

Assessment of Wastewater Quality Status for Urban Farming in Katsina

¹Ekoh, Harrison Charles, ²Suleiman, Olekwu Khadijat and ¹Osuji, Dennis Chiazor

¹Dept. of Geography, University of Abuja, Nigeria. ²Dept. of ASTAL. NASRDA, Nigeria.

Corresponding author: ekohharrison@gmail.com

Abstract

The study assesses the quality of domestic wastewater discharged and used for irrigation farming along River Ginzo in the Metropolis with the aim of determining its suitability for cultivating crops along the river in the area. Three sampling sites, Kofar Marusa, Kofar Durbi and Kofar Sauri were selected from the study area, and two sampling points each from the three sample sites were chosen using the purposive sampling technique. Six sampling points were obtained in total and two sets of samples were collected, first in the peak of dry season April, 2019 and the second in the peak of wet season in August, 2019, giving a total of twelve (12) samples. The results indicated that all the parameters analyzed fall within the FAO (2006) recommended standard values for irrigation water except that of dry season period which has the highest mean average concentration of psysicho-chemicals (Electrical conductivity) and the heavy metals (Cd, Cu and Ni) which are higher in the dry season than in the wet season period. This was found as a result of accumulation of exhaust carbon from automobiles, different land form and uses, high evaporation and human activities zango (2010). The water is suitable for irrigation as confirmed by the accepted hypothesis but the salinity which influences the plants osmotic activities which subsequently reduce absorption of water and nutrients by plants need to be addressed. Focus group discussions among farmers indicated that the water has both positive and negative implications and that the water could be risky but due to the availability of the wastewater and the nutritional values in it, they used it for cultivating crops. However, there is need for further investigation and monitoring of the wastewater and the farming activity in the area as well as using enlightenment campaigns on the risk of the pollutions as well as correctional measures and the use of resistance variety of crops.

Keywords: Wastewater, Urban Farming, Metropolis, Electrical-Conductivity, Irrigation.

Introduction

Urban farming or urban irrigation is a century old practice that is receiving more attention with the increasing shortage of fresh water resources in arid and semi-arid areas. A primary exposure route for urban population in general is the consumption of raw vegetable that have been irrigated with urban wastewater (Scott *et al*, 2004). Today's world population stand at about 7 billion people and is expected to reach 11 billion people by the year 2050, (United Nations, 2009) out of which about 90% will come from developing countries. The imperative for their agricultural growth is strongest where their challenge is not just to produce food but rather to ensure that families have access that will bring them food security. In many developing areas however non-built up urban lands, especially those lying

along the courses of urban drainages systems are used as locations for the production of some agricultural products that are in high demand by urban dwellers (such as vegetables). A significant proportion of city's food requirements in developing countries are supplied from within the urban boundaries, because within those areas substantial amount of wastewater (mainly from homes and industries) is available in urban drains for irrigating lands along the urban courses Ruma and Sheik, (2009).

UNDP (1996) Defines urban agriculture as an industry that produces, processes and markets food largely in response to daily demand of consumers within a town, city or metropolis. According to FAO (2006), the rapid growth of cities in the developing world is placing enormous demand on urban food supply systems using wastewater. Municipal wastewater is the water discharged from the metropolis households as a result of daily activities. In many areas of Africa there is poor attitude toward wastewater reuse as authorities face more challenges from urbanization. The role and importance of water for urban farming and livelihoods varies considerably across cities, both currently and in terms of the visions for the future. However, there are similarities in terms of water source and management, water scarcity, driving factors such as poverty and the need for new innovative systems to allow for the use of other source of water, hence wastewater seems to be associated with risks (Switch, 2006). Wastewater for irrigation is very promising water conservation process as its use for irrigation is beneficial because it contains some important plant nutrients especially if these nutrients are present within tolerable level Zango, (2010). Tanko, (1994), and Yar'adua, (2007) opined that wastewater is rich in fine silt and clay, if used over time may change the soil to sandy loam because of the increase in clay and silt deposition thereby increasing the soils water retention capacity.

Urban and peri-urban farming can offer wide-ranging benefits (Pasquin, 2006). It can contribute substantial amounts to the proportion of food consumed in the city. Estimates shows that about 800 million urban dwellers are actively engaged in urban farming in the world, out of which more than 200 million are providing food for markets, FAO (1999). Urban farming also is practiced for a variety of reasons, such as crisis management when markets are not functioning e.g in Cuba, as a strategy to overcome cash shortages or even for commercial purposes as well as improving food security and nutrition, and also creating employment to the unemployed men and women Lynch *et al*, (2001).

Wastewater use for irrigated farming is important in urban and peri-urban areas where it can serve as a new source of water and fertilizer if it has been properly managed to minimize environmental and health risk. Inadequate quality water and poverty driving untreated wastewater use in urban and peri-urban farming, it is a common pattern in sub-Saharan Africa and other poor regions where there is no economic capacity to afford conventional sanitation and wastewater treatment facilities. This poses health, environmental and agricultural risk if no additional measures are applied Baddegi, (2003).

The practice of wastewater irrigation is widely adopted in sub-Saharan Africa by resource-poor farmers without consideration of the potential health risks to the population, as it

changes the chemical composition of the soil Zakari, (2016). Opportunities that drive people to use waste water for irrigation is that it contains most macro and micro nutrients that plants need to grow (Cordell, *et al.*, 2009). But the risk of wastewater is that it often contains a variety of pollutants: salts, metals, metalloids, pathogens, residual drugs, organic compounds, endocrine disruptor compounds and active residues of personal care products and any of these components can harm human health and environment WHO (2006). Farmers can suffer harmful health effects from contact with wastewater, while consumers are at risk from eating vegetables and cereals irrigated with waste water Jimenez and Asano, (2008).

