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Assessments of Quality Index of River Getsi Irrigation Water in Kano Metropolis, Nigeria

T. S. Jamila[1*] and S. Y. Sule[2]

[1]Department of Biology, Gombe State University of Science and Technology, Kumo, Nigeria.
[2]Department of Chemistry, Kano State University of Science and Technology, Wudil, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author TSJ developed and conceptualized the research idea, collected data, summarized and interpreted the outcomes. Author SYS was fully involved in manuscript design, editing and review. Both authors read and approved the final manuscript.

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ABSTRACT

The growing problem of water scarcity and absolute constraint in availability of fresh water for irrigation has made the use of waste water necessary for irrigation of agricultural fields. This practice represents an important route for transmission of heavy metals toxicity and pathogens that are of public health and environmental concern. The aim of this study was to assess the water quality index of river Getsi irrigation water in Kano metropolis and substantiate the suitability of the water for a safer irrigation. Results of this experiment have shown a mean biological oxygen demand of 80.43 mg/l, total dissolved solid of 20.63 mg, higher concentration of chromium (8.23 mg/l), and a statistically significant moderate relationship between electrical conductivity and total dissolved solid in the water ($r = 0.556$, $p = 0.037$ at 95% CI) using a Kendall's tau correlation statistics. It is concluded that, river Getsi is not unsafe for irrigational practices as the water indices were within recommended ranges, while the heavy metals were above and possible contamination may occur at a point in time. It is therefore recommended that, farmers should be educated on the need and importance of assessing the water quality before embarking on irrigational practices.

Keywords: Heavy metals; toxicity; pathogens; waste water; contamination.

**Corresponding author: E-mail: jamilats2012@gmail.com;*

1. INTRODUCTION

The use of waste water for crop production has been increasing worldwide due to increasing food demand and the changing climate condition, is making food production through rain fed agriculture less reliable [1]. Waste water reuse in irrigation is largely considered an inevitable option to compensate water shortage in developing countries including Nigeria. Hence, crop irrigation with waste water is a widespread practice in these countries [2]. Economic and agronomic advantages are sometime promoted in waste water reuse but there are several studies warning against health risks and environmental impacts [3]. According to Amoah et al. [3], the use of portable water for vegetable production is constrained because less than 40% of city dwellers are still without drinking water [4].

The need for year round production of vegetables in or near urban areas due to increasing consumption of vegetables as a result of awareness of its health benefits, makes irrigation necessary [4]; hence, farmers in search of water for irrigation often rely on the waste water for irrigation [5]. Available reports on the health consequence of using untreated waste water for vegetables production stated that industrial effluents discharged into the environment (Kano) pose a threat to irrigation products and health, possibly due to indiscriminate use of raw waste water for vegetables production [6,7].

