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Investigating the Impact of the Use of Pre-Treated Sewage in Vegetable Propagation

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Abstract:
The general objective of this project is to assess the uptake of some selected physicochemical and microbiological parameters by two different vegetables grown on agricultural soil irrigated with pretreated sewage waste (greywater), stream water and well water (collected as control sample) and for comparative purposes. Wastewater and vegetable samples were collected from Awolowo Hall junction (University of Ibadan) with vegetables (Ugwu-Pumpkin-Curcubita Maxima) being irrigated with domestic sewage water (Greywater) discharged from both Idia and Awolowo Halls, and tagged location I while other two sampling points were located in Ajibode, Akinyele Local government area of Oyo state , Ibadan (locations I and II), with (Ewedu- Jews Mallow-Corchorus Olitorius) and being irrigated with both well and stream water (stream flow). Samples collected were analyzed for the following physio-chemical parameters such as pH, Temperature, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Conductivity, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Sulphate, Nitrate and Phosphate. In addition, metals (Copper, Cobalt, Chromium, Iron, Manganese, Magnesium, Nickel, Cadmium, Lead, Sodium, Potassium and Calcium. Among others, the presence of microbiological activities such as; Total Coliform Count, Pseudomonas Sp., Aeromonas Sp., Salmonella Sp., Ecoli Count, Enterobacter Sp., were also determined using standard method and procedure. The results of the laboratory analysis on the vegetables sampled, revealed that only phosphorus was found to be more than World Health Organization permissible limit while the remaining physio-chemical parameters were still within the permissible limit and the positive indication enteropatogenic micro-organisms; Pseudomonas Sp., Salmonella Sp., Proteus Sp., Aeromonas Sp., Enterocbacter Sp., Klebsiella Sp., Staphylococcus Sp., E-coli. In vegetables under the study areas, indicates that these vegetables are not safe for human consumption. Therefore, it is now pertinent to note that the use of wastewater for irrigation may have positive impacts for short term productivity because of the presence of nutrients but might have negative consequences in the long term hence domestic sewage water should be properly disposed and or recycled if it was to be used for irrigation and appropriate risk analysis should be performed to clarify the risks associated with the reuse of greywater for irrigation. Based on the results of the risk analysis, new standards for greywater reuse (specific to greywater) should be developed.

Keywords: Sewage, Pre-treated, Vegetable, microbiological, Physicochemical etc.

Introduction

Once water has been used for an economical or beneficial purpose, it is generally discarded as waste (UNEP, 1997). Domestic or sanitary wastewater as defined by Hammer and Hammer (2000), refer to liquid discharge from residences, business buildings, and institutions, while industrial wastewater is discharged from manufacturing and food processing plants. Sources of wastewater from small communities (municipal wastewater) include houses, farms, hospitals, and business premises. This can be composed of any debris from streets, and waste oils, pesticides, fertilizers and waste from humans and animals. Wastewater from a typical household might include toilet washes, used water from sinks, baths, showers' washing machines and dishwater and anything else that can be put down the drain or flushed down the toilet (Tailor *et.al.*, 1996). The volume of wastewater generated by domestic, industrial and commercial sources has increased with population, urbanization, improved living conditions, and economic development (Qadir *et al.*, 2008). In urban areas of many (developing) countries, urban and periurban agriculture depends, at least to some extent, on wastewater as a source of irrigation water. The quality of the water and the conditions under which this water is used vary greatly. In poor countries this water may, in extreme cases, take the form of diluted raw sewage, even if this is considered illegal (Huibers *et al.*, 2004).

In many arid and semi-arid countries, water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically and effectively to promote further development. At the same time, with population expanding at a high rate, the need for increased food production is apparent. The potential for irrigation to raise both agricultural productivity and the living standards of the rural poor have long been recognized (APHA, 1998). Irrigated agriculture occupies approximately 17 percent of the world's total arable land but the production from this land comprises about 34 percent of the world total (APHA, 1998). Whenever good quality water is scarce, water of marginal quality will have to be considered for use in agriculture. Although there is no universal definition of 'marginal quality' water, for all practical purposes it can be defined as water that possesses certain characteristics which have the potential to cause problems when it is used for an intended purpose. For example, brackish water is a marginal quality water for agricultural use

because of its high dissolved salt content, and municipal wastewater is a marginal quality water because of the associated health hazards. From the viewpoint of irrigation, use of 'marginal' quality water requires more complex management practices and more stringent monitoring procedures than when good quality water is used. (Vigneswaran and Sundaravadival, 2004). However, the quality of the wastewater used and the nature of its use vary enormously, both between and within countries. In many low-income countries in Africa, Asia, and Latin America, the wastewater tends to be used untreated, while in middle-income countries such as Tunisia and Jordan, treated wastewater is used (Faruqui *et al.*, 2004).

