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# Microbiological and physicochemical evaluation of Jakara canal wastewater used for irrigation in Kano

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## Abstract

Municipal wastewater as alternative sources of water for urban agricultural (irrigation) in Kano, was analyzed to determined the coliform and physicochemical parameters. Three sampling units were designed along the canal. Seven (7) samples were collected at each point. Coliform counts were determined by most probable number (MPN) techniques. Total suspended solids (TSS), total dissolved solids (TDS), organic carbon (OC), nitrates ($NO_3^-$), ammonium-nitrogen ($NH_3^-$), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), dissolve oxygen (DO), temperature, pH, conductivity and biological oxygen demand (BOD), were all determined by standard methods. Mean fecal coliform count ranged from 64.43 ± 63.20 MPN 100/ml to 216.85 ± 350.16 MPN 100/ml with a significant different ($P < 0.05$) in the first point as compared to second and third points. Mean conductivity value ranged from 3.33 ± 21 dS/m to 3.44 ± 40 across the canal. There were fluctuations in pH, Temperature, TDS, DO, BOD and Na, values, but within normal range. A remarkable decrease in the mean values for $NH_3^-$, $NO_3^-$, TSS, K and Mg, was observed. In contrast, the mean values for OC = 87.43 ± 3.78, 89.86 ± 7.80 and 92.43 ±3.91, Ca = 0.38 ± .20, 0.40 ± .13, .40 ± .14 and MPN = 64.4 ± 63.2, 172.1 ± 210.6, 216.9 ± 350.2 for point 1, 2 and 3 respectively, increases as the water moved along. All physicochemical parameters were within FEPA and WHO/FAO acceptable limits, except for conductivity which need to be monitored to avoid salinity.

## Keywords

Coliform, Physicochemical Parameters, Wastewater Quality, Salinity and Urban Agriculture

## 1. Introduction

In many arid and semi-arid regions of the world, water has become a limiting factor, particularly for agricultural and industrial development. Low quality waters such as wastewater, drainage waters and brackish waters are considered as alternative sources for less restrictive uses. Millions of families in developing world improve their access to food and raise income through agricultural activities in urban and peri-urban areas, which is now widely accepted as an urban livelihood strategy (Rakodi and Lloyd-Jones, 2002; Dreschel, *et al.,* 2008 and Karanja *et al.*, 2010). As many as 800 million people in cities and towns world-wide are already raising livestock and cultivating crops in vacant plots, on marginal lands, and in small private plots (Hussain *et al.,* 2001). Urban farming has also been reported to provide for 70% of vegetables consumption in Dakar and 90% in Dar es Salaam (Nugent, 2000 cited by Karanja *et al.*, 2010). Agricultural use of water resources is of great importance due to the high volumes that are necessary. Irrigated agriculture now plays a dominant role in the sustainability of crop production and in years to come (WHO/UNEP 1997). In many cases, untreated or partially treated wastewaters are used to irrigate crops grown by this large number of people (Faruqui *et al.,* 2004; Scott *et al.*, 2004). For example, in Dakar, Senegal, more than 60% of the vegetables consumed in the city were grown in urban areas by use of a mixture of groundwater and untreated wastewater, while 90% of lettuce and spring onions consumed in Kumasi, Ghana are produced in the urban areas (Faruqui, *et al.,* 2004). Many of such water contain high volume of organic matter, which serves as good source of manure for the irrigation farmers as well as medium for the growth of pathogenic microorganisms. Wastewater used for irrigation has often been shown to contain microbiological contaminants exceeding the WHO guidelines (Blumenthal *et al*., 2000 and WHO, 2006). In China, the use of contaminated industrial wastewater for crop production has been associated with a 36% increase in hepatomegaly (enlarged liver), and a 100% increase in both cancer and congenital malformation while in Japan, Itai-itai disease, a bone and kidney disorder, was associated with chronic cadmium pollution of paddy water coming from the Jizu River (Kakar *et al.,* 2006).

