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Microbiological Quality Assessment of Spinach (*Amaranthus hybridus*) and Lettuce (*Lactuca sativa*) Harvested from the Kwakwachi Area of Kano State

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Abstract

This study aimed at assessing the microbiological quality of irrigation water, Spinach and lettuce from Kwakwachi area of Kano State. The results of the microbiological counts of irrigation water, spinach and lettuce from Kwakwachi recorded a least Clostridium sp.counts of 8.93±1.26[a], 14.79±1.31[b], 18.50±2.47[b]respectively. Salmonella sp., Shigella sp., and Aspergillus sp.were found to occur at 16% prevalence rate in all the samples. The COD, BOD and THS (total hardness) were found to be 55.02±4.40, 29.40±13.04[b] and 25.28±10.69mg/l respectively. The chromium concentration of 0.45±0.04[a] was higher than cadmium, lead and iron in the study area. The study stresses the need for adequate treatment of effluents before discharge and proper handling and washing of vegetables before consumption.

Keywords: *Microbiological Quality Assessment, Spinach, Lettuce, Heavy Metals, Physicochemical Parameters*

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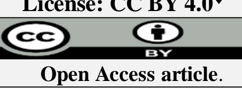

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1. Introduction

More than 10% of the world's population consumes foods produced by irrigation with wastewater (WHO, 2006). The percentage is considerably higher among populations in low-income countries with arid and semi-arid climates. Both treated and untreated wastewaters are used directly and indirectly for irrigation in developed and less developed countries (WHO, 2006). One of the most economically feasible agricultural uses of reclaimed water is the irrigation of vegetables which typically has high returns per volume of water invested in it (Toze, 2006). Although, the environmental and public health risks posed by wastewater irrigation are alarming, especially when untreated and/or partially treated wastewater is used for such purposes (Ackerson *et al*., 2012). There is increasing evidence that consumption of raw fresh produce is a major factor contributing to human gastrointestinal illness, due to the potential for contamination with pathogenic microorganisms.

The Microbiological Quality of vegetables and Cereal crops grown with wastewater is highly alarming (Ajayi *et al*., 2008). Thermal processing is one of the domestic techniques of processing vegetables in Nigeria but for fear of denaturation of beneficial nutrients during heating (Udousoro *et al*., 2013), Vegetables are served and consumed raw. Faecal coliforms are the indicator bacteria most commonly used in discussions of wastewater reuse (Blumenthal *et al*., 2000). They are broadly equivalent to "thermotolerant coliforms". The preferred grouping is thermos-tolerant "coliforms/*Escherichia coli*" which eventually allows *E. coli* to be used as the preferred and exclusively faecal indicator bacterium (Edberg, 2000). The need to assess the microbiological quality of irrigation water, irrigated vegetables in Nigeria is eminent in order to propose

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alternatives to prevent consumers from disease outbreaks. This study aimed to assess the microbiological quality of irrigation water, spinach and lettuce from Kwakwachi area of Kano State, with specific objectives; to enumerate microbial load in water for irrigation and vegetable samples, to investigate the physicochemical parameters of the water used for irrigation from the study area, to isolate and identify microbial flora from the irrigation water, spinach and lettuce from the study area, to determine the frequency of occurrence of the identified organisms, and to conduct the heavy metal analysis of irrigation water, spinach and lettuce from the study area.

2. Methodology

Study Area

Kwakwachi is an area in Fagge Local government situated along Zungeru road, Nomansland Sabon Gari, Kano state. It located at longitude 8.518^{0}E and latitude 12.029^{0}N (NIPOST, 2009). It has a lot of commercial activities going on which include irrigation farming.

Samples Collection

A total of 42 samples consisting of 14 irrigation water samples, 14 spinach samples and 14 lettuce samples were collected. The sources of contamination of irrigation water from the study area were composed mainly of abattoir waste, industrial effluent terminals and domestics waste. Two samples of irrigation water were collected on weekly basis for seven consecutive weeks using a Sterile wide mouth, screw capped glass sample bottles (250ml).

