Physicochemical Determination of Pollutants in Wastewater and Vegetable Samples along the Jakara Wastewater Channel in Kano Metropolis, Kano State, Nigeria

J.C. Akan
Department of Chemistry, Faculty of Science, University of Maiduguri, P.M.B 1069 Maiduguri, Borno State, Nigeria
E-mail: joechemakan@yahoo.com
Tel: 2348036000506

F.I. Abdulrahman
Department of Chemistry, Faculty of Science, University of Maiduguri, P.M.B 1069 Maiduguri, Borno State, Nigeria

G.A. Dimari
Department of Chemistry, Faculty of Science, University of Maiduguri, P.M.B 1069 Maiduguri, Borno State, Nigeria

V.O. Ogugbuaja
Department of Chemistry, Faculty of Science, University of Maiduguri, P.M.B 1069 Maiduguri, Borno State, Nigeria

Abstract

Wastewater and vegetable samples were collected from the Jakara wastewater channel near the Airport Road Bridge, Kano metropolis. Samples were collected between the periods of November 2007 to May 2008 to determine the following parameters, pH, temperature, turbidity, chemical oxygen demand (COD), Biological oxygen demand (BOD), dissolved oxygen (DO), conductivity, total dissolved solid (TDS), total suspended solid (TSS), sulphate, nitrate, nitrite and phosphate. In addition, metals (copper, cobalt, chromium, iron, manganese, magnesium, nickel, cadmium, lead, sodium, potassium and calcium were determined. Levels of pH, conductivity, temperature, nitrate, nitrite, sulphate, phosphate, TSS, TDS, DO, BOD and COD were higher than the maximum permissible limits set by Federal Environmental Protection Agencies (FEPA) Nigeria. The concentrations of the metals in the wastewater and vegetables samples were higher than limits set by WHO and the maximum contaminant levels (MCL). The high concentration of metals in the vegetable samples suggests that the wastewater used for the irrigation of these vegetables within the study area can be classified as polluted and thus unfit for irrigation of crops. Thus, the wastewater around the Jakara channel is highly polluted. Domestic and industrial waste should be properly disposed and or recycled. Relevant agencies should make continuous effort to control, regulate and educate populace on indiscriminate waste disposal from domestic and industries within the study area.
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Keywords: Physicochemical, Pollutant, Wastewater, Vegetable, Jakara channel.

Introduction
Heavy metals are present in food in very minute quantities; the existence is due to their role in body metabolism, it has been establish that whatever is taken as food might cause metabolic disturbance if it does not contain the permissible upper and lower limits of heavy metals. Thus, both deficiency and excess of essential micro-nutrients (iron, zinc and chromium) may produce undesirable effects (Konofal et al., 2004; Kocak et al., 2005). Effect of toxic metals on human health and their interactions with essential heavy metals may produce serious consequences (Abdulla and Chmielnicka, 1990). From this viewpoint, metals such as iron, lead, chromium, nickel, arsenic and cadmium are considered suitable for studying the impact of various foods on human health. Arsenic occurs naturally in food at concentration levels, which are rather essential.

Wastewater discharge from sewage and industries are major component of water pollution, contributing to oxygen demand and nutrient loading of the water bodies, promoting toxic algal blooms and leading to a destabilized aquatic ecosystem (Morrison et al, 2001; DWAF and WRC, 1995). High or low pH values in a river have been reported to affect aquatic life and alter toxicity of other pollutant in one form or the other (DWAF, 1996c). Low pH values in a river for examples impair recreational uses of water and effect aquatic life. A decrease in pH values could also decrease the solubility of certain essential element such as selenium, while at the same time low pH increases the solubility of many other element such as Al, B, Cu, Cd, Hg, Mn and Fe (DWAF, 1996c).

High nitrate concentrations are frequently encountered in treated wastewater, as a result of ammonium nitrogen. High nitrate levels in wastewater could also contribute to eutrophication effects, particularly in freshwater (OECD, 1982). Many workers have been reported to have potential health risk from nitrate in drinking water above threshold of 45 mg/l, which may give rise to a condition known as methaemoglobinemia in infants and pregnant women (Speijer, 1996).

