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Bacteriological Quality Assessment of Irrigation Water and Irrigated vegetables in Maiduguri, Borno State, Nigeria

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Abstract

Three water sampling points with their corresponding vegetable production sites along the river Ngada, Maiduguri were selected for the study. A control vegetable production site was also selected. Samples were replicated three times at each sampling points to determine the bacteriological quality of irrigation water and irrigated vegetables using standard methods of analysis. The faecal coliform count for the irrigation water ranged between 6.35×10^3 and 92.1×10^3 cfu/100ml and the faecal coliform count of the irrigated vegetables ranged between 0.02×10^2 and 19.05×10^2 cfu/100g. The results demonstrated that the irrigation water and irrigated vegetables were heavily polluted with faecal material which were above the recommended standard values of less than 1000 feacal coliform/100ml and 1000 faecal coliform/100g set by World Health Organization (W.H.O). The results also showed the presence of *Escherichia coli*, *Staphylococcus Spp*, *Shigella Spp*, *Klebsiella*, and *Salmonella Spp* in the irrigation water and irrigated vegetable samples. All these bacteria are of public health significance and their presence indicate feacal contamination. It is recommended that wastewater from Maiduguri main abattoir be treated before discharging into the receiving river Ngada. It is also recommended that irrigated vegetables are washed thoroughly with brine before consumption.

Keywords: Bacteriological, Irrigation, Vegetable, River Ngada, Contamination, water sample and Abattoir

1. Introduction

Wastewater irrigation is the mechanical means of applying wastewater to agricultural crops during the growing season. The use of wastewater for irrigation is a century-old practice that is receiving more attention with the increasing scarcity of fresh water sources in many arid and semi-arid areas, in which Maiduguri belongs (Ackerson *et al*., 2012). Hussain *et al*., (2001) estimated that at least 20 million hectares in 50 countries are irrigated with raw or partially treated wastewater. Of the World's total arable land, 17% is irrigated and produces 34% of the needed crops (Pescod, 1992). Smit and Nasr, (1992) estimated that one tenth or more of the World's population consumes foods produced on land irrigated with wastewater.Three-quarters of the irrigated area (192 million hectares) is located in developing countries (United Nations, 2002). Frequently in these countries, wastewater is used to irrigate land because of high demand for water (70% of total use), the availability of wastewater, the productivity boost that the added nutrients and organic matter provide, and the possibility to sow all year round. Economic and agronomic advantages are sometimes promoted in wastewater reuse. One of the most economically feasible agricultural uses of reclaimed water is the irrigation of vegetables which typically have high returns per volume of water invested in it (Toze, 2006). However, there are several studies warning about health risks and environmental impacts.

In developing countries, continued use of untreated wastewater and manure as fertilizers for the production of vegetables is a major contributing factor to contamination that causes numerous foodborne disease outbreaks (AdeOluwa, and Cofie, 2012). Sou *et al*., (2011), have demonstrated a very close relationship between the consumption of fruits and vegetables irrigated with raw wastewater and diseases such as gastroenteritis, cholera, chemical toxicity e.t.c

The microorganisms present in the wastewater can contaminate crops, then pass into the food chain and eventually infect humans (Pianetti *et al*., 2004). The enteric bacteria are perhaps the most common pathogens present in wastewater and *Salmonella* species that occur most frequently. Coliform bacteria have served as indicators of faecal contamination of water for many years, and their densities have been utilized as criteria for the degree of pollution (Teltsch *et al*., 1980).

In Nigeria, it was also reported by (Nafarnda *et al.,* 2012), that untreated abattoir wastewater discharged into water bodies contains bacterial counts above the recommended level for discharge into water bodies. This can have a negative impact on the water quality and subsequent contamination of the surface water meant for various purposes including irrigation. In Nigeria, it was also reported by (Nafarnda *et al.,* 2012), that untreated abattoir wastewater discharged into water bodies contains bacterial counts above the recommended level for discharge into water bodies. This can have a negative impact on the water quality and subsequent contamination of the surface water meant for various purposes including irrigation. In Nigeria, it was also reported by (Nafarnda *et al.,* 2012), that untreated abattoir wastewater discharged into water bodies contains bacterial counts above the recommended level for discharge into water bodies. This can have a negative impact on the water quality and subsequent contamination of the surface water meant for various purposes including irrigation. Due to inappropriate and inadequate urban sanitation infrastructures in Maiduguri metropolis, the wastewater generated in the city and the abattoir is channeled directly without treatment into the receiving river Ngada, which is often used as a source of water for irrigation. Hence the study was necessary to investigate the irrigation water quality and irrigated vegetables in Maiduguri, Nigeria.