Municipal water is source of biological and chemical pollutants that may affect human health, tens of thousands of contaminants are being used routinely in industries, hospitals, domestics and agricultural production, and unfortunately, there is no cost-effective method to monitor routinely the hazardous biological and chemical pollutants in wastewater. The use of such waters constituted major public health hazards, ranged from microbial contamination and accumulation of toxic chemicals through bioaccumulation in the food chain system. Vegetables farmer in Kano municipality has been using wastewater as alternative source for irrigation water source. Wastewater from domestics, laundries, hospital, abattoirs and few tanneries, collects into central canals, then delivered to final collection point, "Wase Dams". A part from water coming from tanneries that received partial treatment; other waters are not treated. People in Kano municipality has almost yearly suffered gastrointestinal disease outbreaks, which coincided with the season of high consumption of vegetables, with the speculations that these vegetables were contaminated, the sources which were never investigated. It is in view of these, and need to provide continuous flow of data for wastewater quality, the research aimed at finding the microbiological and physicochemical limits of Jakara wastewater canal contamination in particular, which are presently relatively unavailable, as a resource for better public health decisions by health agencies.

## 2. Material and Method

### 2.1. Study Area

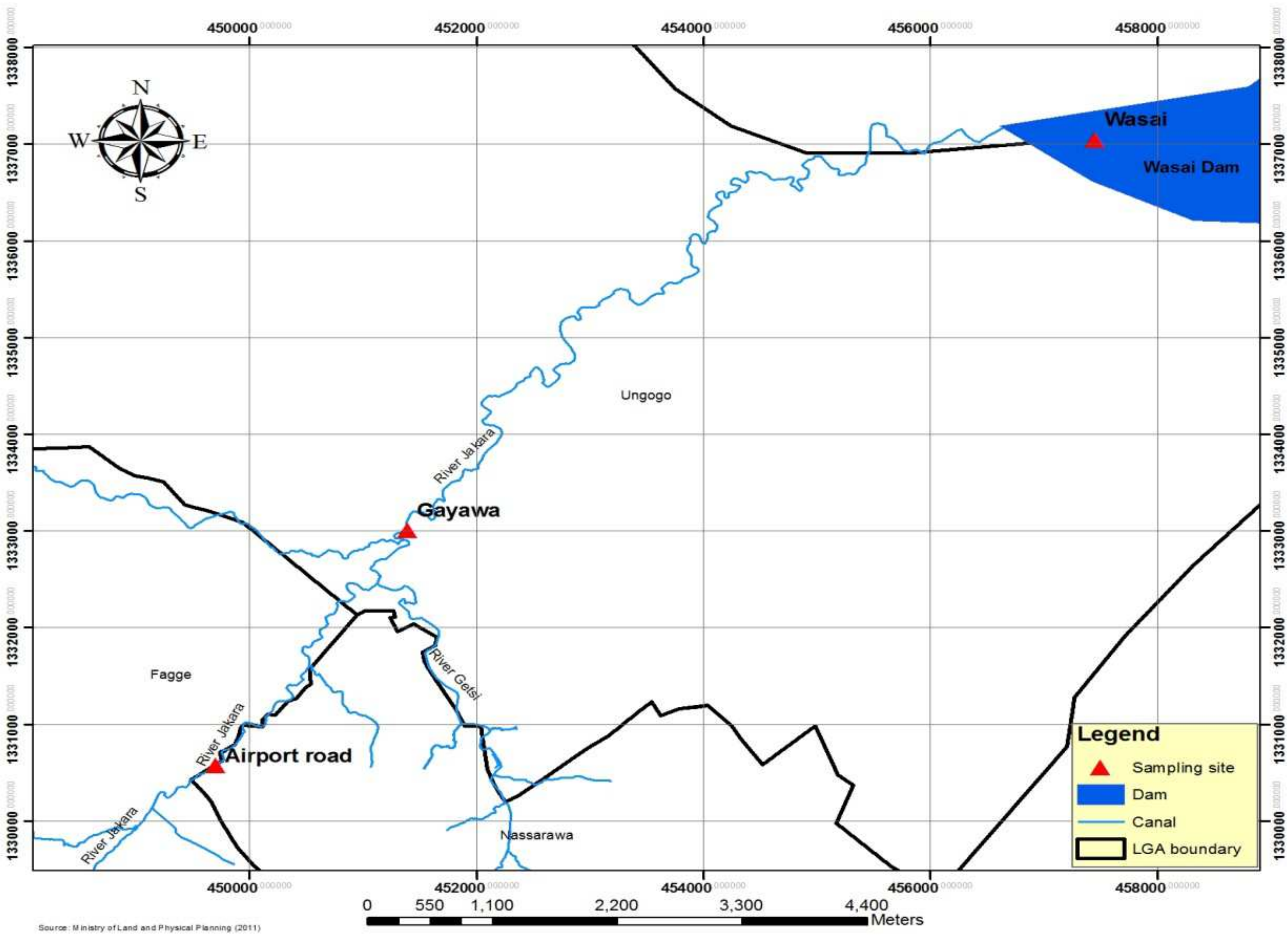


***Figure 1.*** *Map of Jakara wastewater cannal showing the three sampling sites in red.*

Samples were collected from Jakara canal Kano city, Northern part of Nigeria. The canal is located at North-Eastern part of Kano city. It originates from Jakara quarter and transverses a number of villages terminating at “Wase” Dam, in Minjibir local Government area. Wastewater generated from the city’s main abattoir, Dala, Fagge, Nassarawa and Ungogo local government’s areas are collected into this canal. Other sources of wastewater to Jakara canal include two sewage treatment plants (former Nigerian telecommunication company (NITEL) training institute and Airport road treatment plant), the most highly attended Hospital in Kano (Murtala Mohammed General Hospital) and the infectious disease Hospital. The wastewater from this canal, serves as sources of irrigation water, to vegetables farmers during dry season, in Kano municipality.