Biological oxygen demand (BOD) measure the amount of oxygen requires by bacteria for breaking down to simpler substances the decomposable organic matter present in any water, wastewater or treated effluent. It is also taken as a measure of the concentration of organic matter present in any water. The greater the decomposable matter present, the greater the oxygen demand and the greater the BOD values (Ademoroti, 1996; Standard methods, 1998). Electrical conductivity of water is a useful and easy indicator of its salinity or total salt content. Wastewater effluents often contain high amounts of dissolved salts from domestic sewage. High salt concentrations in waste effluents however, can increase the salinity of the receiving water, which may result in adverse ecological effects on aquatic biota (Ademoroti, 1996). Vegetables are staple part of human meals taken as food in raw and cooked forms.

The Jakara site is located near Airport Road Bridge in a high-density residential area of Kano Metropolis, Kano state, Nigeria. Substantial vegetable production takes place on the south west side of the road, and crops are irrigated by domestic wastewater released from the residential areas of Kano’s ancient walled city, Sabon-Gari, and Gwagwarwa into the Jakara channel and serves as the main drain for built-up areas along the way. While some small-scale tanneries are located in certain parts of the old city, where effluent are discharged into the Jakara channel.

In view of the continues used of wastewater for the irrigation of vegetable crops in these area of Kano state, this study is aimed to assess the levels of some physicochemical parameters in wastewater and vegetable samples from the Jakara channels of Kano metropolis.
Materials And Method
Sample area and Sampling Points

Wastewater samples were collected from the Jakara channels for the analysis of physicochemical parameters. Measurement points for the sampling were designated as N1 to N4. Wastewater samples were collected at the discharge point from old ancient walled city designated as N1; 200 metres away from the ancient walled city (N2); and at 500 metres along the Sabon-Gari discharged point from the ancient walled city (N3); N4 was located at Airport Road Bridge where substantial vegetable production takes place on the southwest side of the road. Both the wastewater and vegetable samples were sampled at these points.

Sample Collection

Wastewater samples were collected in plastic containers previously cleaned by washing in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO3 for 24 hours and finally rinsed with deionised water prior to usage.

During sampling, sample bottles were rinsed with sampled water three times and then filled to the brim at a depth of one meter below the wastewater from each of the four designated sampling points (N1 to N4). The samples were labeled and transported to the laboratory, stored in the refrigerator at about 4ºC prior to analysis. Vegetables samples such as Spinach (*Amaranthus caudatus*), lettuce (*Lactuca sativa*), cabbage (*Brassica oleracea*), carrot (*Daucus carota*), onion (*Allium cepa*), tomato (*Lycopersicon esculentum*) water leaf (*Talinum triangulare*), eggplant (*Solanum melongena*), and watermelon (*Citrullus vulgaris*) grown along the Jakara wastewater channel were also collected for analysis. Samples were collected between the periods of November 2007 to May 2008.

Determination of Physicochemical pollutant indicators

All field meters and equipment were checked and calibrated according to the manufacturer’s specifications. The pH meter was calibrated using HACH (1997) buffers of pH 4.0, 7.0 and 10.0. Dissolved oxygen (DO) meter was calibrated prior to measurement with the appropriate traceable calibration solution (5%HCl) in accordance with the manufacturer’s instruction. The spectrophotometers (HACH DR2010) for anions determination were checked for malfunctioning by passing standard solutions of all the parameters to be measured; Blank samples (deionized water) were passed between every three measurements of wastewater samples to check for any eventual contamination or abnormal response of equipment.