For vegetable samples, 2 samples of Spinach and 2 samples of lettuce were collected on weekly aseptically by cutting with a sterilized scissors and dropped into a polythene bag. All samples were kept in an iced box maintained at 4^{0}C and then transported to the laboratory for analysis (APHA, 2005).

Bacteriological analysis of the water and vegetable Samples

Enumeration of Aerobic Mesophilic Bacteria (APC) from Water for Irrigation

This was carried out by Pour Plating Technique and Serial Dilution. Specific volume (10ml) of the sample was transferred into a conical flask containing 90ml of buffered peptone water using sterile pippette syringe and labeled 10^{-1} (stock solution). About 1ml from tube 10^{-1} was transferred after agitation into another test tube containing 9ml of BPW (using a separate syringe) and labeled 10^{-2}. This was repeated to obtain 10^{-3}, 10^{-4} and 10^{-5}. Using another fresh syringe, 1ml of sample from each dilution was transferred into two sterile petridishes and labeled accordingly. This was followed by pouring cooled molten nutrient agar in each petridish and allowed to solidify. Finally, the plates were incubated at 37^{0}C for 24 – 48hours (ISO, 2013)

Enumeration of Aerobic Mesophilic Bacteria (APC) from the Vegetable Samples

This was carried out by pour plating technique and serial dilution. About twenty-five grams of each vegetable was weighed using a weighing balance and soaked for 15 minutes in 250ml peptone water. About 10ml of the sample was transferred into a conical flask containing 90ml sterile peptone water. Serial dilution of the vegetable washing was made in sterile peptone water at dilutions 10^{-1} to 10^{-5}. Using another fresh syringe, 1ml of sample from each dilution was transferred into two sterile petridishes and labeled accordingly. Cooled molten nutrient agar was poured and allowed to solidify and the plates were finally incubated at 37^{0}C for 24 – 48hours (ISO, 2013)

Enumeration of Coliform Bacteria Using MPN Method from the irrigation Water

This test was carried out on water for irrigation using multiple tube fermentation technique. Coliform determination of the irrigation water sample was carried out by inoculating 10ml of water sample into 5 test tubes each containing 10ml sterile double strength lactose broth with inverted durham tubes (ensuring that no air bubble is captured). Then 1ml of each sample was then inoculated into 5 tubes each containing 5ml sterile single strength lactose broth with inverted durham tubes. Then 0.1ml of each sample was then inoculated into 5 tubes containing 5ml single strength lactose broth. The tubes were incubated at 37°C for 24 - 48 hours and compared with the MPN table (APHA, 2012)

Enumeration of Coliform Bacteria Using MPN Method from the Vegetable Samples

A set up was made of nine (9) test tubes each containing 9ml of lactose broth with Durham tube. One millilitre of inoculum (serial dilution of the soaked vegetables) from 10^{-1} dilution was transferred to each of the first 3 tubes and were all labelled 10^{-1}. Then 1ml from 10^{-2} dilution was transferred to each of the second three tubes and labelled 10^{-2}. Lastly, 1ml of inoculum (serial dilution of the soaked vegetables) was transferred to each of the last three lactose broth tubes and were and were labeled 10^{-3}. The tubes were then incubated at 37°C for 24 – 48 hours (APHA, 2012)

Detection of Faecal Coliform Bacteria

From the positive tubes (water and vegetables) showing lactose fermentation (gas production), a loopful of broth from the tubes was streaked on to Eosine Methylene Blue (EMB) agar plate and incubated for 24-48 hours at 45°C. Colonies that formed green metallic sheen on EMB are suspected *E.coli* and were inoculated on agar slant for further confirmatory test (Cheesbrough, 2006).

Detection of Some Specific Organisms

Some specific organisms like *Salmonella* sp., *Shigella* sp., *Proteus* sp., *Staphylococcus* sp. etc. were also determined by inoculating a loopful of broth from the positive and negative test tubes on MacConkey agar, Deoxycholate citrate agar, Baird- Parker Agar respectively and incubated for 24 – 48 hours at 37^{0}C. This was further confirmed with biochemical test (Cheesbrough, 2006).