Waste waters could be contaminated with trace elements like lead (Pb), copper (Cu), zinc (Zn), boron (B), cobalt (Co) chromium (Cr), arsenic (As), molybdenum (Mo), manganese (Mn) etc. many of which are non-essential and over time toxic to plants, animals and human beings (Kanwar & Sandha, 2000). Long-term application of treated and untreated waste water resulted in significant buildup of heavy metals in soil (Khan *et al.*, 2008; Ullah *et al.*, 2011; Gosh *et al.*, 2012) as well as pathogens in vegetables and cereals and their subsequent transfer to food chain causing potential health risk to consumers (Singh *et al.*, 2010; Gupta *et al.*, 2011). Heavy metal concentrations in plants grown in wastewater-irrigated soils were significantly higher than in plants grown in the reference soil (Khan *et al.*, 2008; Singh *et al.*, 2010; Gupta *et al.*, 2011). Sharma *et al.*, (2006) concluded that the use of treated and untreated wastewater for irrigation had increased the contamination of Cd, Pb, and Ni in edible portion of vegetables causing potential health risk in the long term. Sachan *et al.*, (2007) found that bioaccumulation of Pb and Cr in vegetables was above the critical concentrations for plant growth while Pb and Cd were above the prescribed limit in the diet of animals. Chary *et al.*, (2008) assessed Zn, Cr, Cu, Ni, Co and Pb in soils, forage grass, milk from cattle, leafy and non-leafy vegetables.

Objectives of the Study

The general objective of this project is to assess the uptake of some selected physicochemical and microbiological parameters by two different vegetables grown on agricultural soil irrigated with pretreated sewage waste (greywater), stream water and well water (collected as control sample) and for comparative purposes.

Composition of Wastewater

Although, the actual composition of wastewater may differ from community to community, all municipal wastewater contain the following broad group of constituents (USEPA, 2002 and Hussain *et.al.*,2002).

i. Organic matter
ii. Nutrients (Nitrogen, Phosphorus, Potassium)
iii. Inorganic matter (dissolved minerals)
iv. Pathogens
v. Toxic metals

The quantity and composition of wastewater will depend upon the source and characteristics of the water. In the case of mixed municipal wastewater these depend on the types and numbers of industrial centers (USEPA/USAID, 2002) and the characteristics of the residential communities, which are influenced by the number of occupants, the age distribution of the occupants, their lifestyle characteristic and water usage patterns (Waller *et.al.*, 1998).

Agricultural Wastewater Reuse

With the increasing global population, industrialisation, urbanization and competition in water demand, the gap between supply and demand for water is widening and is reaching such an alarming levels that in some countries it is posing a threat to human existence. It is therefore mandatory to find alternative sources of water. an approach to addressing this problem has been the reuse of wastewater for irrigation (Saxena and Frost, 1992 and Hussain *et.al.*, 2002). This could release more freshwater for use. The reuse of wastewater in agriculture is not new, for urban effluent, have been utilized on agricultural land as a source of nutrients for crop production with varying degrees of success throughout the world (Asano and Levine , 1996).

Studies have concluded that an estimated 80 percent of wastewater may be used for irrigation (Cooper, 1991). Isreal is said to be at the forefront of agricultural wastewater reuse (IWMI, 2000), while China and South-Asia are also making a significant use of untreated wastewater (Mara and Cairnocross, 1989). In Latin America alone, at least 500,000ha of land is being irrigated with untreated wastewater (Moscoso, 1996), over half of which is in Mexico (Rodriguez *et.al.*, 1994). In China and indian 1.33 million and 85,500 ha of land respectively are irrigated by sewage. In some major cities of Africa notably Accra, Dakar and Nairobi Studies indicate an extensive use of wastewater in agriculture (IWMI, 2000).