Statement of the Research Problem

Considering the ever-increasing demand for food especially fresh vegetable in Katsina urban area necessitated the use of wastewater as an alternative source for crops production. On the other hand, the water has the potentialities of raising soil fertility and soil amendments due to the important nutrients in the effluents. Meanwhile, looking at the main sources of the irrigation water which is Ginzo stream that passes through the town collecting the domestic wastewater (effluents from Bathing, washing, urination, inadequate sewage facility, as well as chemicals from various car wash, agro chemicals, oil from automobile workshops etc), there seems to be suspicions as regard to the quality of the Wastewater used for cultivating the crops especially by the elites who have started shunning the agricultural products from the irrigation sites due to the purported claims of contamination by pollution and the nature of the wastewater used in cultivating the crops. Also, looking at the nature of the crops where most are consumed at their raw stage may likely transmit some chemical elements in to human body and possibly cause diseases. The above are the reasons that prompted this study in the need for urgent attention and investigation to confirm the suitability of the water in terms of psycho-chemicals and the trace elements.

Research Questions

- a. What is the wastewater quality status of some selected physico-chemical parameters of the Wastewater in the study area?
- b. Is there any difference in quality of the wastewater between wet and dry seasons in the study area?
- c. Is the wastewater use for urban farming suitable and in line with the existing guidelines and standards for urban farming?
- d. Does benefits of using the wastewater for urban farming overshadow the risks attached to it?

Aim and Objectives

The aim of this study is to assess the quality of wastewater being used by the urban farmers

for cultivating crops along Ginzo River in Katsina urban area. In order to achieve this aim, the following objectives are pursued.

Objectives

- a. To analyze the Wastewater quality status of some Physico-chemical Parameters selected.
- b. To assess the temporal variations of Wastewater used for urban irrigation between dry and wet seasons.
- c. To compare the result obtained in the laboratory with the standard recommended permissible limit of maximum concentrations of trace elements in irrigation water, so as to find out if they are within acceptable limits and suitable for urban farming.
- d. To assess the implication of using the wastewater for urban farming in the Study Area.

Literature Review

Concept of Urban Farming

It is not easy to define urban farming because a large variety of urban farming systems is operated. According to World Food and Agriculture Organization FAO (2007) urban agriculture is defined as "the growing of plants and the raising of animals for food and other uses within and around cities and towns, and related activities such as the production and delivery of inputs, processing and marketing of products." Veenhuizen, (2006), reported that urban farming is generally characterized by closeness to markets, competition for land, limited space, and use of urban resources such as urban organic wastes, wastewater, and others. Farming in and around the city is not the same as farming in the rural areas in many aspects. It is possible to use various agricultural inputs such as artificial Fertilizers, Pesticide, Insecticide, water (waste and/or fresh), soil and others in the Urban farming, however it needs firm regulation and inspection Mougeot, (2000).

The number of people around the world who live in and around cities is increasing steadily. Cities around the world face enormous challenges in creating sufficient employment, in providing basic services, in planning, and also in management of urban wastes. To eradicate the above and improve livelihood, cities requires innovative ways to stimulate local economic development in combination with enhancing food security and nutrition, and urban farming is one of such strategy Switch, (2006).

Urban farming is defined as the growing of crops (Food and vegetables) within and around the cities or towns, and related activities and production systems ranging from subsistence production and processing at household level to fully commercialized agriculture Switch, (2006). Obuobie, *et al.*, (2006), similar opinion and contribute that apart from the above, in West Africa, market oriented irrigated farming occupies between 20-650 ha in each major city, producing 60 -80% of the locally consumed perishable vegetables.

Urban farming has a long history throughout the world, but recently the phenomenon has gained more attention in several cities for various reasons Smith *et al.* (2001). The oasis towns of Iran are an early example of urban farming. The towns and cities of early civilizations on Java and in the Indus Valley showed traces of urban farming practice (for example: raised-bed farming systems). The most important historic evidence of urban farming was discovered in Latin America: Aztec, Mayan, and Incan cities were self-sufficient in perishable fruits and vegetables that were produced in and around the cities Smith *et al.* (2001).

Each farming tradition is highly connected in local societal and cultural practices. During the 1980s and 1990s, the importance of urban farming increased throughout the world in both developed and developing countries. A study in Moscow in 1970 and 1991 indicated that a shift of families engaged in urban agriculture from 20% to 65%. Similarly surveys in Dares Salaam, Tanzania in 1967 and 1991 showed an increase of urban family agriculture from 18 to 67%. Reports from three cities such as Kinshasa, Kampala, and Maputo also indicated that a large change of urban land from open space to agricultural production Smith *et al.* (2001). Also, in Kenya and Tanzania, most families (three out of five families) in towns and cities are engaged in urban farming Smith *et al.* (2001). The use of municipal waste water is a century old practice that is receiving attention with the increase scarcity of fresh water resources, in many arid and semi-arid areas. Fatasal *et al.* (1999) in Scot *et al.* (2004). Use of urban space for irrigation has received little attention from policy makers who often see it is a negative way. But the urban and peri-urban irrigation is greater in many countries than is mainly acknowledged and is increasing. For example, average farm in Zimbabwe capital, Harare (Africa), doubled between 1990 and 1994 Mbiba (1995).

