



Evaluation of Wastewater and Soil of some Irrigation Farmlands within Bauchi Local Government Area

¹Buteh D. S., ¹Okeke, C. U., ²Nwachukwu, C. B., ²Ani, P. I.

¹Department of Chemistry,

Adamu Tafawa Balewa College of Education, Kangere Bauchi State, Nigeria

²Department of Science Laboratory Technology,
Federal Polytechnic Bauchi, Bauchi State, Nigeria

ABSTRACT

The physicochemical properties of wastewater and soil samples collected from three irrigated commercial farms within Bauchi L.G.A were determined using standard procedure in order to ascertain the suitability of the soil and wastewater samples for growing the vegetables. The values of the parameters studied were compared to the NESREA/SON and WHO/FAO standards. The values of pH, turbidity and temperature of the wastewater samples were 7.00 ± 0.01 – 8.10 ± 0.00 , 6.00 ± 0.00 – 47.00 ± 0.00 and 31.00 ± 0.00 – 31.5 ± 0.01 respectively. Levels of turbidity and temperature exceeded the WHO standards. All the study metals were present in the soil and water samples analyzed. The concentrations (mg/kg) of Ni, Fe, Pb, Cu, Zn, Cd in the wastewater samples are: 0.052- 1.105, 0.043-1.040, 0.163- 4.004, 0.023- 0.042, 0.051-0.096 and 0.002-0.005 respectively, while in the soil samples, the levels were: 3.650-16.05, 9.670-39.65, 24.80-70.45, 1.000-1.350, 7.950-9.600 and 0.600-1.400. With the exception of Cd, the concentrations of the metals were below the stipulated permissible limits for soil samples. The levels of the metals in the wastewater were substantially higher than the compared standards, except Zn. It is therefore recommended that the quality of wastewater used for agricultural purposes should also be constantly monitored and regulated to reduce food contamination and its associated human risk.

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INTRODUCTION

Irrigation is a process of applying water to soil, especially during the dry season in order to provide the needed moisture for plant growth. Sources of water for irrigation in many farms include rivers, streams, boreholes, wells and waste water from households, industries and road run-offs. Wastewater for irrigation of agricultural land is one way to reuse waste water from urban and industrial areas. The increase in industrial activities has led to the discharge of large quantities of wastewater. This source of water is nowadays used in the cultivation of vegetables in urban areas due to the unavailability of clean water, especially in the dry season (Adebayo *et al.*, 2020; Salawu *et al.*, 2015).

Wastewater for irrigation purposes has been shown to increase soil organic carbon

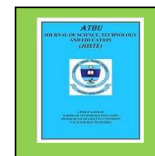
and other macro nutrients such as available N, P, K and Mg contents. However, it can contain heavy metals such as Pb, Hg, As, Cd, Cu, Zn and Ni. These metals interact with dissolved and particulate organic matter, soluble organic and inorganic anions, thus impacting the mobility and bioavailability these macro nutrient (Goitom *et al.*, 2020). Heavy metals are toxic to humans. Studies have shown that untreated waste water released to soil for agricultural purpose could leach through the soil profile to pollute the ground water sources. Even when sewage effluents contain low concentrations of heavy metals, the continual use of these effluents results in the build-up of heavy metals in soil. Although some of these heavy metals such as Fe, Zn, Cu, Ni, Co and Mn are necessary for the growth and normal function of living things at trace amounts, they can

Corresponding author: Okeke, C. U.

✉ okekeudoka77@gmail.com

Department of Chemistry, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State

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cause acute or chronic toxicity when consumed in large amount (Liang et al., 2019; Kinuthia et al., 2020; Mawari et al., 2022). Heavy metals are not readily removed from the environment by natural process like biodegradation; they therefore persist and accumulate over time causing serious contamination or pollution problems. According to Orisakwe et al., (2012), the entry of these metals into the food chain would result in the increased susceptibility and exposure of humans to the metals, resulting in poisoning of the local population. Considering the level of damages caused by the these toxic metals to the human body as a result of the continuous consumption of the contaminated vegetables collected from wastewater irrigated farmlands, it has become very important to investigate the physico-chemical properties of the soil samples in the farmland; and to ascertain the suitability of the wastewater for irrigation.