RESEARCH METHODOLOGY

Study Area

This study was carried out in University of Ibadan and Ajibode in Akinyele Local Government Area (LGA) of Oyo State, Nigeria which lies between latitude $7°26^1$ N to$7° 40^1$ 30 N and between longitude $3° 47^1$ E to $4° 05^1$ E. Akinyele is a Local Government Area in OyoState, Nigeria. Its headquarters is at Moniya. Akinyele local government area shares boundaries with Afijio Local Government to the north, Lagelu Local Government Area to the east, Ido Local Government Area to the west and Ibadan North Local Government Area to the south. It occupies a land area of 464.892 square kilometers with a population density of 516 persons per square kilometer. The 2010 estimated population for the Local Government is 239,745.

3.2 General Procedure

Based on the rainfall data, sampling was done for 12 weeks (April-March) 2011. Grab sampling techniques were adopted in accordance with A.P.H.A., A.W.W.A., W.E.F., (2005) and samples were taken from three major locations which are: Awolowo Hall junction (University of Ibadan) (Plate 1) tagged as location I, with vegetable planted (Ugwu-Pumpkin-*Curcubita Maxima*) is being irrigated with domestic sewage water (Greywater) discharged from both Idia Hall and Awolowo Hall, and the other two sampling points were located at Ajibode area (Plate 2 and 3) with (Ewedu- Jews Mallow-*Corchorus Olitorius*) irrigated with both well water and stream flow, tagged as location II and III respectively. Samples were collected in the morning at 7-10 am. During each sampling,

three items were collected from each location which includes; water, soil (with the use of field auger) and vegetables, three days per week.

Samples were collected in polythene nylon and bottles, for physio-chemical analysis viz: PH, Electrical Conductivity, Total Dissolved Solid, Biochemical Oxygen Demand, Calcium, Magnesium, Chlorine, Nitrate, Ammonia, Sulphate, Phosphate, Chemical Oxygen Demand and Total Suspended Solid. Heavy metals like Copper, Zinc, Chromium, Cadmium, Lead, Cobalt, Nickel, Iron, were also considered in the analysis as well as microbiological activities within the same samples obtained, as per standard procedure.

Analysis was done as per the given standard methods by APHA, (1998). Multiple tube fermentation techniques were followed for coliform, e-coli and faecal coliform estimation by Method 9222-B described in Standard Methods for the Examination of water and wastewater.

Where in the results of examination of positive tubes were reported in term of most probable number (MPN). Heavy metals concentration in water samples were determined on Atomic Adsorption Spectra (AAS, Perking Elmer AA4BB)

Plate 1 (a and b): Location I, Vegetable Irrigated with Domestic Sewage Water (Greywater).