Wastewater Reuse in Urban Farming

The use of domestic wastewater for agriculture has been in practice for thousands of years in different regions of the world. The earliest documented sewage farms were operated in Germany and Scotland in the 16th and 17th centuries. With the development of biological wastewater treatment processes in the early 1900s, sewage farms fell into decline in industrialized countries due to concerns about public health, such as the possible transmission of disease from vegetables irrigated with raw sewage. Municipal wastewater mainly comprises water and small amounts of organic solids, including natural and synthetic organic chemicals from industrial processes. Approximately 10% of the world's wastewater is currently being used for irrigation, allowing farmers to reduce or even eliminate the purchase of chemical fertilizers. However, the use of wastewater in agriculture can also contribute to water pollution and contamination, which can affect the health of living organisms and make water unsuitable for desired uses. In urban areas, where domestic wastewater is readily available, urban farmers may use wastewater for irrigation.

Risks of Wastewater Use in Urban Farming

Wastewater use in urban farming has substantial benefits in water resources management, but can also pose substantial risks to public health—especially when use untreated for crops irrigation. There can also be chemical risks to plant health, and risks to the Environment in the form of soil, and groundwater pollution. Countries seeking to improve wastewater use in agriculture must reduce the risks, in particular those to public health, and maximize the benefits through properly planned, implemented and managed wastewater Irrigation practices Asano, *et al.*, (2007).

- a. **Microbial risks to public health;** in low- and middle-income countries, the greatest risks are primarily to public health from the microbial pathogens (disease-causing organisms) contained in domestic wastewater, including bacteria, virus, protozoa and helminthes (World Bank, 2010). Epidemiological studies carried out over the past four decades have linked the uncontrolled use of untreated or partially treated wastewater for edible crop irrigation to the transmission of endemic and epidemic diseases to farmers and crop consumers. Actual risks of using untreated wastewater for irrigation include the increased prevalence of helminthes diseases (such as ascariasis and hookworm) in field workers and consumers of uncooked vegetables, and bacterial and viral diseases (such as diarrhea, typhoid, and cholera) in those consuming salad crops and raw vegetables Barton, *et al.*, (2010).
- b. **Chemical risks to public health;** Chemical risks are greater in developing countries where industrial wastewaters may be discharged to public sewers and contaminate municipal waters. Chemical risks to human health may be caused by heavy metals (such as cadmium, lead, and mercury) and by many organic compounds (such as pesticides). There is also increasing concern in high-income countries about an emerging class of “anthropogenic” chemical compounds, which include pharmaceuticals, hormones and endocrine disruptors, antibiotics, and personal care products – although their long-term health effects are less clearly understood Barton *et al.*, (2010).
- c. **Risks to plant health;** The principal risk to plants is reduced crop yields if the physicochemical quality of wastewater used for irrigation is unsuitable – for example by being too saline or having excessive concentrations of boron, heavy metals or other industrial toxicants, nitrogen, and/or sodium. Risks to plant health are reduced if there is little industrial effluent in the wastewater, but in all cases five parameters should be monitored during the irrigation season: electrical conductivity, the sodium adsorption ratio, boron, total nitrogen, and PH, (ETWWA/World Bank, 2010).
- d. **Environmental risks;** Soil and groundwater pollution is the main risk of using wastewater in agriculture; the microbiological pollution of groundwater is a lesser risk as most soils will retain pathogens in the top few meters of soil except in certain hydro geological situations like limestone formations. Chemical risks include, among others, nitrates in groundwater from sewage irrigation, salinity of soils and aquifers,

and changes in soil structure from, for example, boron compounds common in industrial and domestic detergents Barton, *et al*, (2010). The key to controlling many of the chemical risks to humans, crops and the environment is to put in place effective industrial wastewater pretreatment and control programs. Of course, effective programs are not the norm in developing countries, so special attention has to be paid to chemical risks in such circumstances Barton, *et al*, (2010).

Benefits of Wastewater Use in Urban Farming

When properly planned, implemented and managed, wastewater irrigation can have several benefits that accrue to the agricultural, water resources management, and environmental sectors, Barton, *et al*, (2010).

- a. **Agricultural benefits;** Agricultural benefits may include: reliable, and possibly less water supply; increased crop yields, often with larger increases than with freshwater due to the wastewater's nutrient content; more secure and higher urban agricultural production and contribution to food security; income and employment generation in urban areas; and improved livelihoods for urban agriculturalists, many of whom are poor subsistence farmers, including a large share of women *Water resources management benefits*. In terms of water resources management, the benefits may include: additional drought-proof water supply, often with lower cost than expanding supplies through storage, transfers, or desalinization; more local sourcing of water; inclusion of wastewater in the broader water resources management context; and more integrated urban water resources management, Barton *et al*, (2010).
- b. **Environmental benefits;** The use of wastewater despite its obvious benefits has some recorded human and environmental health concern Phung *et al*, (2011). Many reports correlate the relationship between fresh vegetables and food borne diseases outbreaks that have led to the concern about contamination of the vegetable with faecal pathogenic bacteria in the agricultural environment Zakari, (2006). Among the environmental benefits that may occur to well-managed wastewater irrigation schemes are: avoidance of surface water pollution, which would occur if the wastewater were not used but discharged into rivers or lakes – major environmental pollution problems, such as dissolved oxygen depletion, eutrophication, foaming, and fish kills, can thereby be avoided; conservation or more rational use of freshwater resources, especially in arid and semi-arid areas – that is, freshwater for urban demand, wastewater for agricultural use; reduced requirements for artificial fertilizers, with a concomitant reduction in energy expenditure and industrial pollution elsewhere; soil conservation through humus build-up and through the prevention of land erosion; and desertification control and desalter acclimation, through irrigation and fertilization of tree belts, (Barton,*et al*, 2010) Facing these risks and benefits, countries seeking to improve wastewater use in farming should pursue the following key objectives: (i) minimize risk to public health; (ii) minimize

risk to the environment; (iii) improve livelihoods for urban farmers and (iv) integrate waste water into the broader water resources management context Wortman, S. E., & Lovell, S. T. (2013).