MATERIALS AND METHOD

Sampling sites

Three selected vegetable farmlands and irrigation sites, located within Bayara community, Federal Government Girls' College and Kofar Idi in Bauchi Local Government Area were selected for the purpose of this study. These farmlands are among the major vegetable producers within Bauchi L.G.A., ensuring steady supply of vegetables to sellers from close-by markets during the dry seasons. The sources of irrigation water were from sewage water few kilometres from the study farmland.

Wastewater and Soil Sampling

Water samples from the irrigation water sources for selected sites were collected in 100cm³ pre-cleaned, capped polyethylene bottles and properly labeled. The collected samples were immediately placed in dark polyethylene leathers. The pH, turbidity and temperature were taken in-situ with the appropriate instruments using the standard method for examination of water and wastewater of the American Public Health Association (APHA, 2016). Soil sample from the selected farmlands were randomly collected at a depth of 30cm to form a composite sample. 2.0kg of soil

samples were stored using polyethylene bags.

Sample Preparation and Treatment

The glassware and sample bottles were properly washed with detergents, rinsed with tap water and soaked in 10% HNO₃ for 48 hours. They were thereafter rinsed with distilled water, before oven drying to eliminate metal contaminations. The sampling bottles were then rinsed on site with waste waters being sampled (Ogunfowokan *et al.*, 2013; Usman *et al.*, 2013). The collected soil samples will be first dried at room temperature, ground using mortar and pestle and then sieved using a 2mm in diameter sieve before digestion (Goitom et al., 2020).

Sample Digestion and Analysis

100cm³ of each of the representative wastewater sample was transferred into Pyrex beakers, to which 10ml of Conc. HNO₃ was added. The mixture was boiled slowly and evaporated on a hot plate to about 20cm³. More of the Conc. HNO₃ was added as heating continues until the digestion was completed. The mixture was then evaporated again to dryness and cooled. 5.0cm³ of HCl solution (1:1v/v) was again added to the mixture and then warmed. 5.0cm³ of NaOH was added to the mixture and filtered thereafter. The filtrate obtained was transferred into a 100cm³ volumetric flasks and diluted to the mark with distilled water.

1.0g of each soil samples was weighed into a 250cm³ beakers and a mixture of 1.5 cm³ H₂O₂, 4.5 cm³ HCl and 1.5 cm³ HNO₃ was added to the sample. Each sample was filtered, transferred into a 50 cm³ volumetric flask, which was diluted to the mark with distilled water (Elbagermi *et al.*, 2013). The digested samples were then analyzed for the heavy metals using the AA320N Atomic Absorption Spectrophotometer. All assays were done in triplicates.

Statistical Analysis

Statistical analysis was carried out using the SPSS statistical package (ver.20).

Corresponding author: Okeke, C. U.

✉ okekeudoka77@gmail.com

Department of Chemistry, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State

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The means and standard deviations of the metal concentrations and physico-chemical properties of the samples were determined at 5% level of significance.

RESULTS AND DISCUSSION

The results of the physico-chemical properties of the wastewater and soil samples are presented in Tables 1 and 2. These values were compared to the NESREA/SON and WHO/FAO standards.

Physico-chemical Properties of Wastewater Samples

The mean pH of the wastewater samples ranged from 7.00 to 8.10 in all the study sites (Table 1). The pH values of the wastewater recorded in all the sites were within the limits recommended by NESREA/SON and the WHO/FAO; and are therefore suitable for irrigation purpose. pH values of the wastewater samples in this study are within the range of 7.28–8.78

reported in Kinuthia (2020) and the 4.7 – 9.5 in Ishaya et al., (2011); higher than the values of 7.21 – 7.31 in Gin et al., (2018); compared favourably with the 5.37 – 7.60 in Olowookere et al., (2018) but lower than the 1.84 – 1.87 in Hussaini et al., (2023).

The mean turbidity level of the wastewater samples were between 6.00 – 47.0 NTU. These values are observed to be higher than the WHO/FOA maximum permissible limit of 1-5NTU. The turbidity values indicate an elevated concentration of suspended matter in the water samples. Relatively high turbidity levels have been associated with lower hydraulic soil conductivity and increased soil pollution (Olowookere et al., 2018). These levels of turbidity are lower than the 160.33–544.67ppm (480.99-1634.01NTU) in Kinuthia (2020) but within the 7.93 – 188.55NTU reported in Olowookere et al., (2018).