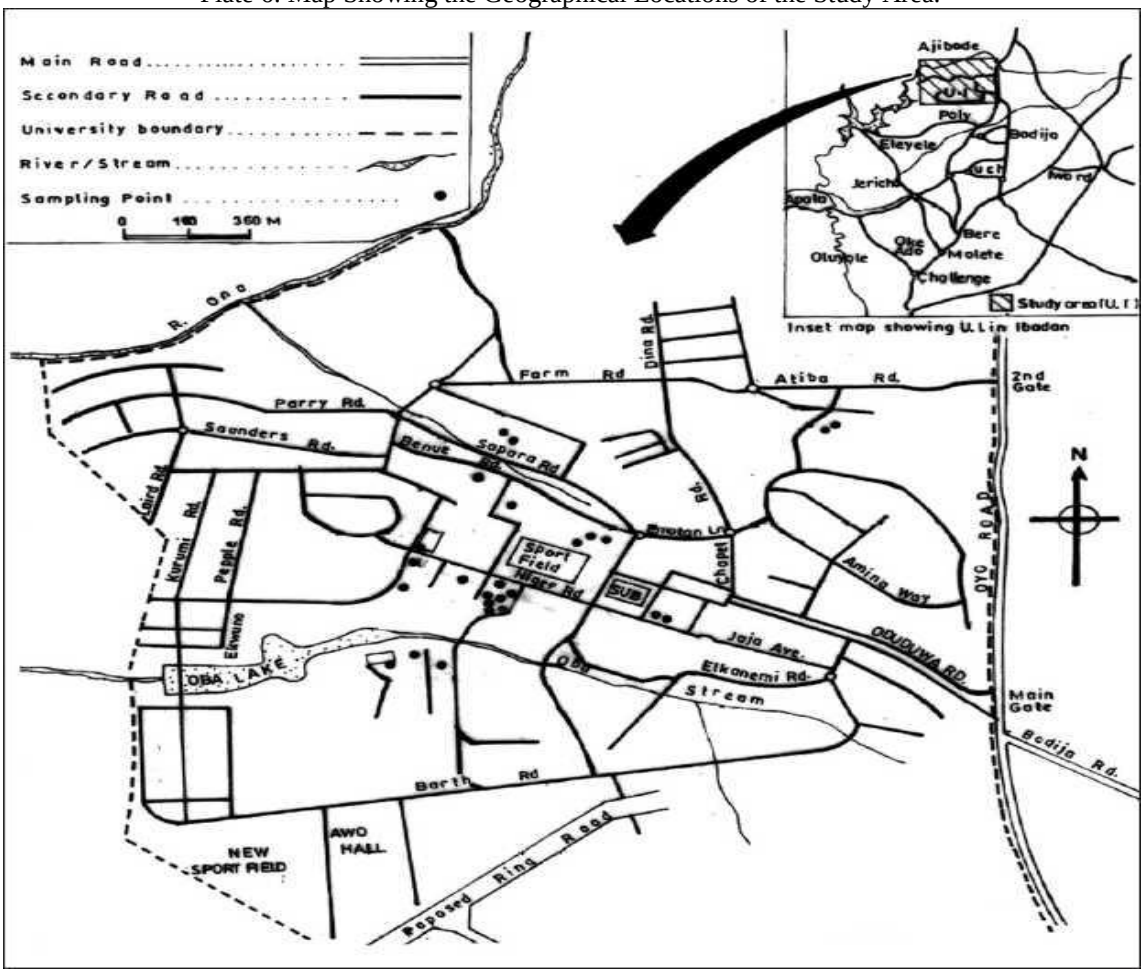
Plate 2(a and b): Location II, Vegetable irrigated with Well Water.

Plate 3 (a and b): Location III, Vegetable irrigated with Stream Water.

Plate 4 (a and b): Method of Obtaining Water Sample

Plate 5: Injection of $Mnso_4$ (Reagent) into Water Sample to Retain Oxygen Prior Analysis.

Plate 6: Map Showing the Geographical Locations of the Study Area.



Source: Journal of Medical Physics (2010)

3.3 Sampling Procedures

In collecting the samples, the following requirements were strictly adhered to

i. Precautions were taken to make sure that the water, soil, and vegetables reaching the laboratory have the same composition as it did when the sampling was done.
ii. The representative samples of water that was taken were the ones that truly reflect the composition of the water sample to be analyzed.
iii. The sample details were adequately described and sample containers were properly labelled to avoid error.
iv. The volume of water collected is large enough to permit accurate analysis.
v. Samples were collected, stored and dispatched in suitable sterilizers.
vi. In order to prevent any significant change in the composition of a collected sample prior to analysis, sample was discharged as soon as possible for storage in a refrigerator.
vii. MnSO4 was used as a reagent to rinse the bottles and to retain the oxygen in the collected water sample prior analysis (Plate 4 and 5).

3.4 Laboratory Analysis

The major analytical techniques in the determination of water quality characteristics include Volumetry, Colorimetry, Spectophotometry and Flame photometry. Bacterialogical procedure is also done for obtaining the Coliform count of the sample.

3.4.1 Electrical Conductivity

This was done with the use of conductometer. The instrument was dipped into the water sample and conductivity value of the water sample appears on the meter screen.

3.4.2 PH-Hydrogen-ion Concentration

PH was used to express the intensity of the acid or alkaline condition of the solution. Before sample measurement, the P^H meter was standardized with two buffer solutions of different PH values (4.0 – 9.0) to serve as check for proper instrument response. The P^H meter was switched on and electrode dipped into the sample. The reading was then taken after getting a stable value. The procedure was repeated for the entire samples. It is however, important to rinse the probe with distilled water before another sample reading is taken to avoid changes in the concentration of sample.