2. Materials and Methods

2.1 The Study Area

Maiduguri is the capital of Borno State, Nigeria. It lies between latitudes 110 45'N and11 51'N and longitudes 130 2'E and 130 9'E. It is located in the Ngada Basin, with a seasonal stream that flows through Maiduguri. Maiduguri has a total population of 540,016 (NPC, 2007). The River is used for various human activities including domestic, car washing, and irrigation of vegetables and fishing activities. The River originates from River Yedzram and Gombale both in Nigeria which meet at Sambisa, and flows as the river Ngada into Alau Dam and stretches down across Maiduguri metropolis where it empties into Lake Chad.

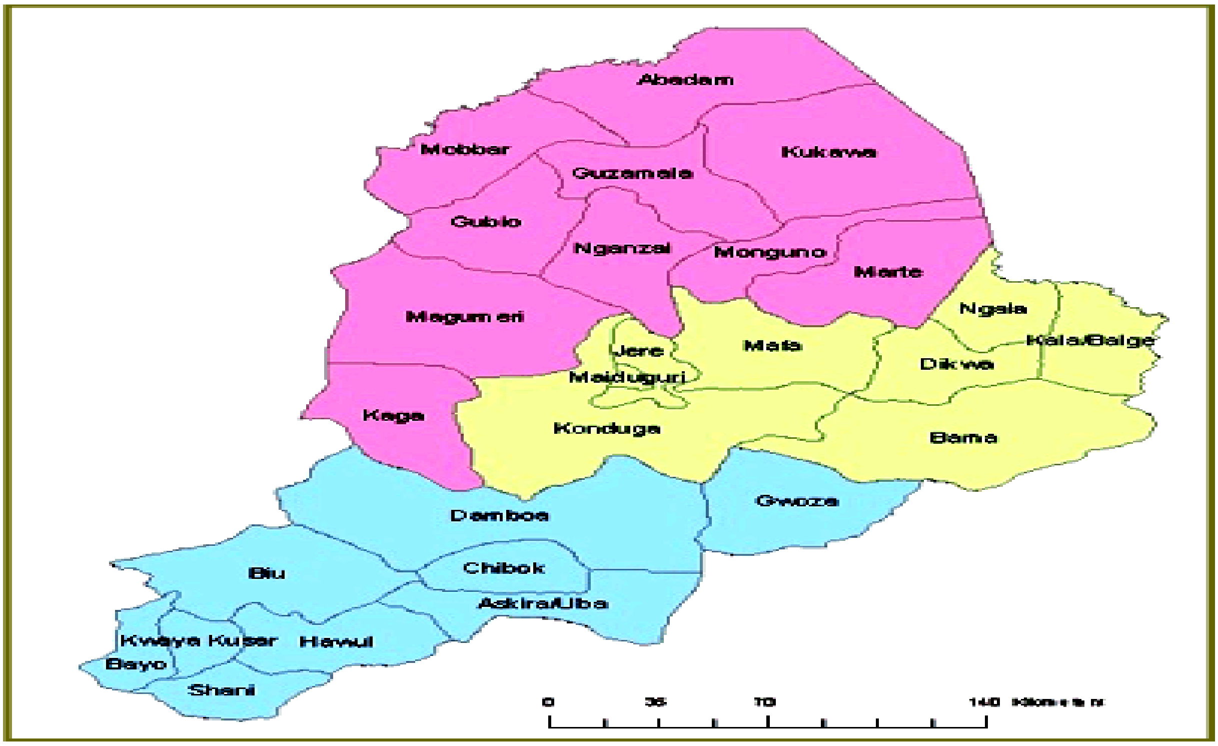

Figure 1. Map of Borno State Showing Maiduguri

Plate 1. Google Map Showing the Study Area and Sampling Locations

2.1.1 Data collection

Irrigation water samples were collected from three locations along the river Ngada where farmers abstract water for irrigation. Vegetable (lettuce) production sites were also selected at each location. A total of nineteen samples comprising of nine irrigation water samples and ten vegetable samples were collected and analyzed. The Samples were replicated three times at each sampling point at an interval of one week between the months of March to April. This period marked the dry season when the demand of water for irrigation purposes was very high in the area. Sampling was carried out between the hours of 8 and 10am at the time when farmers were irrigating. Water samples were collected according to the procedure recommended by American Public Health Association (APHA 1992). Water samples were collected using universal container and vegetable samples were cut into a factory sterilized polythene bags, labeled accordingly and transported to the laboratory within two to three hours of sampling for analysis.