The dependent variables analyzed were pH, temperature, dissolved oxygen, total dissolved solid, nitrate, sulphate, phosphate and heavy metals concentration. Standard methods were followed in determining the above variables (APHA, 1998). In-situ measurements for some of the parameters, pH and temperature (°C) were measured using WTW pH Electrode SenTix 41. Dissolved oxygen was measured with Jenway Model 9070 waterproof meter. Conductivity/TDS meter (Hach model C0150) was used to measure the conductivity and total dissolved solids of the water samples. The power key and the conductivity key of the conductivity/TDS meter were switched on, and the meter was also temperature adjusted; the instrument was calibrated with 0.001M KCl to give a value of 14.7μS/m at 25°C. The probe was dipped below the surface of the wastewater and surface water. Time was allowed for the reading to be stabilized and reading was recorded. The key was then changed to TDS key and recorded. The probe was thoroughly rinsed with distilled water after each measurement. Levels of turbidity and total suspended solid of the wastewater samples were determined using standard procedures approved by AOAC (1998).

The biological oxygen demand determination of the wastewater samples in mg/l was carried out using standard methods described by Ademoroti (1996). The dissolved oxygen content was determined before and after incubation. Sample incubation was for 5 days at 20OC in BOD bottle and
BOD was calculated after the incubation periods. Determination of chemical oxygen demand was carried out using closed reflux method as described by Ademoroti (1996).

**Digestion of Wastewater Samples for Heavy Metals Determination**

The wastewater samples were digested as follows. The sample, 100cm³ was transferred into a beaker and 5ml concentrated HNO₃ was added. The beaker with the content was placed on a hot plate and evaporated down to about 20ml. The beaker was cool and another 5ml concentrated HNO₃ was also added. The beaker was covered with watch glass and returned to the hot plate. The heating was continued, and then small portion of HNO₃ was added until the solution appeared light coloured and clear. The beaker wall and watch glass were washed with distilled water and the sample was filtered to remove any insoluble materials that could clog the atomizer. The volume was adjusted to 100cm³ with distilled water (Ademoroti, 1996). Determination of heavy metals in the wastewater samples was done using Atomic Absorption Spectrophotometer (AAS, Unicom 969) as described in the manufacturer’s instruction manual.

**Digestion of Vegetable Samples for Heavy Metals Determination**

The vegetables samples were weighed to determine the fresh weight and dried in an oven at 80°C for 72 hours to determine their dry weight. The dry samples were crushed in a mortar and the resulting powder digested by weighing 0.5g of oven-dried ground and sieve (<1mm) into an acid-washed porcelain crucible and placed in a muffle furnace for four hours at 500°C. The crucibles were removed from the furnace and cooled. 10ml of 6M HCl was added covered and heated on a steam bath for 15minute. Another 1ml of HNO₃ was added and evaporated to dryness by continuous heating for one hour to dehydrate silica and completely digest organic compounds. Finally, 5ml of 6M HCl and 10ml of water were added and the mixture was heated on a steam bath to complete dissolution. The mixture was cooled and filtered through a Whatman no. 541 filter paper into a 50ml volumetric flask and made up to mark with distilled water.

**Elemental Analysis of Digested Samples**

Determination of heavy metals (copper, cobalt chromium, iron, manganese, magnesium, nickel cadmium, and lead) was made directly on each final solution using Perkin-Elmer AAnalyst 300 Atomic Absorption Spectroscopy (AAS) as described by Floyd and Hezekiah (1997). Flame emission spectrometer (FES) Gallenkamp (FGA330) was used to determine sodium (Na), potassium (K) and Calcium (Ca).

**Determination of Nitrate, Nitrite, Sulphate and Phosphate in the Wastewater Samples**

The concentration of nitrate, nitrite, sulphate and phosphate were determined using DR/2010 HACH Portable Data Logging Spectrophotometer. The spectrophotometers were checked for malfunctioning by passing standard solutions of all the parameters to be measured; blank samples (deionized water) were passed between every three measurements of water samples to check for any eventual contamination or abnormal response of equipment. Nitrate as nitrogen was determined by the cadmium reduction metal method 8036[Standard methods, 1976., DWAF, 1992]. The cadmium metal in the added reagent reduced all nitrate in the sample to nitrite; while sulphate was determined by using Sulfa Ver methods 8051 [Standard methods, 1976., DWAF, 1992].
Determination of Nitrate, Nitrite, Sulphate and Phosphate in the Vegetable Samples