3.4.3 Dissolved Oxygen

The amount of oxygen found by determination in a sample of water or wastewater at the time of collection is the dissolved oxygen (DO). The method used for the measurement was Winkler's titration and electrometric method using oxygen – detecting electrode.

3.4.4 Biochemical Oxygen Demand (BOD)

BOD can be taken as a measure of the concentration of organic matter present in the wastewater. The greater the decomposable matter present the greater the oxygen demand and greater the BOD value. BOD tests were carried out by measuring the amount of dissolved oxygen present in the samples before and after incubation in the dark at 20^0C for five days.

It is common practice that the samples be diluted and then aerated so as to be sure that not all the dissolved oxygen is used up during incubation period. Dilution of samples is carried out by using dilution water which is prepared from nutritive chemicals viz: phosphate buffer, magnesium sulphate, calcium chloride and iron III chloride solution.

3.4.5 Phosphorus

This occurs in natural water, domestic water and sludges almost entirely in phosphate form. Analysis was carried out by two steps viz :

i. Conversion of the naturally occuring phosphorus to soluble orthophosphate and then.
ii. Colorimetric determination of the soluble phosphate.

3.4.6 Chloride

Chroride ion was measured by volumetric procedures employing internal indicators. The major method used was potassium chromate as indicator and mercury (II) nitrate method using diphenylcarbasone as indicator.

3.5 Determination of Nitrate, Sulphate and Phosphate in the Wastewater Samples

The concentrations of nitrate, nitrite, sulphate and phosphate were determined using DR/2010 HACH Portable Data Logging Spectrophotometer. The spectrophotometers were checked for malfunctioning by passing standard solutions of all the parameters to be measured; blank samples (deionized water) were passed between every three measurements of water samples to check for any eventual contamination or abnormal response of equipment.

Nitrate as nitrogen was determined by the cadmium reduction metal method 8036 [Standard Methods]. The cadmium metal in the added reagent reduced all nitrate in the sample to nitrite; while sulphate was determined by using Sulfa Ver methods 8051.

3.6 Sodium Na^{2+}, Calcium Ca^{2+}, Magnesium Mg^{2+} , Lead Pb^{2+}, Zinc Zn^{2+}, Cobalt Co^{2+}, Nickel Ni^{2+}.

The instrument used was Atomic spectrometric machine (AAS machine) 210A model. The Absorbtion of the sample solution was compared with that of a known solution under identical conditions. From the comparison the concentration of the above parameters test tube was then found out in each case.

3.7 Digestion of Vegetable Samples

The vegetables samples were initially weighed to determine the fresh weight and dried in an oven at 80ºC- 90ºC for 72 hours to determine their dry weight. The dry samples were crushed in a mortar and the resulting powder digested by weighing 0.5g of oven-dried ground and sieve (<1mm) into an acid-washed porclain crucible and placed in a muffle furnance for four hours at 500ºC. The crucibles were removed from the furnance and cooled. 10ml of 6M HCl was added covered and heated on a steam bath for 15mins. Another 1ml of HNO3 was added and evaporated to dryness by continuous heating for one hour to dehydrate silica and completely digest organic compounds. Finally, 5ml of 6M HCl and 10ml of water were added and the mixture was heated on a steam bath to complete dissolution. The mixture was cooled and filtered through a Whatman no. 541 filter paper into a 50ml volumetric flask and made up to mark with distilled water.

3.8 Analysis of Digested Samples (Heavy Metals)

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

3.9 Determination of Nitrate, Sulphate and Phosphate in the Vegetable Samples

3.9.1 Nitrate and Nitrite

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

3.9.2 Phosphate

Each of the vegetables samples was chopped into small pieces. The chopped samples were then air dried. The air-dried samples were ground and sieved with a siever of mesh 1mm. A known amount (1g) of each of the ground and sieved samples was weighed into acid-washed porcelain crucibles. The crucibles were labeled and 5ml of 20% (w/v) magnesium acetate were added and evaporated to dryness. The crucibles were then transferred into the furnace and the temperature was raised to 500ºC. The samples were ashed at this temperature for four (4) hours. Removed and cooled in desiccators. Ten (10) ml of 6M HCI were then added to each of the crucible and covered, then heated on a steam bath for fifteen minutes. The contents of each crucible were completely transferred into different evaporating basins and 1ml of concentrated HNO3 was added. The heating continued for 1 hour to dehydrate silica. 1ml of 6M HCl was then added, swirled and then followed by the addition of 10m l distilled water and again heated on the steam bath to complete dissolution. The contents of the evaporating basins were cooled and then filtered through a Whatman no.1 filter paper into 50ml volumetric flasks and the volumes made up to the marks with distilled water. Phosphate was determined using Hach Direct Reading 2000 Spectrophotometer.