Some of the Parameters Analyzed on the Wastewater for Irrigation

The parameters examined are pH, Electrical conductivity (EC), Total Dissolve solids (TDS), and hazardous Heavy metals such as Lead (pb), Cadmium (Cd), Zinc (Zn) Copper (Cu), Nickel (Ni), and Iron (Fe).

a) Electrical conductivity (EC)

Salinity as defined by Sachwab et al (1981) and Rhodes (1972) is the total concentration of soluble salt which may retard and sometimes even may prohibit the growth and successful development of crops, making the transportation of solute difficult. Irrigation water with an Electric Conductivity of 1650 microhms/cm and greater is defined as high in salinity.

Salt concentration or salinity of irrigation water influences the plants osmotic activities which subsequently reduce absorption of water and nutrients by plants. Therefore, the greater the soluble salt contents of irrigation water the greater/higher the risk of creating saline soil or making a soil waterless available to plants. Moreover, a salinity problem related to water quality occurs if the total quantity of soil in the irrigation water is higher for the soil to accumulate the crop root zone to the extent that yields are affected. If excessive quantities of soluble soil accumulate in the root zone the crop has difficulty in extracting enough water from the salty soil solution these results in slow or reduced growth Zango (2010).

b) Total Dissolve Solids (TDS)

Total dissolved solids related to the amount of dissolved salt in the water. Higher salinity results in higher electrical conductivity. As the salt level increases, the plant must expend more energy to take nutrients dissolved in the water. TDS is calculated from Electrical conductivity.

c) pH

The pH balance describes how acidic or alkaline water is. The acidity (or alkalinity) can affect plant growth and efficiency. The general accepted pH for irrigation water is between 5.5 and 7.5 but some problems can occur even within that range.

d) Lead (Pb)

Lead is highly toxic metal whose widespread use has caused excessive water and environmental contamination and health problems in many parts of the world. Lead is a bright silvery metal slightly bluish in a dry atmosphere. It begins to tarnish on contact with air Sharma & Dubey (2005).

e) Cadmium (Cd)

Cadmium is the seventh most toxic heavy metal; it's the by-product of zinc production which humans or animals may get exposed to. Once this metal gets absorbed by humans,

it will accumulate inside the body throughout life. The danger of cadmium is that it accumulates along the food chain i.e from water to soil, to plants and then to humans, in us, more than 500, 000 workers get exposed to cadmium each year as per the agency for toxic substance and diseases registry Bernard, (2008); mutlu et al (2012).

f) Zinc (Zn)

Zinc is bluish-white lustrous, diamagnetic metal, though most common grades of the metal have a dull finish it is less dense than iron and has hexagonal crystal structure. Zinc is essential trace element for human and other animals, for plants and other microorganisms. Zinc flowing through industrial and mining areas can be as high as 20 ppm, Sharma & Dubey, (2005).

g) Copper (Cu)

Copper together with silver and gold are in group 11 of the periodic table, it has natural colour other than gray or silver. The softness of copper explains its high electrical conductivity, and high thermal conductivity. Copper is toxic to human exposure and plants readily absorbs and accumulates heavy metals including copper but the health implications of copper in the body are yet not clear Chen et al, (2012).

h) Iron (Fe)

Iron (Fe) is a cubic crystal, grayish and a d-block metal. It belongs to period 4 and group X. It has atomic number 26, Atomic mass 55.845, density 7.874 g/cm³. According to Shuai, (2005) iron exists in soils and ground water. Iron is the most abundant mineral on the earth's crust, but its availability to plants is usually very low Shuai, (2005), further more irrigation water with iron levels above 0.1ppm may cause clogging of drip irrigation emitters and above 0.3ppm may lead to iron rust stain and discoloration on foliage plants.

i) Nickel (Ni)

Nickel is a silvery-white metal with slight golden tinge that takes a high polish. It is one of only four elements that are magnetic at or near room temperature, the others being iron, cobalt and gadolinium. Its Curie temperature is 3550C (6710F), meaning that bulk nickel is non-magnetic above this temperature.

Although not recognized until the 1970s, nickel is known to play an important role in the biology of some plants, eubacteria, archeabacteria, and fungi. Nickel enzymes such as urease are considered virulence factors in some organisms. Urease catalyzes the hydrolysis of urea to form ammonia and carbonate.

Table 2.1 Recommended Maximum Concentration of Trace Element in Irrigation water

Trace Elements	Maximum Permissible Level (mg/l)
Cadmium	0.01
Copper	0.20
Iron	5.0
Lead	5.0
Nickel	0.20