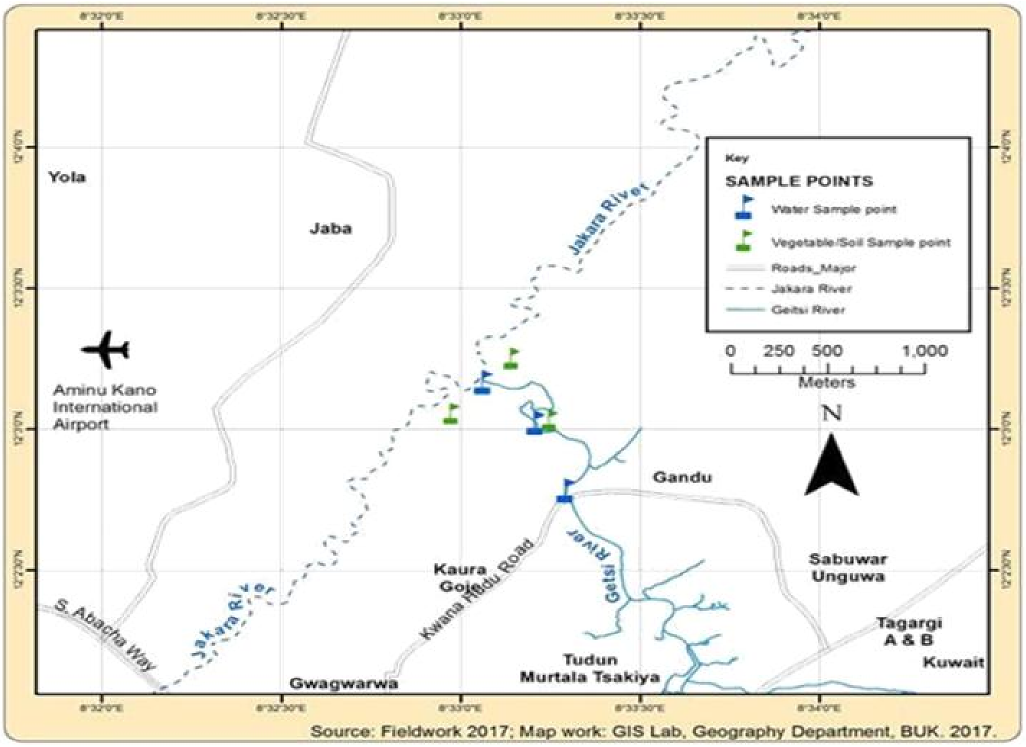
The ever increasing worldwide populations, especially in urban and peri-urban areas of the developing economies calls for serious thoughts and approaches in meeting the food demands whiles taking care of the environment for sustainable development [8]. In many countries in sub-Sahara Africa, urban waste water is used to irrigate agricultural lands. This way of disposing sewage has several advantages. Waste water contains a lot of nutrients, which increase crop yields without use of fertilizers [8]. Furthermore, sewage water is an alternative water source where water is scarce. However, waste water also contains a variety of chemical substance and microbial loads from domestic and industrial sources [9]. Vegetables take-up heavy metals and accumulate them in their edible and inedible parts in quantities high enough to cause clinical problems both to animals and human beings when they consume these metal-rich vegetables [10]. However, the consumption of heavy metal-contaminated vegetables can seriously deplete some essential nutrients in the body that are further responsible for decreasing immunological defenses, causes problems such as intrauterine growth retardation, impaired psycho-social functions, disabilities associated with malnutrition and high prevalence of upper gastrointestinal cancer rates [11,12].

Point sources of contamination to water bodies include industrial effluents, municipal/domestic waste water, abattoir waste, while non-point source include animal defecation, storm water drainage and urban runoff [13]. In Kano State Nigeria, wastewater discharge from Bompai Industrial Estate which drains into River Getsi contributes to a major source of the metropolitan irrigation water contamination [14,15]. Within this industrial estate, there is a large number food processing industries, aluminum, metal and wood factories, plastic rubber and tyre factories, chemical and cosmetic industries as well as tannery and textile industries [15]. However, these factories use the largest quantities of water and produce the greatest amounts of waste water, which constitute the main sources of pollution around river Getsi and its premises [14].

The waste bi-products from tanneries were known to contain high concentrations of the heavy metals chromium and cadmium, and a 1989 study, which monitored the activities of 15 tanneries in Kano, found that in all cases permissible limits for effluent discharge were violated, with the exception of pH and temperature [16,17]. Microbes and pathogens (Bacteria, Viruses, Protozoa, Cysts and Helminthes eggs), other organic and inorganic toxic substances have also exceeded the health protection standards [18]. Principally, River Getsi water quality index taints because of the convergence of waste water derived from streams that flow through the city and often through densely populated and/or industrialized areas [19]. Consequently, the public health impacts of using the river Getsi water for irrigation could be overwhelming if the water quality index does not conform to the universally permissible limits for irrigation. Hence, this experimental study was carried out to assess the water quality index of river Getsi irrigation water in Kano metropolis, Nigeria.

2. MATERIALS AND METHODS

This study was conducted in river Getsi irrigation area. River Getsi (12°2'N and 8°32'E) carries effluents from Bompai industrial estates and



Source: Fieldwork 2017; Map work: GIS Lab, Geography Department, BUK. 2017.

Fig. 1. Map of river Getsi irrigation area

formed a confluence with river Jakara which drains municipal wastewater from Kano old city district. It is located within the metropolis of Kano in the Sahelian geographical region south of the Sahara [20]. The climate features of the region lies within savanna vegetation and a hot semi-arid climate and about 690 mm (27.2 in) precipitation per year the bulk of which falls from June through September [20].