2.1.2 Microbiological Analysis

Total Bacterial Count

A viable plate count method was used in the determination of total bacterial count in each of the samples collected. About 25g of each vegetable was soaked for 15min and washed by shaking thoroughly with sterile distilled water. This method consist of measuring 1ml of each of the irrigation water and vegetable wash water samples into 9ml of sterile saline, and plating series of serial dilution (i.e 10^3, 10^4, 10^5) onto plate counter agar. The number of bacteria per ml of each sample was then isolated and counted by calculating the Colony Forming Unit (cfu).

C.F.U. = no of colonies/inoculums size (ml) × dilution factor C.F.U / ml

Colonies between 30 and 300 were counted while fewer than 30 colonies and more than 300 colonies were neglected.

Faecal Coliform Count

About 25g of each vegetable sample was soaked for 15min and washed by shaking thoroughly with 225ml of 0.1% sterile peptone water. Serial dilutions of each vegetable washing and irrigation water samples were made in sterile peptone water at dilutions 10^1 to 10^5. Faecal coliform count of water samples was determined using the

serial dilution and spread plate method (Ajayi *et al*., 2008). Aliquot of 0.1ml of appropriate dilutions for both sample types were each inoculated on Eosine Methylene Blue (EMB) Agar plates by spread plate technique. Inoculated EMB Agar plates were incubated at 44.5^{o}C for 24h. Characteristic colonies which appeared as green black with metallic sheen on EMB agar were counted as faecal coliforms. Typical colonies were inoculated into lactose broth in test tubes containing inverted Durham`s tubes and were incubated at 44^{o}C for 24h for confirmatory tests. Gas and acid production confirmed faecal coliform test (Ogunshe *et al*., 2006).

Most Probable Number *E. Coli*

Membrane filtration technique was used for the estimation of Most Probable Number of *E.Coli*. Serial dilution of each of the irrigation water and vegetable samples were prepared up to 10^5, by dispensing 1ml of each sample into 9ml of sterile normal saline and then complete the dilution in 5 sterile 20ml universal bottles. 1ml from each of the dilution was aseptically dropped on sterile membrane filter; the membrane filter was then cultured in Mac-Conkey agar. After 24 hours of incubation at 44^{o}C, coliform colonies were then counted under a microscope. All pinkish colonies on the membrane filter were counted. This gives the presumptive number of *E-coli* in each of the samples analyzed.

Isolation of Possible Bacterial Pathogen

Bacterial isolation was restricted to aerobic and facultative microorganisms since river Ngada is shallow and light penetration was at its maximum. Bacterial pathogens were isolated from the samples by inoculating each of the samples onto Blood Agar, Mac-Conkey Agar, Salmonella-shigella Agar and Eosin-Methylene Blue Agar. Cultural, morphological and staining properties as well as sugar fermentation of isolates from each of the selective media were used in identifying any pathogenic bacteria in each of the samples analyzed.

3. Results and Discussions

Table 1. Total bacterial count of the irrigation water

Irrigation waters samples	Total Bacterial Count (cfu/ml)
W1	1.8×10^4
W2	6.2×10^5
W3	5.6×10^5

W1, W2 and W3are irrigation water samples at sample points P1, P2 and P3 respectively

Sample W2 recorded the highest value of total bacterial count of 6.2×10^5 cfu/ml while sample W1 recorded the lowest value of 1.8×10^4 cfu/ml. The high value recorded for sample W2 could be attributed to the point source of pollution from Maiduguri main abattoir wastewater which may contain growth factors that could be utilized by the microorganisms found in the irrigation water, hence the high microbial count.