Determination of nitrate and nitrite
The concentration of nitrate and nitrite analyzed in each of the vegetable samples were carried out using smart spectro Spectrophotometer (LaMotte 2000). Vegetable samples solutions were prepared by chopping each sample into smaller sizes. A known amount (1g) of the chopped sample was transferred into 100ml flask and soaked with 50ml of distilled water. The flask was capped and shaken for 30 minutes, then filtered into another 100ml volumetric flask and the volume made to the mark with distilled water. (Radojevic and Bashkin, 1999) Nitrate was determined spectrophotometrically using standard cadmium reduction method 3649 – SC (Lamotte, 2000), while Nitrite was determined using standard diazotization method 3650 – SC (Lamotte, 2000).

Determination of phosphate
Each of the vegetables samples was chopped into small pieces. The chopped samples were then air-dried. The air-dried samples were ground and sieved with a siever of mesh 1mm. A known amount (1g) of each of the ground and sieved samples was weighed into acid-washed porcelain crucibles. The crucibles were labeled and 5ml of 20% (w/v) magnesium acetate were added and evaporated to dryness. The crucibles were then transferred into the furnace and the temperature was raised to 500ºC. The samples were ashed at this temperature for four (4) hours. Removed and cooled in desiccators.

Ten (10) ml of 6M HCl were then added to each of the crucible and covered, then heated on a steam bath for fifteen minutes. The contents of each crucible were completely transferred into different evaporating basins and 1ml of concentrated HNO3 was added. The heating continued for 1 hour to dehydrate silica. 1ml of 6M HCl was then added, swirled and then followed by the addition of 10ml-distilled water and again heated on the steam bath to complete dissolution. The contents of the evaporating basins were cooled and then filtered through a Whatman no.1 filter paper into 50ml volumetric flasks and the volumes made up to the marks with distilled water (Radojevic and Bashkin, 1999). Phosphate was determined using Hach Direct Reading 2000 Spectrophotometer.

Determination of sulphate
For sulphate determination, 5ml of magnesium nitrate solutions were added to each of the ground and sieved samples in the crucibles. These were then heated to 180ºC on a hot plate. The heating process was allowed to continue until the colour of the samples changed from brown to yellow (Kenneth, 1990). The samples were then transferred to the furnace at a temperature of 500ºC for four hours. Magnesium nitrate was added to prevent loss of sulphur. The contents of each crucible were carefully transferred to different evaporating basins. 10ml of concentrated HCl were added to each of them and covered with watch glasses. They were boiled on a steam bath for 3 minutes. On cooling, 10ml of distilled water were added to each of the basins and the contents of each were filtered into 50ml volumetric flasks and the volumes made up to the marks with distilled water (Radojevic and Bashkin, 1999). Sulphate was determined using Smart spectro Spectrophotometer (2000).

Results and Discussion
The levels of the physicochemical parameters are presented in Table 1. From the results of this study the levels of pH varied between 9.94±1.32 and 8.94±2.03 for point N1 and N2, and 10.34±1.43 to 9.54±0.54 for point N3 and N4 in the wastewater respectively. Generally point N3 shows the highest concentration followed by N1, while point N2 shows the least concentration. The mean pH values recorded for all the sampling point were above the WHO pH tolerance limit of between 6.00 – 9.00 for wastewater to be discharged into channel into stream with exception of point N2.
Table 1: Concentration of Physicochemical Parameters in wastewater samples from Jakara channel, Kano metropolis, Kano State, Nigeria