Table 1: Physico-chemical parameters and means levels of heavy metals (mg/l) in wastewater samples from study locations

Wastewater parameters	Bayara	FGGC	Kofar Idi	Range	NESREA/SON 2011	WHO/FAO 2006
pH	7.00±0.01	7.3 ±0.01	8.10±0.00	7.00–8.10	6.5-8.5	6.5-8.5
Turbidity (NTU)	16.0±0.01	6.00±0.00	47.0±0.00	6.00–47.00	-	1-5
Temperature (°C)	31.3±0.01	31.0±0.0	31.5±0.01	31.00–31.5	-	20-30
Ni	1.105±0.006	0.124±0.011	0.052±0.005	0.052- 1.105	0.1	0.02
Fe	1.040±0.097	0.211±0.003	0.043±0.035	0.043- 1.040	-	0.30
Pb	0.236±0.041	4.004±0.031	0.163±0.001	0.163- 4.004	0.1	0.01
Cu	0.023±0.001	0.042±0.002	0.026±0.001	0.023- 0.042	0.01	0.25
Zn	0.051±0.002	0.096±0.006	0.051±0.001	0.051-0.096	0.2	2.0
Cd	0.003±0.001	0.005±0.001	0.002±0.002	0.002-0.005	0.01	0.003

(Concentrations of heavy metals are expressed in mg/l)

The range of the temperature (°C) of the wastewater samples obtained in the various irrigated farmlands was 31.00–31.5. These values were higher than the WHO/FOA limits. Kinuthia (2020) reported temperature values of 16.75–26.05°C for wastewater samples from open drainage channels in Nairobi, Kenya.

Heavy Metal Concentrations in Wastewater Samples from the Study Farmlands

The range of Ni levels in the wastewater samples was 0.052-1.105mg/l. Only in Kofar Idi was the concentration of Ni lower than the NESREA/SON 2007 limits of

0.1mg/l. All the values obtained for Ni here are higher than the WHO/FOA 2011 maximum permissible limit of 0.02mg/l. The concentrations of Ni in this study are higher than mean values (0.005mg/l and 0.007mg/kg) in Kinuthia et al., (2020) and consistent with the 0.000-0.233mg/l in Olowookere et al., (2018).

Fe levels in the wastewater samples were between 0.043 and 1.040mg/l. The value of Fe observed in wastewater samples in Bayara (with 1.040±0.097mg/l) was higher than the limit of 0.30mg/l set by the WHO/FAO. Fe concentrations in the wastewater in this study are consistent with the

Corresponding author: Okeke, C. U.

✉ okekeudoka77@gmail.com

Department of Chemistry, Adamu Tafawa Balewa College of Education, Kangeri, Bauchi State

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0.70 – 0.77mg/l in Jiya et al., (2010) and 0.04 – 0.24mg/l reported in Gin et al., (2018) in wastewater samples used for agricultural purposes. Salawu et al., (2015) recorded values as low as 0.0021mg/l while higher values (1.493- 4.927mg/l) were reported in Olowookere et al., (2018).

The range of the concentration of Pb in the wastewater samples was 0.163-4.004mg/l. These values exceeded the limits set by the WHO/FAO (0.01mg/l) and NESREA/SON (0.1mg/l). The values here are higher than the 0.015mg/l and 0.014mg/l for Pb in Kinuthia et al., (2020) and 0.006mg/l in Salawu et al.,(2009) but are consistent with 0.09 – 0.24mg/l in Gin et al., (2018); 0.14 – 0.18mg/l in Jiya et al., (2010) and 0.00-0.21mg/l in Olowookere et al., (2018).

The range of Cu (mg/l) recorded in the wastewater samples was 0.023-0.042mg/l. These values were consistently higher than the 0.01mg/l set by NESREA/SON but not substantially different from the permissible limits of 0.25mg/l given by WHO/FAO. Higher levels of Cu have been reported in Gin et al. (2018) (0.06 – 0.18mg/l) in irrigation water obtained from Babani quarters in Bauchi metropolis; Salawu et al. (2009) (10.046mg/l) and Olowookere et al., (2018) (0.603-0.800mg/l) in wastewater used for irrigation.

The concentrations of Zn (mg/l) in the wastewater samples were 0.051 – 0.096mg/l and discovered to be lower than the stipulated standards by the WHO/FAO and

NESREA/SON. The values of Zn in the present study are higher than the 0.0003mg/l in Salawu et al.,(2009) for wastewater used for irrigation in Gusau but consistent with the 0.05 – 0.32mg/l in Gin et al., (2018) and 0.013 – 0.051mg/l in Olowookere et al., (2018) for wastewater used for irrigation in Bauchi metropolis and Akure respectively.