Identification of *Clostridium* sp.

Clostridium sp. was identified by inoculating a loopful of broth from both positive and negative test tubes on Sulfite Polymyxin Sulfadiazine Agar and placed in an anaerobic jar and incubated at 37^{0}C for 24 – 48 hours (Jeffrey and Stanley, 2001). A round, circular, smooth and milky colonies were

suspected *Clostridium* sp. and were inoculated on agar slant for further confirmatory test (Cheesbrough, 2006).

Identification of *Vibrio* sp. and *Pseudomonas* sp.

Vibrio sp. and *Pseudomonas* sp. were identified by inoculating a loopful of broth from both positive and negative test tubes on Thiosulphate Citrate Bile Salt agar and incubated at 37^0C for 24 – 48 hours. Round, flat yellow and blue colonies were suspected *Vibrio* and *Pseudomonas* species and were inoculated on agar slant for further confirmatory test (i.e. Biochemical test) as demonstrated by (Cheesbrough, 2006)

Biochemical test for characterization of bacteria

Bacterial isolates were characterized on the basis of their colonial morphology, cellular morphology through Gram staining and biochemical characteristics (Cheesbrough, 2006). The biochemical test included Catalase Test, Coagulase, Citrate Utilization Test, Indole Test, Triple sugar iron (TSI) Test, Methyl Red VogesProskauer Test (MR-VP)

Fungal Analysis of Water and Vegetable Samples

Enumeration and Identification of Fungi

A known quantity (10ml) from both water and vegetable samples were transferred into a test tube containing 90ml of buffered peptone water (BPW) using sterile syringe and labeled 10^{-1} (stock solution). About 1ml of tube 10^{-1} was transferred after agitation into another test tube containing 9ml of BPW (using a separate syringe) and labeled 10^{-2}. This was repeated to obtain 10^{-3}, 10^{-4} and 10^{-5}. Using another fresh syringe, 1ml of sample from each dilution was transferred into two sterile appropriately labelled Petri dishes. This was followed by pouring cooled potato dextrose agar in each Petri dish, swirled clockwise and anti-clockwise and allowed to solidify. Finally, the plates were incubated at room temperature for 2-5 days. Following incubation, viable fungal colonies were counted, recorded, sub cultured and compared with a mycology atlas for identification (Egboh and Emeshili, 2007).

Determination of Physicochemical Parameters of the Irrigation Water

pH and Temperature

The pH was determined on field using a digital pH meter in which the samples were poured into 5ml beakers and the electrode of the pH meter was dipped inside each beaker for a minute and then readings were taken directly from the meter. Whereas the temperature was determined using mercury-in-glass thermometer calibrated in degree centigrade (^{0}C) as described by (Lawal and Lohdip, 2011)

Electrical Conductivity (EC)

EC of the water sources was measured in the laboratory using a conductivity meter. The EC meter was switched on and its probe dipped into the sample contained in a beaker. The electrical conductivity was read directly and recorded in μScm^{-1} (APHA, 2005)

Turbidity and Colour

Turbidity levels were measured in Nephelometric units (NTUs) using a turbidity meter. The meter probe was dipped into a beaker containing 5ml of water sample and readings were taken directly from the meter (Olaoluwa *et al*., 2010). Whereas the Colour (apparent colour) was determined using Lovibond with disc in which 5ml of the sample was placed in a sample container and ammonia was added and used as a reagent. The lovibond test disc was inserted into the comparator instrument. The sample container was placed in the right-hand comparator compartment and a cell containing a blank of water was placed in the left-hand side. Using standardized lighting, the disc was rotated until a closest colour match with the sample shown in the window of the comparator instrument is obtained (Ogundele, 2010).

Chemical oxygen demand (COD)

A known quantity (50ml) of water sample was mixed with a known quantity (25ml) of standard solution of potassium dichromate (K2Cr2O7) and the mixture was heated. The organic matter was oxidized by the potassium heptaoxodichromate (VI) in the presence of sulphuric acid (H_2SO4) and the oxygen used in oxidizing the water was determined (Ajayi, 2008).