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sampling Points N1</th>
<th>N2</th>
<th>N3</th>
<th>N4</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9.94±1.32</td>
<td>8.94±2.03</td>
<td>10.34±1.43</td>
<td>9.54±0.54</td>
</tr>
<tr>
<td>Temp (°C)</td>
<td>32.34±0.32</td>
<td>31.11±0.11</td>
<td>36.34±2.94</td>
<td>33.34±1.44</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>36.33±2.13</td>
<td>34.23±2.32</td>
<td>42.22±3.10</td>
<td>33.34±2.01</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>564.32±5.43</td>
<td>512.45±7.21</td>
<td>698.11±6.45</td>
<td>531.05±9.23</td>
</tr>
<tr>
<td>BOD (mg/l)</td>
<td>254.11±2.32</td>
<td>223.43±4.23</td>
<td>341.11±4.34</td>
<td>245.22±2.77</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>7.43±0.76</td>
<td>6.22±0.23</td>
<td>8.43±0.56</td>
<td>6.56±0.49</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>2321.23±33.23</td>
<td>2210.21±22.32</td>
<td>2655.43±16.33</td>
<td>2456.22±18.90</td>
</tr>
<tr>
<td>TSS (mg/l)</td>
<td>1237.12±12.45</td>
<td>1131.23±14.32</td>
<td>2673.22±17.32</td>
<td>2673.22±17.32</td>
</tr>
<tr>
<td>Conductivity (µS cm⁻³)</td>
<td>1123.41±10.21</td>
<td>1021.17±14.32</td>
<td>1534.21±12.43</td>
<td>1477.32±14.32</td>
</tr>
<tr>
<td>Sulphate (mg/l)</td>
<td>172.32±0.83</td>
<td>154.33±1.02</td>
<td>252.21±1.32</td>
<td>212.22±0.77</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>223.21±1.21</td>
<td>211.43±0.34</td>
<td>284.33±1.74</td>
<td>234.56±1.92</td>
</tr>
<tr>
<td>Phosphate (mg/l)</td>
<td>110.45±0.42</td>
<td>103.23±0.11</td>
<td>164.22±0.56</td>
<td>153.22±0.67</td>
</tr>
</tbody>
</table>

Temperature is basically important for its effect on other properties of wastewater. Average temperature of wastewater under investigation is 42.34±0.32°C for N1; 41.11±0.11°C for N2; 46.34±2.94 °C for N3 and 43.34±1.44 °C for N4. The results indicate that some reactions could be speeded up by the discharge of this wastewater into stream. It will also reduce solubility of oxygen and amplified odour due to anaerobic reaction (less oxygen). These values were higher than WHO standard of 40 °C for discharged of wastewater into stream. Similarly turbidity values were in the mean of 36.33±2.13NTU for N1; 34.23±2.32NTU for N2; 42.22±3.10NTU for N3 and 33.34±2.01NTU for N4. The values obtained for turbidity in the entire sampling points under study were higher than WHO standard of 5 NTU for discharged of wastewater into stream.

The conductivity values were 1123.41±10.21 µScm⁻³ for N1; 1021.17±14.32 µScm⁻³ for N2; 1534.21±12.43 µScm⁻³ for N3 and 1477.32±14.32 µScm⁻³ for N4 (Table 1). Conductivity of water which is a useful indicator of its salinity or total salt content is high in the wastewater from the Jakara wastewater channel. This result is not surprising, since wastewater from domestic sewage often contain high amounts of dissolved salts. The mean conductivity values for all the sampling point were higher than the WHO guideline values of 1000µScm⁻³ for the discharge of wastewater through channel into stream.

The total suspended solids (TSS) concentrations were 1237.12±12.45 for mg/l N1; 1131.23±14.32 mg/l for N2; 2673.22±17.32 mg/l for N3 and 2673.22±17.32 mg/l for N4 (Table 1). Literature classified wastewater TSS as follows: TSS less than 100 mg/l as weak, TSS greater than 100 mg/l but less than 220 mg/l as medium and TSS greater than 220 mg/l as strong wastewater. Results of the study show that wastewater from the Jakara wastewater channel can be classified as strong wastewater and cannot be discharged into stream.