Table 2. Total bacterial count of vegetables irrigated with river Ngada and fresh waters

Vegetable Samples	Total Bacterial Count (cfu/g)
V1	1.5×10^3
V2	2.3×10^3
V3	3.1×10^3
VC	0.7×10^3

V1, V2, V3 and Vc are vegetable samples at sampling points P1, P2, P3 and Pc (control point) respectively

The total bacterial count presented in table 2 were in the order of V3>V2>V1>VC. The highest value of $3.1x10^3$was recorded for sample V3 and the lowest value of $0.7x10^3$recorded for the fresh water irrigated vegetable sample (VC). The high value of bacterial count recorded for sample V3 could be attributed to the highly polluted water used for irrigation and other anthropogenic activities.

Table 3. Faecal coliform counts of the irrigation water

Water Samples	Faecal Coliform Count (cfu/100 ml)
W1	6.35×10^3
W2	92.1×10^3
W3	27.0×10^3

The faecal coliform counts of the water samples were presented in Table 3. Water sample W2 recorded the highest value for faecal coliform count of 92.1×10^3 cfu/100ml. The presence of faecal coliform is an index for the bacteriological quality of water (Chigor *et al*., 2012). The levels of faecal coliform counts observed in all the water samples were higher than the 1000 faecal coliform/100ml as recommended by W.H.O (2006). The high faecal coliform counts recorded for samples W2 and W3 were a reflection of the level of effluent from point sources of contamination from different sources such as domestic wastewater, market place and abattoir.

Table 4. Faecal coliform counts of vegetables irrigated with river Ngada and fresh waters

Vegetable samples	Faecal Coliform Count (cfu/100 g)
V1	0.09×10^2
V2	19.05×10^2
V3	12.7×10^2
VC	0.02×10^2

From Table 4, the faecal coliform counts for all the vegetable samples analyzed ranged from 0.02×10^2 to 19.05×10^2 cfu/100g. The highest faecal coliform count was recorded for sample V2 while sample VC recorded the lowest value of the faecal coliform count. The faecal coliform counts of vegetable samples V2 and V3 exceeded the recommended standard of 1000 cfu/100g for fresh vegetable by International Commission on Microbiological Specification for Food (ICMSF, 1974) while sample V1 and the fresh water irrigated vegetable (VC) were within the recommended standard values for fresh produce. The high faecal coliform levels observed for samples V2 and V3 could be attributed to the highly polluted river Ngada water. This finding is similar to the results obtained by Abakpa *et al* (2013) of high faecal coliform level that exceeds the recommended standard in irrigation water and irrigated vegetable in Kano, Nigeria.