## 2.2. Samples Collection and Analyses

Three sampling units were chosen for the sample collection along the canal. Then samples were collected from where most farmers use as service point to draw the water for flood irrigation. The sampling points were distributed 1 km radius distance from each sampling unit to ensue appropriate spatial coverage of the study area. Twenty-one samples were collected at different points along the canals, (Initial point of utilization, mid-point and upstream/ terminal point of utilization of each canal), seven from each point. Samples were collected in two [2] sterile bottles, for biologicaloxygen demand [BOD] test, samples were collected in BOD bottles while that for physicochemical and other microbiological analyses were collected in another sterile bottle.

## 2.3. Coliform Counts

Coliform counts were determined by most probable number (MPN) techniques. Wastewater samples of (50 ml, 10 ml, 1 ml, 0.1 ml and 0.01 ml) were dispensed by sterile syringe each, into three sets of five test tubes respectively, the first set contained 10 ml double strength lactose broth medium each. While the other two sets contained 10 ml single strength lactose broth each. All the tubes contain Durham’s tube each, for collection of gas as the case may be. These were incubated for 48 hrs at $37^{O}C$. Tubes that show turbidity and gas production, or a colour change (yellow), an indication of acid production, were regarded as positive after 18, 24 or 48 hrs. Numbers of positive tubes at each dilution set were recorded and interpreted accordance with MPN Table [McCrady table], (Koneman *et al.,* 1994 and Schlegel, 1995).

## 2.4. Physicochemical Analyses

Total suspended solids (TSS), total dissolved solids (TDS), organic carbon (OC), nitrates, ammonium-nitrogen, calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), were determined following procedures described in Manual of soil, plant and water analysis (Ademoroti, 1996 and Udo *et al.*, 2009). While dissolve oxygen (DO), temperature, pH and conductivity were determined by using HORIBA U-10, (Jenway Ltd) water quality checker, at the site of samples collection, while the BOD was determined after five days of incubation of the water sample (Udo *et al*, 2009).

## 2.5. Statistical Analysis

Descriptive statistics was used to determine the mean and standard deviation of the values of various parameters tested, while T- test and correlation analysis where applied to determine locate differences and possible relationships between samples, parameters analyzed and point of collections.