The mean concentration of Total dissolved solid (TDS) in the Jakara wastewater channel are presented in Table 1. The concentration of TDS is 2321.23±33.23 mg/l for N1; 2210.21±22.32 mg/l for N2; 2655.43±16.33 mg/l for N3 and 2456.22±18.90mg/l for N4. These values obtained for TDS in all the sampling points were higher than WHO standard of 2000 mg/l for the discharged of wastewater into surface water.

The concentrations of nitrate, sulphate and phosphate in all the sampling points varied between 211.43±0.34 to 284.33±1.74 mg/l for nitrate; 154.33±1.02 to 252.21±1.32 mg/l for sulphate and 103.23±0.11 to 164.22±0.56 mg/l for phosphate respectively (Table 1). High concentration of nitrate, sulphate and phosphate were observed in point N3, while low concentrations were observed for point N2. The levels of nitrate exceeded the WHO limits of 45mg/l and South Africa guideline of 0.25 mg/l for nitrate in wastewater, while sulphate was below the WHO limit of 250 mg/l for the discharged of wastewater into river. The levels of phosphate in the entire sampling point were higher than the WHO limit of 5mg/l for the discharged of wastewater into river. The levels of nitrate may give rise to
methaemoglobinemia, also the levels of nitrate reported in this study in addition to phosphate levels can cause eutrophication and may pose a problem for other uses.

Dissolved oxygen (DO) values obtained for point N1 to N2 varied between 6.22±0.23 to 8.43±0.56 mg/l as shown in Table 1. The DO is a measure of the degree of pollution by organic matter, the destruction of organic substances as well as the self purification capacity of the water body. The standard for sustaining aquatic life is stipulated at 5mg/l a concentration below this value adversely affects aquatic biological life, while concentration below 2mg/l may lead to death for most fishes (Chapman, 1997). The DO level at point N1 to N4 was above these levels.

An indication of organic oxygen demand content of wastewater can be obtained by measuring the amount of oxygen required for its stabilization either as BOD and COD. Biological Oxygen Demand (BOD) is the measure of the oxygen required by microorganisms whilst breaking down organic matter. While Chemical Oxygen Demand (COD) is the measure of amount of oxygen required by both potassium dichromate and concentrated sulphuric acid to breakdown both organic and inorganic matters. BOD and COD concentrations of the wastewater were measured, as the two were important in unit process design. The wastewater has an average COD concentration of 512.45±7.21 to 698.11±6.45 mg/l for point N2 to N4 (Table 1). BOD concentration of the wastewater obtained for point N1 to N4 ranged between 223.43±4.23 to 341.11±4.34 mg/l respectively. The concentrations of BOD and COD in all the sampling point were higher than the WHO values of 50 mg/l and 1000mg/l for the discharged of wastewater into stream. High COD and BOD concentration observed in the wastewater might be due to the use of chemicals, which are organic or inorganic that are oxygen demand in nature.