Generally, the concentrations of Cd (0.002-0.005mg/l) were below the limits of 0.01mg/l set by NESREA/SON. Only in FGGC was the level of Cd (0.005mg/kg) higher than the WHO/FAO limits. Though the metal values in Bayara and Kofar Idi did not substantially differ from the 0.03mg/l limit by WHO/FAO. While the levels of Cd reported in this study were lower than the 0.02 – 0.10mg/l in Gin et al., (2018) and 0.037mg/l in Salawu et al. (2009), values as low as 0.00009mg/l and 0.00012mg/l were reported in Kinuthia et al., (2020) for wastewater samples used for irrigation. Olowookere et al., (2018) also reported a range of values (0.00-0.72mg/l) in Akure, Nigeria. Constant application of this wastewater for irrigation in the study locations would result to elevated levels of Cd in the soil and consequently in farm produce from these sites.

Heavy Metal Concentrations in Irrigated Soil Samples from the Study Farmlands

The concentrations of the heavy metal in the soil in the irrigated farmlands are shown in Table 2.

Table 2: Mean concentrations of heavy metals (mg/kg) in soil samples from Wastewater Irrigated Farmlands

Metals (mg/kg)	Ni	Fe	Pb	Cu	Zn	Cd
Bayara	3.850±0.005	39.65±0.021	70.45±0.051	1.000±0.001	9.350±0.006	1.050±0.002
FGGC	3.650±0.007	9.670±0.005	24.80±0.010	1.105±0.001	9.600±0.007	0.600±0.002
Kofar Idi	16.05±0.010	29.95±0.019	39.10±0.052	1.350±0.001	7.950±0.011	1.400±0.002
Range	3.650-16.05	9.670-39.65	24.80-70.45	1.000-1.350	7.950-9.600	0.600-1.400
WHO/FOA (2001)	35	425	85	35	50	0.8

All studied metals were present in the soils at varying concentrations. The levels of the metals in this study were all below the WHO/FAO permissible levels for these metals, except Cd in Bayara and Kofar Idi and may not pose much pollution problem in the farm soil.

The level of Cd in the soil may be due to the continual application of wastewater to the farmland. Yaro et al., (2017) reported similar significant levels of Cd, among other metals in soils collected from irrigated urban farming sites of Katsina City, Nigeria, and attributed it

Corresponding author: Okeke, C. U.

✉ okekeudoka77@gmail.com

Department of Chemistry, Adamu Tafawa Balewa College of Education, Kangeri, Bauchi State

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to the wastewater applied to the farm. Hussaini et al., (2020) also observed that while the other metals they studied were below their permissible limits, the level of Cd in soils irrigated using industrial wastewater in Kano metropolis, Nigeria was above maximum acceptable limit. This is an indication that the continual use of wastewater for irrigation in the studied farms could elevate soil pollution levels. Studies have shown that there is a strong linear relationship between increased level of heavy metal and irrigation time (Lucho-Constantino et al., 2005; Goitom et al., 2020). The concentration of Cd should therefore be of serious concerns as Cd does have any biological benefit to living things. It is classified as a carcinogen; and has been associated with reproduction problem, bones and cardiovascular diseases, high blood pressure, anaemia and renal disease (Yaro et al., 2017; Adebayo et al., 2017; Okeke et al., 2018). Elevated levels of heavy metals, above their stipulated thresholds, can enter vegetative biomass, resulting to serious health problems, when consumed. WHO in 2003 attributed the reduced life expectancy in developing countries to diseases associated to the heavy metals load in the environment (Yaro et al., 2013).

CONCLUSION

The result of the physico-chemical analysis in the study shows that all the studied metals were observed in the soil and wastewater samples analysed; and the concentrations of the metals in the wastewater were higher compared to those in the soil samples. The elevated levels of Cd in the soil of the farmland may indicate that its primary source could be from the continual application of the contaminated water to the farm. Concerned authorities such as NESREA and the BASEPA should therefore ensure that policies put in place to regulate wastewater used for irrigation purposes are enforced; and that the quality of wastewater used for agricultural purposes should also be constantly monitored for proper standard to be maintained. This will assist in mitigating the level of heavy metals and other pollutants in the environment.

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Corresponding author: Okeke, C. U.

✉ okekeudoka77@gmail.com

Department of Chemistry, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State

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Corresponding author: Okeke, C. U.

✉ okekeudoka77@gmail.com

Department of Chemistry, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State

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