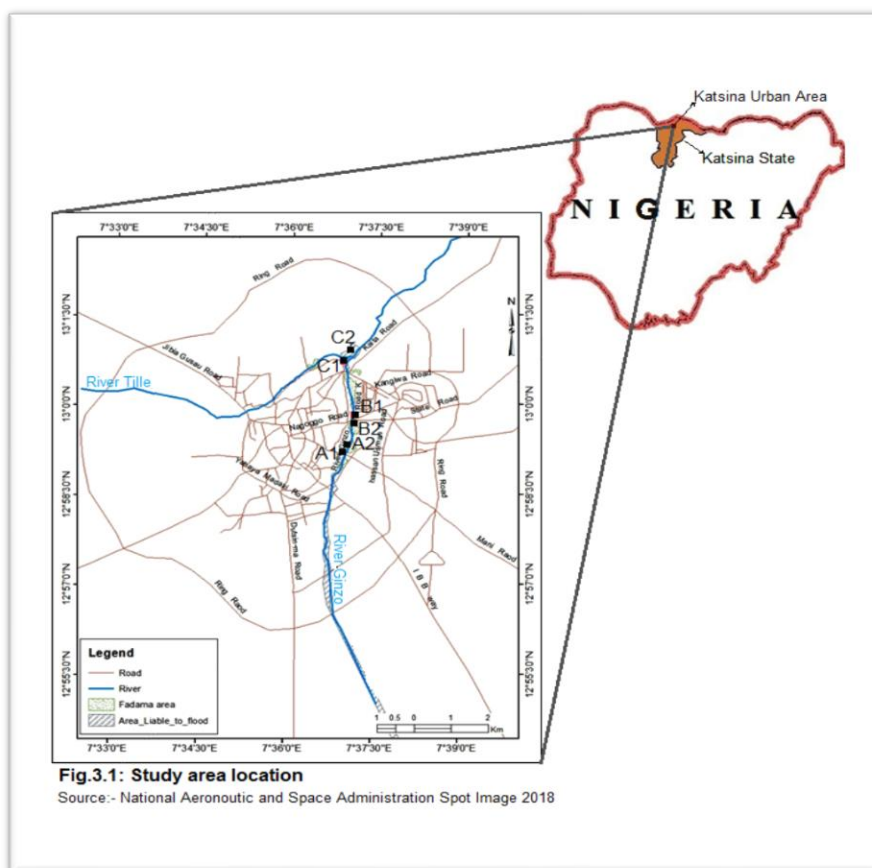
Zinc	2.0
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Source: FAO (2006)

Due to the discharge of large amount of metal contaminated wastewater, industries bearing heavy metals such as Cd, Cu, Ni, As, Pb, and Zn are the most hazardous among the chemical intensive industries. Heavy metals can be absorbed by living organisms. Once they enter the food chain, large concentrations of them may accumulate in the human body. If the metals are ingested beyond the permitted concentration, they can cause serious health disorders Babel and Kurniawan, (2004). Therefore, it is necessary to treat metal contaminated waste water prior to its discharge to the environment.

Research Methodology

Description of the Study Area



Location and Extent

Katsina urban area, is one of the sub-Saharan cities and one of the ancient Hausa settlement renewed for its culture, learning and whose early development is influenced by Trans-Sahara trade. Located at the extreme northern margin of Nigeria and lies between the latitudes $11^{\circ}08'N$ and $13^{\circ}22'N$ and longitude $6^{\circ}52'E$ and $9^{\circ}20'E$. (Fig 3.1).

Katsina is the capital city of Katsina State and border Kaita by the North, Jibia by the west, Batagarawa by the south and Mashi and Rimi by the East. It covers a total land area of about 3,370 square kilometers Ruma, (2009), and Zango, (2010).

Population

According to Zango (2010) Demographic data of 2006 census gave a population of 318,459 people in Katsina local government. Male population is 149,551 while that of female is 168,908. The current fertility rate is in sub-Saharan Africa showing an average of 4.2%, birth rate is generally persistent; the mortality rate is 1.6% which was still declining due to improvement in health care facilities. The projected population of Katsina local government by the year 2016 is 507,191, Aminu (2017).

Climate

The climate of the study Area is Semi-arid continental climate with two distinct seasons of Wet and Dry seasons, the two seasons are controlled by the two air masses, the equatorial maritime air mass and tropical continental air mass. The former is associated with rain bearing south west wind from the Atlantic Ocean and later with dry and dusty harmattan from the desert. The Inter-Tropical Discontinuity (I.T.D) also known as inter-tropical convergence zone; (ITCZ) is dividing the region between the cool and dry, sometimes dusty. When the (ITCZ) moves north wards over the study area in May, rainfall becomes progressively heavier and steadier reaching its peak in August. In September as the (ITCZ) moves southward, rain fall becomes lighter and sporadic, (Asanariman *et al*, 2015) and (Ibrahim, 2016).

Rainfall generally ranges from 500 mm to 800 mm annually in the study Area, (NIMET, 2016). The latitudinal location and the continental location of the region are greatly reflected in temperature characteristic controlled by the movement of the ITD give rise to four seasons of the year. These are:

- Dry and cold season from October to February
- Dry and hot season from March to May
- Wet and Warm season from May/June and September.

A season of decreasing rainfall and fallen temperature from October to November

Weather varies according to the season, it is generally cool in the morning hot in the afternoon and cools again in the evening, maximum temperature ranges between 29°- 42°, Harmattan season (November – February) lower the temperature to 18° – 27° (NIMET Department, Umaru Musa Yar'adua Airport Katsina 2015). . The study area records maximum day temperatures of about 38° in the months of March, April and May while minimum temperature of about 22° is usually recorded in the months of December and January (Ruma and Sheik; 2010). Relative humidity in Katsina and its environs ranged between 20 and 25% with highest humidity occurring in the month of August, and the lowest in February Zayyana, (2010).

Soil

Soils in the study area fall under tropical ferruginous type and weakly developed alluvial soils of the major streams. The exact characters of these soils are dependent on factors such as topographical relations and anthropogenic modifications. Soil color ranges from dark grey or grayish brown in the top soil to yellowish red or yellowish brown in the subsoil. In terms of consistency, the top horizons are loose, when moist, (Ministry of Land and Survey Katsina, 2008). The soils are friable when moist and non-sticky when wet. The top soil develops a weak crumb structure and the lower horizons a weak or moderate sub angular blocky structure. The soils are moderately porous and are well drained over most of the year, although the reddish mottles especially in the lower horizons suggest that many do become saturated at the depth for at least brief period as observed by Aminu, (2016).

Drainage

The main Rivers draining the study area are Ginzo and Tille Rivers. Ginzo River drains the northern part of the city, while Tille River with its dendritic drainage pattern passes through the town in south direction. The stream flow pattern according is seasonal, like other semi-arid rivers which experiences almost zero dry season flow Zayyana, (2010).