***Table 1.*** *Physicochemical parameters of Jakara canal wastewater used for irrigation in Kano*

| Parameter | 1st Point | 2nd Point | 3rd Point | Total | Recommended maximum limit for irrigation wastewater |
|---|---|---|---|---|---|
| | Mean and Standard Deviation | Mean and Standard Deviation | Mean and Standard Deviation | Mean and Standard Deviation | |
| MPN/100 ml | 64.43 ± 63.20 | 172.11 ± 210.56 | 216.85 ± 350.16 | 151.13 ± 239.56 | $10^3$ |
| Temp ($^0C$) | 28.71 ± .80 | 31.52 ± 2.94 | 31.77 ± 3.49 | 30.60 ± 2.91 | 40 $^0C$ [2] |
| pH | 6.73 ± .42 | 6.84 ± .27 | 6.60 ± .23 | 6.72 ± 0.32 | 6.5 -8.4 |
| Conduct (ds/m) | 3.33 ± .21 | 3.49 ± .46 | 3.44 ± .40 | 3.42 ± 0.36 | 0.7 -3.0 dS/m [3] |
| DO (mg/l) | 1.68 ± .07 | 2.50 ± .86 | 1.76 ± .81 | 1.97 ± 0.75 | - |
| BOD (mg/l) | 1.35 ± .18 | 2.28 ± .977 | 1.66 ± .78 | 1.77 ± 0.80 | 10 mg/l [1] |
| Nitrogen (mg/l) | .05 ± .03 | .01 ± .028 | .00 ± .00 | 0.03 ± 0.03 | 5 -30 mg/l [3] |
| Nitrate (mg/l) | .24 ± .11 | .09 ± .12 | .01 ± .01 | 0.11 ± 0.13 | - |
| TDS (mg/l) | 235.71 ± 19.70 | 223.29 ± 23.01 | 254.57 ± 38.75 | 237.9 ± 29.99 | 450 – 2000 mg/l [3] |
| TSS (mg/l) | 106.14 ± 17.57 | 101.29 ± 10.58 | 92.14 ± 7.20 | 99.86 ± 13.31 | 50 -100 mg/l [3] |
| Ca (mg/l) | .38 ± .20 | .40 ± .13 | .40 ± .14 | 0.39 ± 0.15 | - |
| OC (mg/l) | 87.43 ± 3.78 | 89.86 ± 7.80 | 92.43 ± 3.91 | 89.91 ± 5.61 | |
| Mg (mg/l) | .28 ± .14 | .20 ± .08 | .15 ± .06 | 0.21 ± 0.11 | 0.2 [2] |
| K (mg/l) | .14 ± .03 | .16 ± .02 | .11 ± .05 | 0.14 ± 0.04 | - |
| Na (mg/l) | 2.90 ± .66 | 3.15 ± .40 | 3.06 ± .73 | 3.03 ± 0.59 | >100 mg/l [3] |

Keys: Temp = Temperature, Conduct = Conductivity, DO = Dissolve Oxygen, BOD = Biological Oxygen demand, TDS = Total Dissolved Solid, TSS = Total Suspended Solid, OC = Organic Carbon, Ca = Calcium, Mg = Magnesium, K= Potassium, Na = Sodium.

Source: Ayaers and Westcot, 1985

1. US EPA (1992)
2. FEPA (1991)
3. WHO/FAO (1997)

## 3. Result

Mean fecal coliform count observed from the three wastewater sampling points, were within the WHO/FAO/FEPA recommended maximum limit for irrigation wastewater, there was however significant different ($P < 0.05$) in the mean MPN counts from samples collected at point one as compared to second and third points.