The water samples from river Getsi were collected for the determination of 5-Day biological oxygen demand, total dissolved salt, dissolved oxygen and heavy metals (Lead, Mercury, Chromium, Cadmium and Nickel). A 250 ml BOD bottle was immersed into the water using sterilized surgical hand gloves to avoid contamination and was filled to the brim in order to expel air bubbles and gently closed to avoid trapping in air. The excess samples were removed and the rest were incubated at 20ºC ± 0.5ºC for 5 days. The samples were taken to laboratory for digestion. The water samples collection and analysis was done in triplicate in order to make comparison.

The temperature of the irrigation water was determined by means of mercury-in-glass thermometer. The thermometer was first shaken and then was brought into contact with the collected irrigation water that is before putting the irrigation water into the flask and the mercury level was allowed to settle for about two (2) minutes. The temperature of the irrigation water was then read and recorded accordingly [21]. The pH of the irrigation water was determined by means of digital laboratory pH meter. About 20 ml of the irrigation water was measured in a beaker and the pH meters was switched on and allow warming for 15 minutes. It was then calibrated with buffer of pH 4 and 7 after calibration, the electrode was rinsed and cleaned using cotton wool, the electrode was then dipped into the beaker containing the irrigation water, the pH value of the water was read from the digital screen of the pH meter [22].

The electrical conductivity of the irrigation water was determined by means of Conductivity Bridge. About 20 ml of the irrigation water was measured in a beaker and the electrical conductivity bridge was switched on and allowed to warm-up for 15 minutes, and calibrated using 0.01 ml KCl. The electrode of the machine was deepening into the beaker containing the irrigation water and the conductivity value was read from the digital screen of the conductivity meter [23].

The dissolved oxygen was determined using wrinkle method [24], the water samples were first treated with excess of Manganese (II) sulphate, Potassium iodide and Sodium Hydroxide. The white $Mn(OH)_2$ that forms reacts rapidly with oxygen to Manganese (III) Oxide that when acidified oxidizes Iodide to Iodine and the liberated Iodine which is proportional to the amount of oxygen in the sample is determined by titration with thiosulphate.

The biological oxygen demand was determined where by a BOD bottle of 250 ml was filled with the samples by immersing the BOD bottle into the water up to the brim in order to avoid air bubbles. The samples were aerated at 20ºC and saturated at 30 mmHg and three dilution pipette of the appropriate sample volume was transferred into three 250 ml glass Stoppard reagent vessels and fill each bottle with dilution water within 10 min which was siphoned and re-stoppered while ensuring no air bubbles were entrapped in the bottles. The bottles were incubated at 20ºC for 5 days. The concentration of the oxygen in each bottle was measured and dissolved oxygen analysis was also performed. The BOD_5 was then obtained using the following formula [24].

$$BOD_5(mg/l) = \frac{[DOB - DOA] - [DOBB - DOBA]}{D}$$

Where

D = dilution factor
DOB = DO of sample before incubation
DOA = DO of sample after incubation
DOBB = DO of the blank sample before incubation
DOBA = DO the blank sample after incubation

Total dissolved solid was determined using gravitational method [24], where by the water samples were well mixed and filtered through a standard glass fiber filter and the filtrate is evaporated to dryness in a weighed dish and dried to constant weight at 180ºC. The increase in this weight represent the Total Dissolved Solid, the filtrate from the total suspended solid will be used for the analysis using the formula below [24].

TDS = (A-B) x1 000 Sample volume in ml

Where

A = weight of dry residue dish (mg)
B = weight of dish (mg)

Toxic heavy metal impurities were analyzed using atomic absorption spectrometry performed on an AAS VGP 2010 model of atomic spectrophotometer attached to a graphite furnace and out-injector (ASC6000). This instrument has been used to determine heavy metal contents in various chemical preparations. All the experiments were run in triplicate and the data were collected using automatic processor attached to a PC. Working solutions of trace elements would be prepared daily for 5 days by appropriate dilution (0, 1, 5, 10, 15 and 20 ml) of standard heavy metal stock solution (10 ppm). The solutions were transferred to each of six 100 ml volumetric flasks and 5 ml of concentrated HNO_3 was added to each flask. The volumes were completed with deionized water to 100 ml giving 0, 0.1, 0.5, 1.0, 1.5 and 2 ppm concentration of each heavy metal. A calibration curve was drawn by running serial dilutions of the standard heavy metals as described by the manufacturer. The corresponding absorption values were recorded and fitted by using linear regression method. The concentration of trace elements in various vegetables samples were calculated from the calibration curve using the 'slope' and 'intercept' values were obtained by linear regression method.