Ginzo River is a third order stream with a total length of 8.2 km. This river drains the northern of Katsina Metropolis and it is characterized by Seasonal flow like other Rivers of semi-arid climate Aminu, (2016).

Land uses

Land use in the study area is dominated by residential, commercial, and institutional land uses with small area used for farming activities. The residential land use which covers substantial part of the study area is interspersed by commercial, institutional and other land uses. Sabuwar Unguwa extension area of the city functions as industrial lay out, where industries such as steel rolling, packaging, beverage, and processing can be found. A number of stores and markets can also be found in this part of the city. Institutional land use is occupied by schools such as Umar Musa Yar'adua University, Federal College of Education, Hassan Usman Katsina Polytechnic, a School of Nursing and Midwifery in addition to numerous Nursery/Primary and Secondary School. Agricultural activities in the study area are mainly confined to open spaces within the built up areas and at suburb and on the stretches of flood plains both within and outside the city. The most common farming activity in the study area is market gardening where vegetables such as okra, cabbage, spinach, lettuce; onion are grown. Perennial crops and fruits are also grown in the area. Zayyana, (2010); Aminu, (2016).

Methodology**Source of Data**

Two primary sources of data were involved for the purpose of this study. They are, field collection of samples and laboratory procedures. Secondary sources which are published

and unpublished materials such as textbooks, journals, seminar papers and research thesis were also consulted. They provide wider knowledge of the problem under study and some guides in solving the problems.

Field Work

The main field work includes; observation, interviews and procedures for collecting the Wastewater and laboratory analysis of the wastewater samples collected. Pre- field study was conducted in order to have general idea, and understanding of the study area, the location and extent of the study area, the famers, their sites of cultivation and the activities they do with the wastewater. This helped the researcher to identified and located the three sampling Locations (Fig. 3.2).

Sampling Location/Size

Table 3. 1 and 3.2. Sample points 1 and 2 are located at Kofar Marusa, 3 and 4 at Kofar Durbi while 5 and 6 from Kofar Sauri irrigation sites. Also, for the Focus Group Discussion (FGD) in the study area as well as for the purpose of conducting the survey effectively, Jensen (2000), German *et al* (2007) maintained that choosing a study sample is an important step since it is rarely practical, efficient or ethical to study whole populations. This study used Random sampling method to select respondents for the FGDs. The selection of the farmers for vegetable cultivation was based on wastewater level, where three areas were selected based on their position in relation to population and the major farming activities identified. This included Kofar Marusa, Kofar Durbi and Kofar Sauri. In each area, participants were identified (household head with over 10years experience in vegetables cultivation), they were selected for FGD and schedule was drafted for the conduct of the FGD as pointed out by Hoffman, Probst and Christinck (2007); Silverman (2013).

Table 3.1 Location and Sampling Codes of Wastewater Collected in the Dry Season.

Time	Sampling Site	Latitude	Longitude	Elevation
8:15am	Kofar Marusa A ¹	N12°59.308 ¹	E007°36.926 ¹	419m
8:49am	Kofar Marusa A ²	N12°59.339 ¹	E007°36.948 ¹	492m
9:02am	Kofar Durbi B ¹	N12°59.744 ¹	E007°37.006 ¹	494m
9:22pm	Kofar Durbi B ²	N12°59.780 ¹	E007°37.003 ¹	491m
9:42am	Kofar Sauri C ¹	N13°00.293 ¹	E007°36.994 ¹	485m
9:82am	Kofar Sauri C ²	N13°00.883 ¹	E007°37.030 ¹	485m

Source: Researcher Field Work, 2019

Table 3.2 Location and Sampling Codes of Wastewater Collected in the Wet Season.

Time	Sampling Site	Latitude	Longitude	Elevation
8:15am	Kofar Marusa A ¹	N12°59.308 ¹	E007°36.926 ¹	419m
8:49am	Kofar Marusa A ²	N12°59.339 ¹	E007°36.948 ¹	492m

9:02am	Kofar Durbi B ¹	N12°59.744 ¹	E007°37.006 ¹	494m
9:22pm	Kofar Durbi B ²	N12°59.780 ¹	E007°37.003 ¹	491m
9:42am	Kofar Sauri C ¹	N13°00.293 ¹	E007°36.994 ¹	485m
9:82am	Kofar Sauri C ²	N13°00.883 ¹	E007°37.030 ¹	485m

Source: Researcher Field Work, 2019

Sampling Techniques

For the purpose of collecting the water samples from the study area purposive sampling technique was used while Random sampling was used for the interviewing the farmers.

Samples Collection

For the purpose of this study, the sampling collections were made in two distinct seasons in order to have representation for both spatially and temporarily variations (Table 3.1 and 3.2). The samples were collected in four months interval that's between April (peak of dry season) and August (peak of rainy season) 2017. This was done in order to have full representation of the irrigation sites to cover the spatial variation in quality of the wastewater regardless of self-purification known to moving water.

The sampling procedure was adopted as cited in Ruma (2009) and Zango (2010) which among others stated that the plastic bottles must be washed with Nitric-acid and rinse in distilled water and covered immediately to avoid contamination. The bottles were lowered (submerged) halfway to about 15cm between the water level and the river bed, the collected samples were labeled indicating the sampling point, sampling site and also the date and time of collection. Water temperature was also taken before taking the samples to the laboratory for laboratory analysis.