Determination of Dissolved Oxygen (DO)

This was determined using dissolved oxygen meter. Zero oxygen solution was prepared by dissolving 2g of sodium sulphate in 100ml of sample. It was allowed to stand for 2 to 5 minutes. The 'CAL' Key from the colorimeter was pressed and the meter probe was inserted into prepared solution. This was allowed to stand for 30 seconds to calibrate, meter probe was inserted into the sample, allowed to stand for a minute and the final reading was recorded in mg/l (Aderomoti, 1996).

Determination of Biochemical Oxygen Demand (BOD)

This was done by taking the difference of dissolved oxygen for duration of time (5 days). The dissolved oxygen was determined using dissolved oxygen meter. Zero oxygen solution was prepared by dissolving 2g of sodium sulphate in 100ml of the sample. This was allowed to stand for 2-5 minutes. The 'CAL' key was pressed and the meter probe was inserted into a prepared solution. This was allowed to stand for 30 seconds to calibrate. Meter probe was inserted into the sample, allowed to stand for a minute. Then it was recorded in mg/l. The Difference between DO1 and DO5 was been taken as the biological oxygen demand (Aderomoti, 1996).

Nitrates (NO_3^{2-})

The nitrate content of the water samples were determined by mixing 10ml of the sample in a test tube with 2ml of 1M in cold-water bath and thoroughly mixed with 10ml of 1M H_2SO4 acid. This was followed by 0.05ml brucinesulfanilic acid reagent. The tube was placed in a water bath at 95^0C for 20 minutes before cooling to room temperature. An aliquot of the solution was measured at 410nm using distilled water as blank (APHA, 2005).

Phosphate (PO_4^{2-})

This was determined by adding 4ml of Ammonium molybdate reagent and 4-5 drops of stannous chloride reagent to 50ml of filtered sample. After about 10 minutes, the colour developed was measured photometrically at 690nm and calibration curve was determined (APHA, 2005).

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Heavy Metals Determination of Water for irrigation

Heavy metals were determined using Atomic Absorption Spectrophotometer (AAS). This was evaluated to determine the concentration of Cadmium (Cd), Iron (Fe), Lead (Pb) and Chromium (Cr). The sample was poured into a 100ml beaker and 5ml of HNO_3 was added and covered with watch glass. The sample was slowly boiled on hot plate and evaporated to about 10ml. HNO_3 was added as necessary until light-coloured clear solution was obtained. The samples were then filtered with Whatman paper into 100ml conical flask and made up to volume (Adekoya *et al*., 2006).

Total Hardness

About 25ml of the sample was placed in a clean 250ml conical flask. To this 3ml of ammonium chloride in concentrated buffer (NH_4CL/concentrated NH_3) and 2 drops of Eriochrome Black T indicator was added. This was titrated against 0.01M EDTA solution until the colour changes from violet to blue (Kolhe *et al*., 2008)

Total solid (TS)

This was determined gravimetrically, 10ml of the water sample was measured into a pre weighed evaporating dish and it was dried in an oven at a temperature of 103 to 105^{0}C for two and half hours. The dish was transferred into a desiccator and allowed to cool to room temperature and then it was weighed. The total solid was been represented by the increase in the weight of the evaporating dish i.e. Total solids (mg/L) = (W2-W1) mg 1000/mL of sample used Where W1= initial weight of evaporating dish, W2= final weight of the dish (evaporating dish+ residue) (Kolhe *et al*., 2008).

Total dissolved solids (TDS)

This was carried out gravimetrically, here a portion of the water sample was filtered out and 10mL of the filtrate was measured into a pre weighed evaporating dish and dried in an oven at a temperature of 103 to 105^{0}C for two and half hours. The dish was transferred into a desiccator and was allowed to cool to room temperature and weighed. The total dissolved solids content of the water sample was calculated as follows:

Total dissolved solids (mg/L) = (W2-W1) mg1000/mL of filtrate used

Where W1 = initial weight of evaporating dish

W2 = final weight of the dish (evaporating dish + residue) (Kolhe *et al*., 2008).