The results for elemental concentration in wastewater samples from Jakara wastewater channel for different sampling points are presented in Figure 1. The composition of metals in the wastewater samples ranged from 2.87 to 5.22 mg/l for Mn; 4.57 to 7.45 mg/l Mg; 2.32 to 3.78 mg/l Cu; 1.00 to 3.58 mg/l Cd; 1.23 to 2.87 mg/l Pb; 2.34 to 5.23 mg/l Co; 14.56 to 21.45 mg/l Fe; 1.56 to 4.33 mg/l Cr; 11.65 to 18.45 mg/l Ni; 20.91 to 32.94 mg/l Na; 19.43 to 27.34 mg/l K and 9.56 to 16.93 mg/l Ca for point N1 to N4. The concentrations of heavy metals in the Jakarta wastewater channel are in the following order Na> K> Fe> Ni> Ca> Mg> Co> Mn> Cr> Cu> Cd> Pb. From the result of these study the concentrations of all the parameters study (Table 1) are in the following order N1>N2<N3>N4. This variation is due to the fact that point N1 is the discharged point from Kano old city walled, and decrease towards point N2. While the high values at point N3 is due to the discharged of wastewater from the Sabon-Gari area into the Jakarta channel which might increase the concentration of these parameters, and finally decreases toward point N4 due to sedimentation and dilution.
The mean elemental concentrations in vegetable samples are presented in Figure 2. The concentrations of metals in Spinach are 1.22 µg/g Mn; 2.34 µg/g Mg; 1.32 µg/g Cu; 0.32 µg/g Cd; 0.67 µg/g Pb; 2.32 µg/g Co; 7.45 µg/g Fe; 1.01 µg/g Cr; 6.44 µg/g Ni; 8.54 µg/g Na; 5.34 µg/g K and 4.87 µg/g Ca. 2.54 µg/g Mn; 2.11 µg/g Mg; 1.87 µg/g Cu; 0.76 µg/g Cd; 1.34 µg/g Pb; 1.76 µg/g Co; 6.45 µg/g Fe; 0.87 µg/g Cr; 7.86 µg/g Ni; 5.98 µg/g Na; 9.9 µg/g K and 4.11 µg/g Ca for lettuce. 2.00 µg/g Mn; 1.94 µg/g Mg; 1.09 µg/g Cu; 2.01 µg/g Cd; 1.22 µg/g Pb; 2.19 µg/g Co; 6.98 µg/g Fe; 2.45 µg/g Cr; 11.00 µg/g Ni; 10.34 µg/g Na; 12.00 µg/g K and 6.44 µg/g Ca for cabbage. 0.94 µg/g Mn; 1.00 µg/g Mg; 0.14 µg/g Cu; 0.21 µg/g Cd; 0.32 µg/g Pb; 1.34 µg/g Co; 3.22 µg/g Fe; 0.54 µg/g Cr; 4.44 µg/g Ni; 3.67 µg/g Na; 3.87 µg/g K and 2.11 µg/g Ca for carrot. 1.34 µg/g Mn; 2.33 µg/g Mg; 0.74 µg/g Cu; 0.56 µg/g Cd; 1.34 µg/g Pb; 1.98 µg/g Co; 4.34 µg/g Fe; 3.22 µg/g Cr; 5.34 µg/g Ni; 6.67 µg/g Na; 1.43 µg/g K and 5.88 µg/g Ca for onion. 0.33 µg/g Mn; 0.55 µg/g Mg; 0.33 µg/g Cu; 0.11 µg/g Cd; 0.23 µg/g Pb; 1.02 µg/g Co; 2.03 µg/g Fe; 0.21 µg/g Cr; 2.32 µg/g Ni; 2.65 µg/g K and 1.65 µg/g Ca for tomato. 2.76 µg/g Mn; 1.87 µg/g Mg; 1.32 µg/g Cu; 2.87 µg/g Cd; 1.43 µg/g Pb; 2.90 µg/g Co; 5.78 µg/g Fe; 1.34 µg/g Cr; 6.87 µg/g Ni; 6.44 µg/g Na; 7.08 µg/g K and 3.98 µg/g Ca for water leaf. 0.43 µg/g Mn; 0.53 µg/g Mg; 0.43 µg/g Cu; 0.11 µg/g Cd; 0.25 µg/g Pb; 1.21 µg/g Co; 2.22 µg/g Fe; 0.19 µg/g Cr; 1.67 µg/g Ni; 2.54 µg/g Na; 2.56 µg/g K and 1.44 µg/g Ca for water melon. 0.45 µg/g Mn; 0.54 µg/g Mg; 0.45 µg/g Cu; 0.13 µg/g Cd; 0.26 µg/g Pb; 1.23 µg/g Co; 2.44 µg/g Fe; 0.18 µg/g Cr; 1.68 µg/g Ni; 2.56 µg/g Na; 2.45 µg/g K and 1.46 µg/g Ca for egg plant. From the result of this study cabbage shows the highest concentrations of these metals, follows by lettuce> spinach> water leaf> onion> carrot> water melon> egg plant> tomato.
In the whole vegetables studied, leaves contained much higher concentrations of heavy metals than roots and fruit. Similar study was carried out by Santamaria et al., (1999) shows that the heavy metals content of various parts of plant differs, the researchers reported that in vegetables organs the concentrations of heavy metals are in the order of leaf> stem> root> tuber> bulb> fruit> seed. Anikwe and Nwobodo (2002) have reported high level of heavy metals (Pb, Fe, Cu and Zn) in their study of the long term effects of municipal waste disposal on soil properties and productivity of sites used for urban agriculture in Abakaliki, South eastern part of Nigeria. Amusan et al., (1999) studied plant uptake of heavy metals on a similar site at University of Ife garbage dump and found out that Pb uptake by water leaf (Talinum triangulare), okra (Albennucus esculentus) increased in leaves and roots of water leaf and in the fruit of okra relative to those grown in the non-dump sites Similar work by Ademoronti (1996) showed that vegetables accumulate considerable amount of heavy metals especially Pb, Cr, Cu, Zn in roots and leaves.