Result and Discussions

Physico-Chemical and Trace Elements Analysis of the Wastewater

The result of some selected physic-chemical parameters such as Temperature, pH, EC, TDS, COD, BOD, DO, NO₂, NO₃, and PO₃, and also the Trace elements of Lead, Cadmium, Zinc, Copper, Nickel and Iron, collected from three sampling sites (K/Marusa, K/Durbi and K/Sauri irrigation site), were analyzed in the laboratory. The results were summarized using descriptive statistics to find the mean, variance and standard deviation for effective comparison with the FAO (2006) permissible limits and presented in table 4.1 and 4.2 for dry and wet seasons respectively.

Table 4.1: Mean Average Values for Laboratory Analysis of Dry Season Wastewater from the Sampling Points (K/Marusa 1, K/Durbi 2 and K/Sauri 3)

Parameters	Mean Average			Standard FAO (2006)
	Sampling point 1 (K/Marusa)	Sampling point 2 (K/Durbi)	Sampling point 3 (K/Sauri)	
Temp.	27.3±1.94	29±1.14	28.3±1.14	21 °C-30°C
pH	6.1±1.10	6.7 ±1.14	6.6±1.14	6.4 -7.4
TDS	1852±19.2	2530±22.4	2192±20.9	1500 mg/l
BOD	13.8±8.15	16.4±9.09	12.8±9.29	30 mg/l
COD	57.7±37-7.7	52.8±42.4	56.4±39.1	100 mg/l
E. C	1093±14.7	1376±16.5	1272±15.9	1000µ/cm
DO	21.8±9.2	27.8±10.2	22.2±1.12.1	≥10 mg/l
NO ₃	6.04 ±4.02	8.23±6..12	7.08±6..12	10 mg/l
NO ₂	0.2±0.04	0.2±0.03	0.4±0.06	0.2mg/l
PO ₃	0.02±0.25	0.10±0.13	0.13±0.14	10mg/l
Lead	0.10±0.14	0.06±0.10	0.04±0.08	5.0 mg/l
Cadmium	0.35±0.26	0.15±0.17	0.35±0.26	0.10 mg/l
Zinc	0.11±0.14	0.09±0.13	0.05±0.1	2.0 mg/l
Copper	0.22±0.20	0.22±0.20	0.22±0.20	0.20 mg/l
Nickel	0.26±0.22	0.15±0.17	0.11±0.02	0.20 mg/l
Iron	0.09±0.13	0.03±0.07	0.03±0.07	5.0 mg/l

Source: Field work (2019)

The study analyzed the physicochemical characteristics of surface water in three sampling points during the dry season. The results indicated that all sampling points were within the recommended permissible limits of FAO for pH and temperature. However, sampling point 2 had the highest average temperature (29°C), highest total dissolved solids (1526 mg/l), highest electrical conductivity (2530 µ/cm), and highest biochemical oxygen demand (16.4 mg/l), which exceeded the recommended permissible limits for TDS and EC. Sampling point 1 had the highest average chemical oxygen demand (57.7 mg/l), while sampling point 3 had the highest average nitrate (8.23 mg/l) and cadmium (0.35 mg/l) concentrations. All sampling points exceeded the recommended permissible limits for lead, but were within the permissible limits for copper and zinc. Sampling point 1 had the highest average nickel concentration (0.26 mg/l), which exceeded the recommended permissible limit. Overall, the study suggests that the surface water in the three sampling points during the dry season may not be suitable for direct human consumption due to the high levels of some physicochemical parameters.

Table 4.2: Mean Average Values for Laboratory Analysis of Wet Season Wastewater from the Sampling Points (K/Marusa 1, K/Durbi 2 and K/Sauri 3)

Parameters	Mean Average			Standard FAO (2006)
	Sampling point 1 (K/Marusa)	Sampling point (K/Durbi) 2	Sampling point (K/Sauri) 3	
Temp.	27.3±1.94	29±1.41	28.3±0.81	21 °C-30°C
pH	6.5±1.14	6±1.09	6.9±1.17	6.4 -7.4
TDS	1044±14.4	1375±16.5	1132±15.0	1500 mg/l
BOD	13.8±8.15	16.4±9.09	12.8±9.29	30 mg/l
COD	50.1±34.6	50.9±42.5	53.1±38.6	100 mg/l
E. C	1093±14.7	1376±16.5	1272±15.9	1000µ/m
DO	19.1±9.7	15.7±20.8	19.9±11.5	≥10 mg/l
NO ₃	4.17 ±3.10	8.08±6.12	5.08±4.12	10 mg/l
NO ₂	0.2±0.03	0.23 ±0.13	0.14±0.06	0.2mg/l
PO ₃	0.10±0.13	0.74±1.67	0.02±0.14	10mg/l
Lead	0.06±0.10	0.08±0.12	0.08±0.12	5.0 mg/l
Cadmium	0.15±0.17	0.02±0.2	0.02±0.2	0.10 mg/l
Zinc	0.05±0.1	0.04±0.08	0.05±0.1	2.0 mg/l
Copper	0.13±0.16	0.13±0.16	0.13±0.16	0.20 mg/l
Nickel	0.46±0.09	0.26±0.22	0.15±0.17	0.20 mg/l
Iron	0.12±0.15	0.09±0.13	0.05±0.1	5.0 mg/l

Source: Field work (2019)

Table 4.2 presents the results of water quality testing at three sampling points during the wet season. All the recorded average temperature, pH, TDS, BOD, COD, DO, NO₃, NO₂, PO₃, Pb, Cd, Zn, Cu, and Fe concentrations were within the recommended permissible limits of FAO (2006). However, the highest EC concentrations were above the limit at all sampling points. Ni concentrations were also above the limit at sampling point 1, but not at the other two points. Sampling point 2 had the highest average temperature, TDS, BOD, and COD concentrations, while sampling point 3 had the highest average pH, DO, NO₃, and PO₃ concentrations.