2.1 Statistical Analysis

The data collected were subjected to descriptive statistics in form of mean, standard deviations and range. Pearson's' moment correlation statistics was used to analyzed relationship between the water quality parameters while the association between other water indices was determined using a Kendall's tau correlation statistics. All the statistical analyses were performed using SPSS software version 25 at 95% confidence interval at preset p-value of < 0.005.

3. RESULTS

Results of this experimental study show that the average temperature of the water was 30.72ºC, the mean biological oxygen demand was 80.43 mg/l, with a mean value of 20.63 mg/l for the total dissolved solid and mean electrical conductivity of 1.72 mg/l as shown in Table 1. Table 2 shows that among the identified heavy metal Chromium has the high concentrated with an average value of 8.23 mg/l while Mercury has the least concentration (0.00 mg/l). From the Table 3, there was a statistically significant moderate positive correlation between temperature and PH ($r = 0.667$, $p = 0.05$ at 95% CI) using Pearson's moment correlation statistics. No relationship exists between the other indices of the water quality as shown in the Table 3. In Table 4, a statistically significant moderate relationship was found between electrical conductivity and total dissolved solid (r = 0.556, p = 0.037 at 95% CI) U=using a Kendall's tau correlation statistics.

4. DISCUSSION

This study was conducted in river Getsi irrigation water with the aim of assessing the quality and suitability of the water which had been of used for irrigational purposes during both dry and rainy seasons. The need to assess water quality indices was eminent in view of the epidemiological and environmental significance of the use of waste water for irrigation. Even though, urban water scarcity could not be address to meet the immediate domestic and irrigational needs of the water, ensuring quality of the availably utilized water may reduce the persisting trends of disease endemics. Recently, environmentalists and public health practitioners are considering water treatment through disinfection and quality assessment as an option towards achieving water availability for both public consumption and irrigational purposes. Assessing water quality is now an inexhaustible attempt due to the vast and interrelating indices associated with water quality establishment based on international recommendations.

Table 1. Physicochemical indices of the water

Index	M ± SD
T^o	30.72 ± 0.78
pH	7.49 ± 0.31
DO	4.88 ± 0.97
EC	1.72 ± 0.21
BOD_5	80.43 ± 8.24
TDS	20.63 ± 1.59

T^o = temperature (^{o}C), DO = dissolved oxygen (mg/l), EC = electrical conductivity (mg/l), BOD_5 = biological oxygen demand (mg/l), TDS = total dissolved solid (mg/l), M = mean, SD = standard deviation

The result of the total dissolved solid (TDS) in this present study show a mean TDS value of 20.63 mg/l. This value has no any hazardous effect as stipulated in the manual of the United State Regional Salinity Laboratory (FAO, 2013) which states that water with TDS value of less than 160 mg/l is excellently recommended for irrigational purposes. This finding is consistent

Table 2. Concentration of the heavy metals contents in the water

Heavy metal (mg/l)	M ± SD	Maximum permissible limit
Cd	1.16 ± 0.32	0.010
Cr	8.23 ± 2.60	0.100
Hg	ND	0.001
Ni	1.87 ± 0.92	0.200
Pb	6.10 ± 1.80	5.000

Cd = Cadmium, Cr = Chromium, Hg = Mercury, Ni = Nickel, Pb = Lead, ND = Not Detected