Bicarbonate Ion (HCO_3)

This was determined using titrimetric method. About 50ml of the sample was measured into a conical flask then 2 – 3 drops of phenolphthalein indicator was added and a pink colour developed. The solution was titrated against 0.1M HCL to a colourless end point. Rapidly, 2 – 3 drops of methyl orange was added to the same solution, the colour changed to yellow after which the titration was continued to an orange colour end point then the reading was taken (APHA, 2005).

Heavy Metal Analysis of Vegetables

Air dried plant material was pulverized into powder. The sample was then put out in a crusable and transferred to a muffle furnace and then heated at 500^{0}C for 3 hours. The sample was then removed and allowed to cool in a desicator. About 500mg of the ashed sample was transferred to 250ml beaker, and to this, 10ml of 6 molar concentration of hydrochloric acid was added. The beaker was covered and heated for another 15 minutes, the solution was allowed to cool. One millilitre of 6M hydrochloric acid was added again and 10ml of distilled water was added, it was then heated on a hot plate in a fume cupboard until a clear digest was obtained. The solution was removed for filtration using Whatman's filter paper No.1 into 100ml mark and then transferred into polyethylene bottle for elemental analysis using Atomic Absorption Spectrophotometer (bulk scientific model) (Mohammed *et al*., 2015; APHA, 1995).

Statistical Analysis

The Data obtained from the results were subjected to one way ANOVA using Statistical Package for Social Sciences (version 23) and presented as the mean value ± SEM (standard error of mean). The means were assessed using the Duncan's Multiple Range Post Hoc Test.

3. Results

Table 1 shows the microbiological count of Irrigation water, spinach and lettuce from Kwakwachi. The aerobic bacterial and fungal counts in Irrigation water from Kwakwachi were significantly ($p < 0.05$) higher than in spinach and lettuce. Irrigation water had the least Clostridium sp.count of 8.93±1.26^{a}cfu/ml and the highest coliform count of 2400MPN/ml.

Table 2 shows the occurrence of bacteria in irrigation water, spinach and lettuce from Kwakwachi. The result showed that *Salmonella* sp. and *Shigella* sp. occurred more (both 16% each) in irrigation water from Kwakwachi while *E.coli, Proteus* sp. and *Klebsiella* sp. had a frequency of (9%) for the water samples. However, the occurrence of *vibrio* sp. and *Pseudomonas* sp. was least (2%). Kwakwachi grown Spinach and Lettuce also showed *Salmonella* sp. and *Shigella* sp. to have the highest frequency 6 (14%) while *Pseudomonas* sp. had the least frequency of 1 and 2 (2 and 5%). Table 3 shows the occurrence of fungi in irrigation water from Kwakwachi. The result showed *Aspergillus* sp. occurred more at 16, 14, and 18% in Kwakwachi irrigation water, spinach and lettuce. The least was *Trichodarma* sp.which occurred at 7 and 5% in irrigation water and spinach. Fusarium sp. and Trichoderma sp. were found to occur less in lettuce at 9% each.

The Table 4 presents the physicochemical properties of the water for irrigation collected from Kwakwachi. It was shown in the result that Kwakwachi water for irrigation had the pH value (8.68±0.08). The water turbidity was found to be (6.59±1.18 x 10^2). Water for irrigation from Kwakwachi had colour value of (14.40±6.93), temperature (30.72±1.91° C), total hardness (25.28±10.69 x 10^2), total soluble solid (14.13±6.93 x 10^2), bicarbonate concentration (10.86±3.76), biological oxygen demand (29.40±13.04) and COD (55.02±4.40). Table 5 presents the concentration of some heavy metals in Kwakwachi. Cadmium and Chromium concentrations were significantly ($p<0.05$) higher in water for irrigation than in spinach and lettuce. No lead concentration in lettuce harvested from Kwakwachi. The result showed that phosphorous concentration was significantly ($p<0.05$) higher

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in spinach than water or irrigation and lettuce. Iron concentration was higher in water for irrigation than in spinach and lettuce harvested from Kwakwachi.