There were significant differences in the values obtained between sampling points of all the physicochemical parameters measured, except for Nitrogen and Nitrate, which only second point showed significant difference ($P < 0.05$) in both parameters. However, they were all within the acceptable limit, if not for electrical conductivity which is a little above 3 dS/m. It ranged from 3.33 ± 21 dS/m to 3.44 ± 40 across the sampling points. Even though, there were little fluctuations in the values observed for pH, Temperature, TDS, DO, BOD and Na, they all showed statistical significant difference ($P < 0.05$) in the values obtained across sampling points. Never the less, values were within the acceptable limit for irrigation wastewater. In the values obtained for ammonium-nitrogen, nitrate, TSS, K and Mg, there were remarkable decrease along the canal as the water moves from the initial point of release to its point of destination, for instance Nitrogen values obtained ranged from 0.05 ± .03, 0.01± .03 and 0.00 ± .00 for point 1st ,2nd and 3rd point respectively. In contrast, the values obtained for OC, Ca and MPN increases as the water moved along the canal (e.g. Ca 0.38 ± .20, 0.40 ± .13, .40 ± .14 for point 1, 2 and 3 respectively). There were no significant positive correlation between values of all parameters analyzed and the MPN coliform of the wastewater except at second point, where organic carbon showed a positive correlation at $P > 0.01$ significant level (Table 2).

***Table 2.*** *Pearson correlation coefficients and their respective p-values describing relationships between the Coliform Counts (MPN) of Jakara Canal Wastewater, collected at different points and other measured parameters.*

| Variables | 1st point | | 2nd point | | 3rd point | |
|---|---|---|---|---|---|---|
| | Pearson \|r\| | \|p\| | Pearson \|r\| | \|p\| | Pearson \|r\| | \|p\| |
| MPN/100 ml | 1 | | 1 | | 1 | |
| Temp (⁰C) | -.368 | .417 | -.272 | .555 | -.491 | .264 |
| pH | .023 | .962 | .035 | .941 | .024 | .959 |
| Conduct (ds/m) | -.608 | .147 | .124 | .792 | -.302 | .510 |
| DO (mg/l) | -.126 | .788 | -.062 | .895 | .028 | .953 |
| BOD (mg/l) | -.364 | .423 | -.023 | .961 | .071 | .880 |
| Nitrogen (mg/l) | -.565 | .186 | .096 | .837 | -.175 | .708 |
| Nitrate (mg/l) | -.565 | .186 | .096 | .837 | -.175 | .708 |
| TDS (mg/l) | -265 | .565 | .056 | .905 | .083 | .859 |
| TSS (mg/l) | -.420 | .348 | .397 | .377 | .084 | .858 |
| OC (mg/l) | -.335 | .462 | -.954** | .001 | .602 | .153 |
| Ca (mg/l) | -.100 | .831 | .041 | .930 | .293 | .524 |
| Mg (mg/l) | -.514 | .238 | .064 | 891 | -.242 | .601 |
| K (mg/l) | -.173 | .711 | .044 | .925 | .173 | .711 |
| Na (mg/l) | -.731 | .062 | .743 | .056 | -.191 | .682 |

Key = ** Statistically significant relationships (p>0.01), Temp = Temperature, Conduct = Conductivity, DO = Dissolve Oxygen, BOD = Biological Oxygen demand, TDS = Total Dissolved Solid, TSS = Total Suspended Solid, OC = Organic Carbon, Ca = Calcium, Mg = Magnesium, K= Potassium, Na = Sodium.