Paired Sample T-Test for the Trace Elements

To assess the variations of the wastewater used for urban irrigation between dry and wet seasons in the study area. Paired sample T-test statistics was conducted to test the hypothesis (H₀) that Wastewater is not suitable for irrigation and there is significant difference in the trace elements between the dry and wet seasons in the study area.

Table 4.3: Paired Sample T-Test Statistics between Concentrations of the Sampled Elements between the Seasons (Dry and wet Seasons).

Parameters	Seasons		95% CI for mean Difference		
	Dry season	Wet season			
	MEAN	MEAN		t-stat.	Df
Pb	0.071±0.084	0.079±0.032	0.042431	0.303	5
Cd	0.266±0.121	0.183±0.075	0.047859	1.535	5
Zn	0.087±0.027	0.035 ±0.06	0.010253	2.696	5
Cu	0.226±0.095	0.132±0.049	0.038544	3.872	5
Ni	0.178±0.079	0.294±0.141	0.051923	0.277	5
Fe	0.061±0.246	0.062±0.787	0.393889	0.238	5

Source: Field work (2019)

Table 4.3 indicates that during the wet season, Pb and Cd concentrations were higher than during the dry season, while Zn concentrations were higher during the dry season. Cu and Ni also had significant differences between seasons, but Fe had similar averages. However, the paired sample t-test showed that while there were reasonable differences in Cd, Zn, and Cu between seasons, the confidence interval indicated that the differences were not significant at a 95% confidence level.

Comparison of Laboratory Result with the Standard Permissible Limits

The study analyzed the quality of wastewater in three sampling locations during wet and dry seasons. The pH levels were within the permissible limits, but the level of electrical conductivity (EC) exceeded recommended limits, especially in the dry season due to various human activities. Total dissolved solids (TDS) were also higher in the dry season. BOD was higher in the dry season but within recommended limits. The study found that the concentration of lead (Pb) in wastewater was negligibly higher in the wet season. Cadmium (Cd) concentration in wastewater was higher in the dry season and exceeded permissible limits, which could cause health problems. Copper (Cu) concentration in wastewater was reasonably higher in the dry season and slightly exceeded permissible limits, which could cause liver damage. Zinc (Zn) concentration was negligibly higher in the dry season, while Nickel (Ni) concentration was higher in the wet season due to washing and accumulation of minerals. The study also observed slight variations in average concentrations of COD, BOD, DO, PO₃, NO₂, and NO₃ but all were within recommended limits.

Implication of Using Wastewater for Urban Farming in the Study Area

Table 4.4 Summarizes the results obtained from Focus group discussion conducted with the famers in the study area. The study area was categorized as sampling points (sampling point 1 Kofar marusa, sampling point 2 Kofar durbi and sampling point 3 Kofar sauri). The results obtained were summarized using simple percentages to shows the implications of using the wastewater or river water for urban farming and also from the respondents experience to assess the spatial and temporal variations which will be assist the scientific

finding in drawing conclusion and recommendation in responses and the views of the respondents.

Table 4.4 Kofar Marusa (Sampling point₁), Kofar Durbi (Sampling Point 2) and Kofar Sauri (Sampling Point 3) Farmer's Responses

S/ No.		Sampling Point 1	Sampling Point 2	Sampling Point 3
1.	Sources of irrigation water	Percentage	Percentage	Percentage
	a) River	75%	83%	80%
	b) Other sources	25%	17%	20%
	Total	100	100	100
2.	Reason for using the river water	Percentage	Percentage	Percentage
	a) Shortage of water	36%	33%	47%
	b) Wastewater nutritional quality	64%	67%	53%
	Total	100	100	100
3.	Choice of crops grown using the river water	Percentage	Percentage	Percentage
	a) Exotic vegetables only	75%	75%	67%
	b) Exotic vegetables and others	25%	25%	33%
	Total	100	100	100
4.	Reason for choice of crops cultivated	Percentage	Percentage	Percentage
	a) Higher demand by people and marketability	75%	67%	60%
	b) Easy cultivation and tolerance of the crops	25%	33%	40%
	Total	100	100	100
5.	Level of satisfaction on the river water	Percentage	Percentage	Percentage
	a) Satisfied with the wastewater	75%	87%	73%
	b) Necessity forced the use of the wastewater	25%	17%	27%
	Total	100	100	100
6.	Water quality and crop yield	Percentage	Percentage	Percentage
	a) The crops produced with the river water	75%	75%	87%
	b) Crops produced using other sources of water	25%	25%	13%
	Total	100	100	100

The results of a focus group discussion with farmers in three different sampling points revealed that up to 75% of them use water directly from the river for cheaper production, and prefer it over other sources. The majority of farmers in all three areas cultivate exotic vegetables due to higher demand and marketability. The farmers also believe that crops cultivated using river water yield more than those cultivated with other sources of water. While some farmers expressed concerns about contamination, they also see the benefits of using wastewater for its nutritional qualities.

Conclusion

From the findings that emerged from this study the following conclusion is drawn. Most of the water used for the irrigation in this study area comes from the domestic use which make it seems to be polluted. But the result of the water analyzed indicated that some of the parameters exceeded the recommended permissible limits while majority are within the recommended permissible limits of FAO (2006). Also, the findings show that there is difference in quality of the wastewater between dry and wet seasons in the study area. Also, the findings show that despite the variations in the parameters analyzed the statistical tools shows that the wastewater is suitable for urban irrigation as confirmed by the rejected T-test hypothesis H_0 . On the other hand, from the Focus group discussion with the farmers on the implication of the water, the water has both positive and negative effects and also their preference of the wastewater overshadow the risk attached to it.

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