Table 1: Mean Microbiological counts of Irrigation water, Spinach and Lettuce from Kwakwachi

Sample	Microbial count (cfu/ml x 10^4)				
	Aerobic Bacterial	Fungal Count	*Staphylococcus* sp. Count	*Clostridium* sp. Count	Coliform count (MPN/ml)
Water	133.21±8.26^b	77.86±7.91^b	33.00±3.65^b	8.93±1.26^a	2400
Spinach	47.93±9.56^a	33.79±7.70^{ab}	42.14±5.54^b	14.79±1.31^b	1318
Lettuce	56.57±7.82^a	34.57±6.65^{ab}	42.43±4.88^b	18.50±2.47^b	1133

Values are Mean ± SEM of duplicate determinations. Values with different alphabets along a column are significantly (p = < 0.05) different (**WHO Standard Unit1000 MPN/100ML**)

Table 2: Occurrence of Bacteria in Irrigation, Spinach and Lettuce from Kwakwachi

Isolated Bacteria	Frequency (%)		
	Water (%)	Spinach (%)	Lettuce (%)
E. coli	4 (9)	5(11)	5(11)
Salmonella sp	7 (16)	6(14)	6 (14)
Shigella sp	7(16)	6(14)	6 (14)
Staphylococcus sp	3(7)	4(9)	5 (11)
Enterobacter sp	5(11)	5(11)	4 (9)
Proteus sp	4(9)	3(7)	4 (9)
Klebsiela sp	4(9)	6(14)	4 (9)
Clostridium sp.	3(7)	3(7)	3 (7)
Vibrio sp	1(2)	2(5)	3 (7)
Pseudomonas sp	1(2)	1(2)	2 (5)

Table 3: Occurrence of fungal isolates in irrigation water from Kwakwachi

Isolated Fungi	Frequency (%)		
	Water	Spinach	Lettuce
Fusarium sp	4 (9)	5 (11)	4 (9)
Aspergillus sp	7 (16)	6 (14)	8 (18)
Rhizopus sp	5 (11)	4 (9)	5 (11)
Trichoderma sp	3 (7)	3 (7)	4 (9)

Table 4: Mean Physicochemical Analysis of Irrigation Water from Kwakwachi

Parameters	Water analysis	WHO /FAO Max limit
pH	8.68±0.08^b	6.5 – 8.50
Turbidity x 10^2 (NTU)	6.59±1.18^b	
Colour x 10 (H)	14.40±6.93^b	
Temperature (^{O}C)	30.72±1.91^b	
Conductivity x 10^2 (μs/cm)	8.83±1.63^{ab}	
Nitrate (mg/l)	0.21±0.08^a	
Phosphorous (mg/l)	3.51±1.59^b	
Total hardness x 10^2 (mg/l)	25.28±10.69^b	
TSS x 10^2 (mg/l)	14.13±6.93^c	
TDS x 10^2 (mg/l)	3.80±0.28^b	
Bicarbonate x 10^2	10.86±3.76^c	
BOD (mg/l)	29.40±13.04^b	
COD (mg/l)	55.02±4.40^c	

Values are Mean ± SEM of duplicate determinations. Values with different alphabets across a row are significantly (p = < 0.05) different.

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Table 5: Heavy Metals in Water for Irrigation, Spinach and Lettuce from Kwakwachi

Heavy Metals	Water	Spinach	Lettuce
Phosphorus (Mg/1)	3.51 ± 1.59^{b}	47.70 ± 0.80^{c}	11.30 ± 0.20^{b}
Cadmium (mg/l)	0.44 ± 0.04^{a}	0.03 ± 0.00^{ab}	0.01 ± 0.00^{a}
Chromium (mg/l)	0.45 ± 0.04^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}
Lead (mg/l)	0.25 ± 0.03^{b}	0.12 ± 0.01^{b}	0.00 ± 0.00^{a}
Iron (mg/l)	0.2 ± 0.02^{b}	1.77 ± 0.05^{c}	0.17 ± 0.14^{a}

Values are Mean ± SEM of duplicate determinations. Values with different alphabets along a column are significantly ($p = < 0.05$) different.

