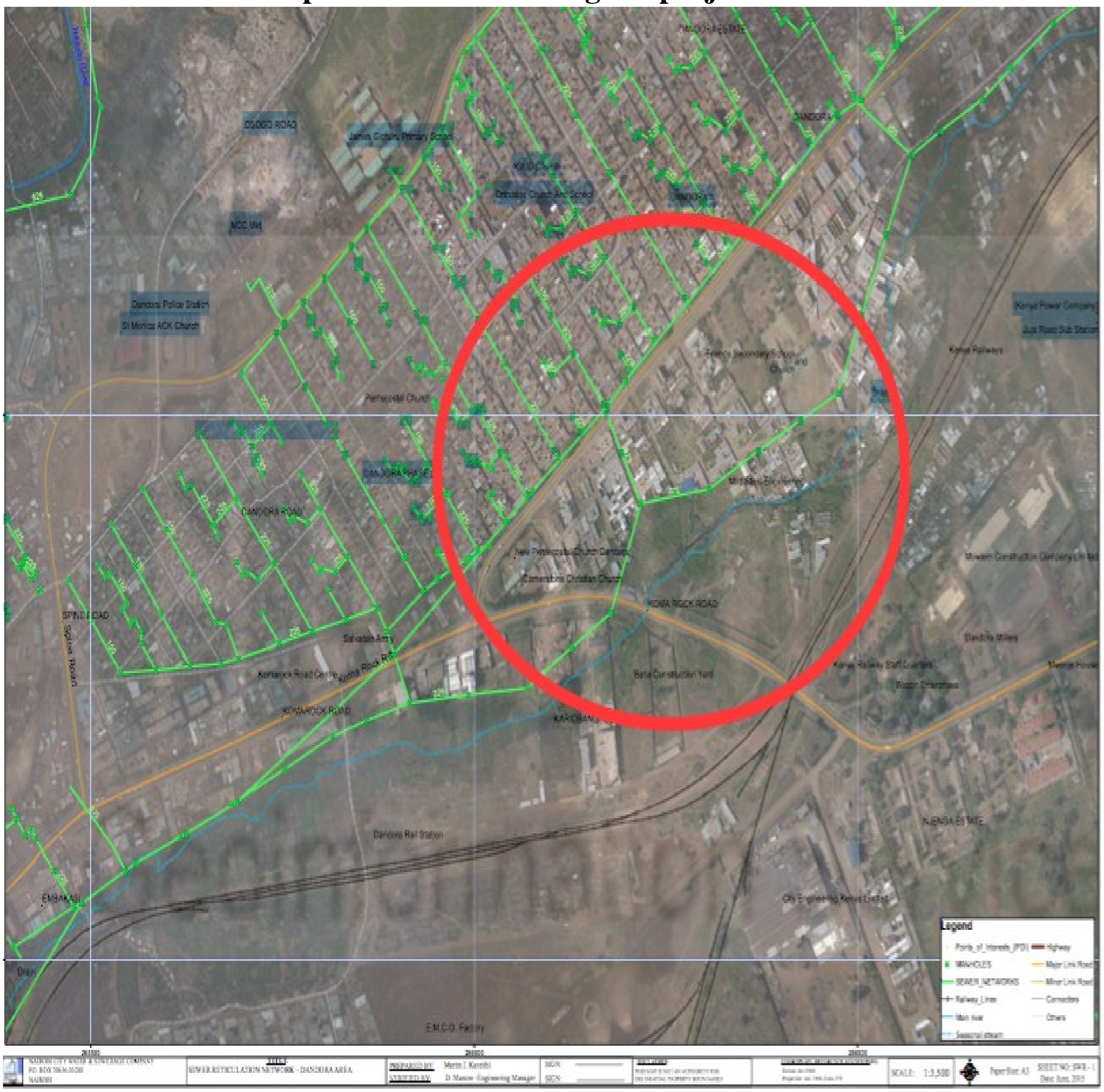
e. Stool has mucous _______

f. Other _______

29. How many such stools per day would cause you to think that your child has diarrhea? __

Appendix III

Map of Dandora showing the project site



KEY:

- Area within the red line is the approximate study area.
- The green line represent sewer line systems in the area.

Appendix IV

Data Analysis Matrix

Specific objective (SO)	Question to respond to with analysis	Variables/ indicators	Basic statistics tests	Advanced statistics tests
SO1:-To determine the socio economic and socio demographic characteristics of individuals utilizing vegetables produced using sewage water	What are the socio economic and socio demographic characteristics of the households that consume the vegetables produced using sewage water	Age Sex Marital status Education levels	Means Medians Skewness Kurtosis 95% confidence interval	ANOVA Chi Square Correlation t - test
SO2:- To determine agricultural practices and utilization of vegetables using sewage water	How do the farmers plant their vegetables and what are their utilization practices	Knowledge practices	Means Medians Skewness Kurtosis 95% confidence interval	ANOVA Chi Square Correlation t - test
SO3:- To analyze specific hazards found in vegetables produced using sewage water at the production, at the markets and during consumption	What kind of hazards (parasites, bacteria and heavy metals) found in each stage of production until consumption?	Parasites Bacteria Heavy metals	Means Medians Skewness Kurtosis 95% confidence interval	ANOVA Chi Square Correlation t - test
SO4:- To find out if there is association between morbidity of children less than 5 years of age with the utilization of vegetables produced using sewage water	Is there any relation of the morbidity of children under 5 years of age to the utilization of vegetables produced using sewage water	Knowledge on illnesses	Means Medians Skewness Kurtosis 95% confidence interval	Chi square