Table 3. Relationship between the water quality indices

		PH	T^o	EC	DO	BOD_5	TDS
PH	Pearson Correlation	1	-.667*	-.009	-.088	-.234	.197
	Sig. (2-tailed)		.050	.981	.823	.545	.612
T^o	Pearson Correlation	-.667*	1	-.383	.337	.416	-.544
	Sig. (2-tailed)	.050		.309	.376	.265	.130
EC	Pearson Correlation	-.009	-.383	1	-.181	.229	.625
	Sig. (2-tailed)	.981	.309		.642	.554	.072
DO	Pearson Correlation	-.088	.337	-.181	1	.394	-.042
	Sig. (2-tailed)	.823	.376	.642		.293	.914
BOD_5	Pearson Correlation	-.234	.416	.229	.394	1	.098
	Sig. (2-tailed)	.545	.265	.554	.293		.802
TDS	Pearson Correlation	.197	-.544	.625	-.042	.098	1
	Sig. (2-tailed)	.612	.130	.072	.914	.802	

**correlation is significant at the 0.05 level (2 tailed), T^o = temperature (^{o}C), DO = dissolved oxygen (mg/l), EC = electrical conductivity (mg/l), BOD_5 = biological oxygen demand (mg/l), TDS = total dissolved solid (mg/l)*

Table 4. Kendall's tau association between the water quality indices

Index			EC	DO	TDS
Kendall's tau	EC	Correlation	1.000	0.560	0.556*
		Sig. (2-tailed)		0.830	0.037
		N	9	9	9
	DO	Correlation	0.560	1.000	0.560
		Sig. (2-tailed)	0.835		0.835
		N	9	9	9
	TDS	Correlation	0.556*	0.560	1.000
		Sig. (2-tailed)	0.037	0.835	
		N	9	9	9

Correlation is significant at the 0.05 level (2-tailed), EC = electrical conductivity (mg/l), DO = dissolved oxygen (mg/l), TDS = total dissolved solid (mg/l)

with previous studies in this domain of water quality [11]. Result of electrical conductivity (EC) showed a mean EC value of 1.72 mg/l which is also a safe value in accordance with recommendation of the System Maintenance of River and public water pollution in Iraq (1998). There was a significant moderately positive relationship between TDS and EC using a Kendall's tau correlation statistics (r = 0.556, P < 0. 05 at 95% CI). This correlation portrays the influence of these dissolved solid in enhancing electrical conductivity of the water and facilitation of the free ionic flow in water. Total dissolved solid includes ionized and deionized matter but only the former is reflected in the conductivity.

TDS is the measure of the amount of material dissolved in water including Carbonate, Chloride, Bicarbonate, Phosphate, Sulfate, Nitrate, Sodium, Calcium, Magnesium, Organic ions, etc. The density of the water, can be harmful due to increase in TDS concentrations, determined the flow of water into and out of an organism's cells. Moreover, the high concentrations of TDS may also reduce water clarity, contribute to a decrease in photosynthesis, combine with toxic compounds and heavy metals, and lead to an increase in water temperature [25]. From the above outcome, despite the established relationship between the electrical conductivity and the dissolved solids in the water, it is obvious that, the salinity of the water and it is turbidity is not in any compromised temporally. It, therefore, implies that, the total dissolved solids and electrical conductivity indices are acceptable and desirable parameters that do not alter the quality of the water and are having no effect or any detrimental public health implication.

Results showed mean dissolved oxygen (DO) of 4.88 mg/l as shown in Table 1. The dissolved oxygen (DO) in water is an important parameter to monitor the biological quality of water, and ascertain its designated best use. It supports the aquatic life forms and regulates the biological degradation of organic impurities. Therefore, this dissolved oxygen level in river Getsi could be attributed to the addition of sewage upstream, industrial effluent of Bompai and domestic waste from the neighboring households. Results from Table 1 have shown a mean value of five day biological oxygen demand (BOD_5) of 80.42 mg/l. The BOD_5 index is a measure of the oxygen demand of biodegradable carbonaceous matter in the water. Water oxidation is a continuous reaction which is complementary to the saturation reaction of dissolved oxygen in the water. This outcomes may justify that river Getsi irrigation water contained moderate levels of dissolved salts and trace elements, many of which result from the natural weathering of the earth's surface. In addition, drainage water from irrigated lands and effluent from city sewage and industrial waste water can impact water quality. In most irrigation situations, the primary water quality concern is salinity levels, since salts can affect both the soil structure and crop yield and this implies to river Getsi as well.