4. Discussion

The Microbiological analysis, Physicochemical and Heavy metal analysis of Water and Vegetables samples were carried out from Kwakwachi and the results are discussed as follows. The high aerobic bacterial, fungal and staphylococcal counts observed in Kwakwachi water for irrigation were probably due to the influx of domestic sewage and other indiscriminate faecal materials such as animal dungs, dead animals and other waste dumps.

The high total coliform count of Kwakwachi water for irrigation could be basically due to pollution from widespread and indiscriminate human and animal defecation and very poor waste disposal practices around the water run way. However, the total and fecal coliform count of water sample from Kwakwachi was 2400 MPN/100ML^{-1} which is higher than the WHO recommended standard (WHO, 2006). High coliform count observed in Kwakwachi is in agreement with the report of Korajkic *et al.* (2011) which was also attributed to the large volume of runoff which increased contamination.

The overall mean counts of total and fecal coliforms of spinach and lettuce from Kwakwachi (1133 and 1608) were in agreement with the findings of Nipa *et al.* (2011) who reported >1100MPN100ML^{-1} from salad Vegetables. In the present study, *Salmonella* sp. and *Shigella* sp. were found to occur in Spinach and Lettuce from Kwakwachi at (14, 11 and 11%).

Staphylococcus sp. and *Proteus* sp. occurred in Spinach and Lettuce from Kwakwachi (9, 2 and 7% and 7, 9 and 2%). *Clostridium* sp. *Vibrio* sp. and *Pseudomonas* sp. were found to occur in both Spinach and Lettuce from Kwakwachi at (7, 11 and 9% and 7, 5 and 5%). Analysis of fungi revealed high Fungal counts in vegetable samples from the study area which could be due to human activities going on around the sampling sites. Fungi revealed in spinach and lettuce from Kwakwachi include *Fusarium* sp. (11, 5 and 14% and 9, 5 and 11%), *Aspergillus* sp. (14, 9 and 20% and 18, 7 and 16%), *Rhizopus* sp. (9, 7 and 11% and 11, 7 and 14%) and *Trichoderma* sp. (7, 7 and 9% and 9, 2 and 9%). The significantly higher Turbidity value obtained in Kwakwachi water for irrigation maybe due to clay, silt, fine organic matter and microscopic organisms, predominantly living algae. The Colour of the Kwakwachi water for irrigation was high. The colour intensity values obtained in Kwakwachi water for irrigation was similar to the values at discharge point of industrial effluent reported by Arimoro, (2009) for Adofi River, Delta State Nigeria.

The mean Temperature of Kwakwachi water for irrigation (Table 4) agrees with the report of Abakpa *et al.* (2013) who evaluated microbial quality of irrigation water and vegetables in Kano State Nigeria and found the mean temperature to range from 25.46±0.77 to 30.50±0.89°C. Significantly, high amount of Total Suspended Solids (TSS) in Kwakwachi water for irrigation was not in consonance with the report of Kwadzah, and Iorhemen, (2015) that assessed the impact of abattoir effluent on the water quality of River Kaduna which is used by several farmers for irrigation. The high COD in Kwakwachi water for irrigation may be as a result of influx of domestic effluents, runoff from farmlands, season (rainy or dry). Table 5 shows the heavy metal concentrations of water for irrigation, spinach and lettuce from Kwakwachi. The result showed that spinach and lettuce from Kwakwachi had the highest concentrations of Cadmium (0.05±0.01 and 0.01±0.00mg/l).

5. Conclusion

The microbial analysis was performed on Kwakwachi water for irrigation. High bacterial and fungal loads were observed at Kwakwachi which pose a threat to human health. Since the physicochemical parameters of water for irrigation are indication of the quality of water for irrigation, it has been observed in the present study that Kwakwachi had high values of physicochemical parameters analysed and this may have direct or indirect effect on the crops and may also affect humans when consumed.

Conflict of interests: The authors declare that they have no conflict of interests.

Authors Contributions: All authors contributed towards the study design, experiment execution, data analysis, and manuscript drafting.

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