## 4. Discussion

Although most of the parameters observed were within the WHO/FAO (1997) and FEPA (1991) recommended maximum limit for irrigation wastewater, however values observed showed fluctuation along the collection points for most of the parameters. The fluctuations in the values from one sampling point to the other, indicates continues introduction or reduction of contaminant as wastewater move along the canal. MPN coliform counts observed from Jakara Canal water, although within $10^3$, and lower than what was reported by Agbogu *et al*. (2006) from Samuru river, (also used for irrigation of vegetables) in Zaria city, Kaduna Nigeria, and the values he reported were within the range of $3.0 \times 10^4 - 3.5 \times 10^5$ , that is >1000MPN/100ml. The high coliform count obtained could be an indicator of faecal contamination (EPA, 2003). These showed that wastewater used for irrigation purpose from Jakara wastewater canal is more contaminated than that of Samuru River microbiologically. Although, the use of domestic wastewater for irrigation poses less risk to both environmental and agricultural practices, than industrial wastewaters, especially where highly toxic chemical are involved in the production processes. But in a situation where wastewater involves the combination of both (domestic and industrial) the water could be hazardous more than what may be expected to be. The MPN coliform concentration was mainly seen to be influenced only by the concentration of organic carbon at second the midstream of the river (second point of collection), at $p > 0.01$ significant level. This probably is an indicator of highest contamination level of the wastewater and a point, at which vegetables grown, surface waters and shallow wells around the area are likely to be more contaminated than any other location (farm) along the canal. This poses a serious public health hazard, capable of causing water borne disease outbreak. Previous percolation studies had demonstrated the movement of bacteria from surface to the underground water, depending on the intensity of water flow and the number of water applications (Trevors *et al*., 1990).

There were significant differences in the values obtained between sampling points of all the physicochemical parameters measured, except for Nitrogen and Nitrate, which only second point showed significant difference ($P < 0.05$) in both parameters. Unlike the toxic chemicals and trace element whose presence in wastewater are link mainly to industrial waste discharge, the wastewater born nitrogen originates primarily from fecal matter and food residues. From agricultural point of view, excess nitrogen in irrigation water may not be beneficial to crop growth. Excess nitrogen often results in luxurious vegetative growth, which delays the time for plant to reach maturity and adversely affect harvest quality (Magnusson and Kristin, 2014).

The most influential water quality guideline on crop production is the salinity hazard as measured directly by a set of parameters such as conductivity, sodium adsorption ratio, sodium and chlorine concentration and dissolve solids. Electrical conductivity (EC) is a measure of all ions dissolved (soluble salts) in a sample. It includes negatively charged ions (e.g., $Cl^-$, $NO^-3$) and positively charges ions (e. g., $Ca^{++}$, $Na^+$). The primary effect of high EC water on crop production is the inability of the plant to compete with ions in the soil solution for water (physiological drought). When there is high EC, there is less water to plant because plant can only transpire “pure water” therefore usable plant water in the soil decrease dramatically as EC increases. In the result obtained from temperature and pH there were no much fluctuations within the wastewater analyzed from both the three sampling points, apart from pH being almost neutral, both were within the recommended maximum limit for irrigation water (FEPA, 1991) and have showed no any significant differences ($P > 0.05$). Despite the fact that, research has demonstrated the antimicrobial activity of Calcium compounds due to their exceptional elevated pH (Estrela *et al*., 1995), for instance, Ethylenediaminetetraacetic acid (EDTA) was reported as chelating agent even at low dose, can (EDTA) serves as candidate in prevention of infection by periodontopathic bacteria (Miura *at el.,* 2012), and also suppress the *Esherichia coli* by removing the metal ions required for its growth. The calcium concentration recorded in this work does not showed any influence in the coliform bacteria observed.

Organic matter in wastewater not only adds nutrient to soils, but also enriches the humic content that increases soil moisture, retains metals that help in the formation of organometallic compounds and enhance microbial activity. This capacity gives wastewater additional advantage over synthetic fertilizers.

Biological oxygen demand (BOD) concentrations of the wastewater were observed to be low, which is normal for wastewater whose largely comes from domestics sources. BOD usually becomes problem when it become extremely high above 500 mg/l and in combination with large volume of total dissolved solids, these could cause clogging of soil (Darrell, 2002). Though suspended solids in wastewater can also results in clogging and reduce percolation, especially when the solids are not biodegradable. It is normal to observe a low potassium concentration in wastewater, mostly insufficient to cover the theoretical demand of potassium by plant, thus wastewater does not normally cause negative environmental impacts.

## 5. Conclusion

The continuous increase in the values of organic carbon content, calcium content and the mean coliform counts indicates a constant introduction of organic matter into the canal, from many sources. Though all the physicochemical parameters analyzed were within the recommended maximum limit, for irrigation wastewater, but there is however need for routine monitoring, especially, of conductivity so that salinity may not occur.

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