There was no any relationship between within or between these indices any of the assessed index using the Kendall's tau and the Pearson's moments correlation statistics (r = 0.00, P < 0. 05 at 95% CI). It was observed that DO concentration in river water is a function of temperature; turbulence, depth, and organic matter present [26]. The mean value of the water temperature was 30.72ºC and a mean pH of 7.49. There was a moderate negative relationship between temperature and pH (r = .050, p < 0.05 at 95% CI) using Pearson's moment correlation statistics. The pH value of aquatic system is an important indicator of the water quality and the extent pollution in the water shed areas. Our pH value in this study is in concordance with results of permissible limit prescribed by World Health Organization [27].

The temperature of water was known to have inverse relationship with water oxygen solubility. However, elevated temperatures and, more importantly, steep temperature gradients can have directly harmful effects on aquatic organisms. This temperature value is within acceptable and recommended values of the Canadian Council of Ministries of the Environment (CCME) (2012). The observed reciprocal relationship between temperature and pH value implies that high temperature cause simultaneous decline in the water pH value and vice versa. Therefore, this implies that water temperature gradients affect the concurrent pH and oxygen solubility of the water. It differs in accordance with weather and climatic features of the environment as well prevailing human activities (e.g global warming, bush burning, industrial exhume … etc.).

When water samples were collected and analyzed for heavy metals (Cd, Cr, Ni, and Pb) it was found that the concentrations of heavy metals i.e. cadmium is beyond the maximum permissible limits set by WHO [28] whereas, chromium, nickel and lead were equally beyond the recommended confines of WHO and United States Environmental Protection Agency [29]. Therefore, this water is hazardous for human household, drinking and perhaps perilous for irrigation due to the probability of food contamination through the soil root interface. These excesses in the heavy metals is apt to the addition of municipal waste water and industrial effluents as the sewage of the city is directly discharged into the water channels that drained in to the river along with that of Bompai industries which are also discharging their effluents directly into the river. This is in agreement with the study of Ruqia et al. [30], who reported that the level of heavy metals was increasing in the Tanda Dam Kohat river due to discharge of industrial effluents and civic pollution of various kinds. This is in turn deteriorating the water quality making it unsuitable for both aquatic and human life.

Our concern is not far from the fear of possible risks to human health poses by vegetables irrigated with waste water and grown in soils contaminated with heavy. This abundance of heavy metals in river Getsi may influence some chemical reactions such as mineral precipitation and dissolution, ion exchange, absorption and re-absorption before their subsequent mobilization, and uptake by the irrigated vegetables. Previous study reported incidences of diseases and endemic outbreaks as results of metal toxicities (Steele et al. 2005). As such, probably, water in river Getsi may become contaminated due the accumulation of heavy metals disposed from the rapidly expanding industrial areas, domestic waste disposal, disposal of high metal wastes, bio-solids, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition. Therefore, the ultimate implications of these heavy metal contaminants are their opportunistic transfer to the vegetables and to the consumers.

5. CONCLUSIONS AND RECOMMENDATIONS

The main objective of this study was to assess the abundance and concentration of some toxic heavy metals and also some water quality indices such as pH, electrical conductivity and total dissolved solid, dissolved oxygen, biological oxygen demand and temperature of water collected from river Getsi. The results show that pH, electrical conductivity and total dissolved solid, dissolved oxygen; biological oxygen demand and temperature of all the water samples were within the permissible limits set by the pertinent authorities, whereas the values of the heavy metals (Cd, Cr, Ni, and Pb) of all the collected water samples were found to be extremely higher than permissible limits set by WHO. Therefore, it is concluded that river Getsi water source is fairly safe for irrigational practices because, the water quality indices were within recommended ranges while the heavy metals were extremely higher. That the water quality may change at any period in time probably as a result of changes in weather and climate, seasonal changes (eg dry season), high discharge of industrial effluents and other factors that may cause water contamination.