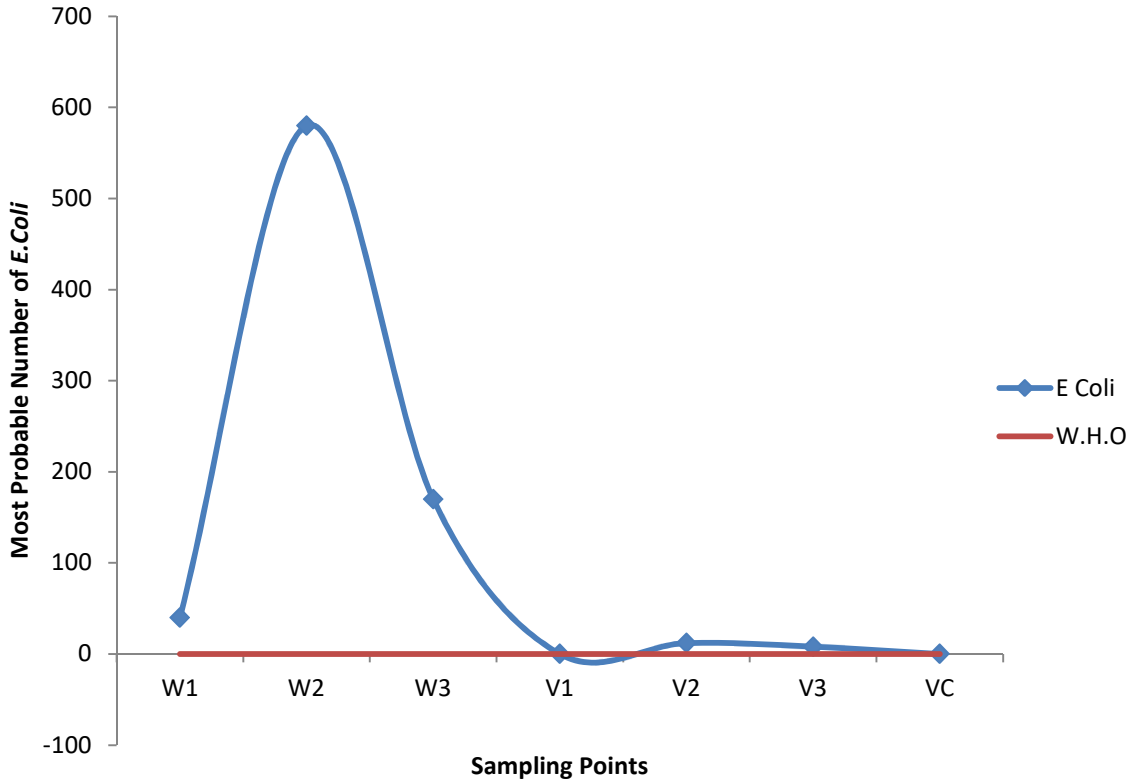

Figure 2. Most Probable Number of *E. Coli* for irrigation water and irrigated vegetables

Figure 2 shows the Most Probable Number of *E. Coli* in both the irrigation water from river Ngada and irrigated vegetable samples. Sample W2 recorded the highest value of the Most Probable Number of *E. Coli* while samples V1 and VC recorded zero values. The irrigation water samples in all the locations were above the recommended standard of less than 1 per 100ml of *E. Coli* for irrigation. The high number of *E. Coli* recorded for sample W2 could be attributed to the abattoir effluent discharge. The presence of *E. coli* is never beneficial to a consumer and always points to the possibility of faecal contamination. *E.Coli* are normal inhabitants of the intestinal tract and are practically always present in faeces and thus also in faecally contaminated water. This has resulted in the almost universal use of *E. coli* as the standard indicator for faecal contamination (Francis *et al.*, 1999). The presence of *E. Coli* in the vegetable samples V2 and V3 indicated the effect of irrigation water on the quality of the irrigated vegetables.

Table 5. Pathogenic bacteria isolates in irrigation water from river Ngada

	Samples		
Organisms	**W1**	**W2**	**W3**
Bacteria	*Shigella Spp*	*Shigella Spp*	*Shigella Spp*
	-	*Salmonella Spp*	*Salmonella Spp*
	Staphylococcus Spp	*Staphylococcus Spp*	*Staphylococcus Spp*
	E.Coli	*E.Coli*	*E.Coli*
	-	*klebsiella*	-

Table 5 shows the bacterial isolates from river Ngada water. The bacterial isolates include *Escherichia coli, Staphylococcus Spp, Shigella Spp, Klebsiella,* and *Salmonella Spp*. Among the isolated bacteria, *shigella spp, E.Coli* and *Staphylococcus Spp* were the most common pathogenic bacteria in all the irrigation water samples analyzed. *Salmonella spp* were isolated from samples W2 and W3.

Table 6. Pathogenic bacteria isolates in vegetables (lettuce) irrigated with river Ngada and fresh waters

	Vegetable samples			
Organisms	**V1**	**V2**	**V3**	**VC**
Bacteria	*Shigella Spp*	*Shigella Spp*	_	_
	Staphylococcus Spp	*Staphylococcus Spp E.Coli*	*Stapphylococcus Spp E.Coli*	*Stapphylococcus Spp*

Table 6 shows the pathogenic microorganisms present on the surfaces of vegetables (lettuce). *Staphylococcus spp* were present in all the vegetable samples while *shigella spp* were present in samples V1 and V. *E.Coli* was isolated from the surfaces of samples V2 and V3 respectively. The presence of these pathogenic bacteria in the irrigation water sources and the irrigated vegetables could be due to the wastewater discharge from Kasuwan Shanu abattoir without treatment and application of manure to the farm land as fertilizer.

4. Conclusion

This study examined the presence of microbiological food contaminants in lettuce and irrigation water from river Ngada. The Results clearly indicated the presence of high counts of bacterial growth in leaves and irrigation water samples. The bacteriological count of river Ngada water and irrigated vegetables obtained in this study exceeded the recommended microbiological limits set by W.H.O (2006). Point sources of effluents from Kasuwan Shanu abattoir contributed significantly to the continuous influx of microorganisms to the irrigation water source. Therefore, it is recommended that wastewater from Kasuwan Shanu abattoir be treated before discharging in to the receiving river and irrigated vegetables be washed thoroughly with brine before consumption.

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