The concentrations of metals in all the vegetable samples study in the present research were higher than the limits set by WHO. The high concentrations of these metals could be attributed to the used of untreated wastewater from the Jakara channel by farmers for the irrigation of these vegetables (Audu and Lawal, 2005). The result of this study agreed with the data reported by Liu et al., (2005). Result from present and earlier reports by some researchers (Muchuweti et al., 2006; Sharma et al., 2007) demonstrated that the plants grown on wastewater-irrigated soils are contaminated with heavy metals and pose a major health concern.

The concentrations of nitrate, nitrite, sulphate and phosphate are presented in figure 3. Levels of nitrate in all the vegetable samples study ranged between 110 to 178 µg/g; 89 to 167 µg/g for nitrite; 59 to 156 µg/g for sulphate and 32 to 73 µg/g phosphates. The concentration of nitrate was highest in the whole vegetable sampled, while phosphate shows the least concentration. The values of nitrate, nitrite, sulphate and phosphate in the vegetable samples show that the leaves are rich in this anion content than other organs studied. Similar study was carried out by Santamaria et al., (1999) stated that nitrate and nitrite content of various parts of a plant differs in the order of leaf> stem> root> tuber> bulb> fruit> seed. Zhou et al., (2000) reported that vegetables that are consumed with their roots, stems and leaves have a high nitrate and nitrite accumulation, whereas melons and those vegetables with only
fruits as consumable parts have a low nitrate accumulation. This observation was also noted by Zhou et al., (2000) where leaf and stem accumulate the most nitrate, sulphate and nitrite followed by roots. Maynard et al., (1976) in their study; “Nitrate and nitrite accumulation in vegetables”, noted that leafy vegetables such as spinach, and lettuce contains nitrate, sulphate and nitrite at significant levels. They noted that plants that develop fruits or storage organs, such as potato and tomato, usually have low nitrite and nitrate concentrations. Nitrite content in vegetables is usually very low compared to nitrate (Aworh et al., 1980; Hunt and Turner, 1994). Result from this study agreed with the above observations. The concentrations of these anions in all the vegetable organs study were higher than the limits set by WHO. The high concentrations of these anions could be attributed to the used of untreated wastewater from the Jakara channel by farmers for the irrigation of these vegetables.

Figure 3: Mean Elemental Concentrations of Some Anions in Vegetable Samples along the Jakara Wastewater Channel, Kano Metropolis, Kano State, Nigeria

Conclusion
From the data collected from this research, the physicochemical parameters monitored in point N1, N2, N3 and N4 showed high levels of all the parameters. This must be as a result of the nature of wastewater from the Kano old city walled and the Sabon-Gari area. Point N3 showed the highest concentration of the physicochemical parameter, while point N2 shows the lowest values. The concentrations of metals and some anions in all the vegetable samples were higher than values set by WHO, this high values is due to the used of untreated wastewater from the Jakara channel for the irrigation of these vegetables. The levels of metals and anions in the vegetable samples were higher in the leaf, while the fruit shows the lowest concentration. Accordingly, wastewater from all the sampling points are polluted as can be observed from the results obtained from the vegetable samples.
References