Based on the outcome of this study, it is recommended that, farmers should be educated on the need and importance of incorporating water analysts for assessing the water quality and suitability before and during the irrigational activity. That, individuals, households and industries should not be allowed to dispose their wastes in to the river Getsi or its water channels. Government should pay attention to improve water quality of river Getsi with great emphasis on heavy metals so that vegetable and other irrigational produce will be exposed to minimum amount of heavy metals. Further study should be carried out to assess the transfer and availability of heavy metals on vegetables irrigated in river Getsi farm sites.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Scott CA, Farouqui NI, Raschid-Sally L. Wastewater use in irrigated agriculture: Management challenges in developing countries. In: Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities CABI, publishing, Oxfordshire, UK. 2004;1– 10.
2. Sou M, Yacouba H, Mermoud A. Fertilising value and health risks assessment related to wastewater reuse in irrigation, case study in a Soudano-Sahelian city. Ouagadougou. Journees Scientifiques du. 2011;6:4-8.
3. Amoah P, Drechsel P, Abaidoo RC. Irrigated urban vegetable production in Ghana: Sources of pathogen contamination and health risk elimination. Irrigation and Drainage. 2005;54:49-61. DOI:10.2166/wh.2007.041
4. Keraita B, Drechsel P, Huibers F, Raschid-Sally L. Wastewater Use in Informal Irrigation in Urban and Peri-Urban Arears of Kumasi, Ghana. Urban Agriculture Magazine. 2002*;* 8:11 – 13.
5. Klansmewyer P, Fhimumy GN, McCloud TD, Shoemaker RH. A novel antimicrobial inlizinium alkaloid from Aniba panurensis. Journal of Natural Products. 2004;67:1732 – 1735.
6. Selma MV, Allende A, Lopez-Galvez F, Elizaquivel P, Aznar R, Gil MI. Potential microbial risk factors related to soil amendments and irrigation water of potato crops. Journal of Applied Microbiology. 2007;103:2542 – 2549. Available:https://doi.org/10.1111/j.1365-2672.2007.03504.x
7. Bala M, Shehu RA, Lawal M. 2008. Determination of the level of some heavy metals in water collected from two pollution-prone areas around Kano Metropolis. Bayero Journal of Pure and Applied Sciences. 2008;1(1). Available:http://dx.doi.org/10.4314/bajopas.vlil.57511
8. Sabiena F, Raheela H, Van der H. Health risks of irrigation with untreated urban wastewater in the southern panjab, Pakistan. Institute of Public Health (IPH) and International Water Management Institute (IWMI) Research report No. 107; 2000.
9. Samuel JC, Mohammed CK, Joseph KK, Mark OA. Microbial contamination in vegetables at the Farm Gait Due to irrigation with Wastewater in the Tamale Metropolis of Northern Ghana. Journal of Environmental protection. 2013;4:676–682. DOI:10.4236/jep.2013.47078
10. Alam MG, Snow ET, Tanaka A. Arsenic and heavy metal contamination of vegetables grown in Samta village, Bangladesh. Sci Total Environ. 2003;308: 83- 96. Available:https://doi.org/10.1016/S0048-9697(02)00651-4
11. Abbas JK. Assessment of water quality in Tigris River-Iraq by Using GIS mapping. Natural Resources. 2013;4:441-448. Available:http://dx.doi.org/10.4236/nr.2013.46054
12. Hassan AN, Frank JF. Attachment of *Escherichia coli* O157:H7 grown in tryptic soy broth and nutrient broth to apple and lettuce surfaces as related to cell hydrophobicity, surface charge, and capsule production. Int J Food Microbiol. 2004;96:103–109. Available:https://doi.org/10.1016/S0168-1605(03)00160-0
13. Odjadjare EEO, Larry CO, Okoh AI. Municipal wastewater effluents as a source of listerial pathogens in the aquatic milieu of the Eastern Cape province of South Africa: A Concern of public health importance. Int J Environ Res Public Health. 2010;7(5):2376–2394. Available:https://dx.doi.org/10.3390%2Fijerph7052376
14. Tanko AI. Spatio – temporal patterns of environmental pollution and control inmetropolitan Kano. Paper presented at the 4th Annual Nigerian Geographical Association Conference, University of Ilorin; 2002.
15. Bichi MH. Surface water quality in the Kano industrial environment. In: Falola J. Afolabi, K. Ahmed, M.A. Liman and A. Maiwada (Eds) Issues in land administration and development in Northern Nigeria, Department of Geography, Bayero University, Kano. 2000;305-313.
16. Odoh R, Kolawole SA. Assessment of trace heavy metal contaminations of some

selected vegetables irrigated with water from River Benue within Makurdi Metropolis, Benue State Nigeria, Pelagia Research Library, Advances in Applied Science Research. 2011;2(5):590-601. Available:www.pelagiaresearchlibrary.com

17. Lawal AO, Audu AA. Analysis of heavy metals found in vegetables from some cultivated gardens in Kano metropolis, Nigeria. J Environ. Chem. Ecotoxicol. 2011;36(6):142-148.
18. Gabriele B, Armin E, Kornelia S, Robert K. Vegetable microbiomes: Is there a connection among opportunistic infections, human health and our 'gut feeling'? Microb Biotechnol. 2014;7(6):487–495. Available:https://dx.doi.org/10.1111%2F1751-7915.12159
19. Mustapha HB. 2013. Management of industrial effluents: A review of the experiences in Kano, Northern Nigeria. International Journal of Advanced Research. 2013;1(4):213-216. ISSN: 2320-5407
20. Imam TS, Balarabe ML. 2012. Impact of Physicochemical Factors on Zooplankton Species Richness and Abundance in Bompai - Jakara Catchment Basin, Kano State, Northern Nigeria. Bajopas. 2012; 5(2). Available:http://dx.doi.org/10.4314/bajopas.v5i2.6
21. Beuchat LR. Ecological factors influencing survival and growth of human pathogens on raw fruits and vegetables. Microbes infect. 2002;4:413-423. Available:https://dio.org/10.1016/s1286-4579 (02) 01555-1
22. Hamilton AJ, Stagnitti F, Premier R, Boland AM, Hale G. Quantitative microbial risk assessment models for consumption of vegetable crops irrigated with reclaimed water. Applied and Environmental Microbiology. 2006;72: 3283-3290. Available:https://dx.dio.org/10.1128/AEM.72.5.3284-3290
23. Akyala IA, David I, Simon A. Prevalence of parasitic contamination of some edible vegetables sold at Alhamis market in lafia metropolis. Scholarly Journal of Bio-technology. 2013;2(2):26 –29. Available:http://www.scholarly-journals.com/SJB ISSN: 2315-6171© 2013 Scholarly-Journals
24. Nordic Council of Ministers. Lead review; 2003. Available:http://www.who.int/ifcs/documents/forums/forum5/nmr [Accessed Jun 8, 2011]
25. Kahlown M, Tahir MA, Rasheed H, Bhatti KP. Water quality status in Pakistan. Fourth Technical Report, (PCRWR). Government of Pakistan, Islamabad; 2006.
26. Tasrina RC, Rowshon A, Mustafizur AMR, Rafiqul MPA. 2015. Heavy Metals Contamination in Vegetables and its Growing Soil. J Environ Anal Chem. 2015;2:3. Available:http://dx.doi.org/10.4172/jreac.1000142.
27. World Health Organization. 2006. Guidelines for Drinking Water Quality. 3rd Edition, Geneva; 2006.
28. Zaigham H, Zubair A, Khalid UK, Mazhar I, Rizwan UK, Jabar ZKK. Civic pollution and Its effect on water quality of River Toi at District Kohat, NWFP. Research Journal of Environmental and Earth Sciences. 2012;334-339. ISSN: 2041-0492
29. EPA (United States Environmental Protection Agency) 2005. Protecting Water Quality from Agricultural Runoff. EPA 841-F-05-001.
30. Ruqia N, Muslim K, Muhammad M, Hameed UR, Naveed UR, Surrya S, Nosheen A, Muhammad S, Mohib U, Muhammad R, Zeenat S. Accumulation of Heavy Metals (Ni, Cu, Cd, Cr, Pb, Zn, Fe) in the soil, water and plants and analysis of physicochemical parameters of soil and water Collected from Tanda Dam kohat. J. Pharm. Sci. & Res. 2015;7(3): 89-97. ISSN: 0975-1459.

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