3.9.3 Sulphate

For sulphate determination, 5ml of magnesium nitrate solutions were added to each of the ground and sieved samples in the

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

3.10 Laboratory Analysis of Isolated Micro-organisms in Soil, Water and Vegetables Sampled

Procedure;

1g each in terms of solid/1ml in terms of liquid sample each of the sample was weighed and subjected to serial dilutions with the range of 10^{-1} and 10^{-4}. Each sample was thoroughly mixed with 9ml of sterile distilled water to give 10^{-1} dilution 1ml of the later was also pipetted into another 9ml of sterile distilled water in screw capped bottles to give 10^{-2}.This was repeated for 2 other screw-capped bottles that have been filled with 9ml of sterile distilled water to give 10^{-3} and 10^{-4} distilled water to give 10^{-3} and 10^{-4} dilution respectively.

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Particle Size Distribution

The particle size distribution of the soil samples collected from the study areas indicate that the textural classes of L1 (Awolowo Hall junction), L2 and L 3 at Ajibode as presented in Table 1

Table: 1 Particle size distribution of the Study Area

Sample	Sand (%)	Silt (%)	Clay (%)	Textural class
Location 1	47.2	43.4	9.4	Silt Loam
Location 2	73.2	19.4	7.3	Loamy Sand
Location 3	64.8	32.1	3.1	Sandy Soil

4.1.2 Weekly Average Leaves Length, Breath, Stem Gap, Root Length

Table 2: Weekly Average Leaves Length, Breath, Stem Gap, Root Length

	week 1	week 2	week3	week 4
LOCATION 1 (Greywater)				
Leaf length	5.33	5.75	6.70	7.00
Leaf Breath	9.30	10.50	11.60	12.30
Stem Gap	5.00	5.50	6.20	6.60
Root length	13.30	18.50	22.30	23.20
LOCATION 2 (Well water)				
Leaf Breath	3.30	3.33	3.49	3.54
Leaf Length	7.53	8.19	8.37	8.51
Stem Gap	3.88	4.23	4.66	4.75
Root length	6.23	6.39	6.77	7.01
LOCATION 3 (Stream water)				
Leaf Breath	3.12	3.25	4.13	4.29
Leaf Length	7.05	7.31	8.47	9.77
Stem Gap	3.63	4.10	4.47	5.02
Root length	11.55	12.07	12.67	12.95

The levels of the physiochemical parameters from both vegetables and waters sampled are presented in Tables 3 and 4.

4.1.3 Physio-Chemical Parameters

Table: 3 Range of Physio-chemical parameters present in the three sources of water used in irrigating the three locations

Parameters	L1W (Greywater)	L2W(Well water)	L3W (Stream water)
Pb	0.01 – 0.02	0.01 – 0.03	0.01 – 0.05
Cr	0.00 – 0.00	0.00 – 0.00	0.00 – 0.00
Cd	0.00 – 0.01	0.00 – 0.01	0.00 – 0.01
Ni	0.00 – 0.02	0.01 – 0.02	0.00 – 0.02
Fe	0.2 – 0.5	0.2 – 0.5	0.3 – 6.0
Ca	65 – 78	78 – 95	70 – 95
Mn	0.01 – 0.02	0.01 – 0.02	0.01 – 0.02
P	1.0 – 2.5	1.0 – 2.5	1.2 – 4.0

N	0.2 – 0.8	0.2 – 1.0	0.3 – 1.5
Do	4.3 – 7.2	5.0 – 6.8	4.5 – 6.8
BOD	3.5 – 12.0	5.0 – 15.0	6.0 – 27.5
Ts	1600 – 1750	1690 – 1885	2042 – 2955
TDS	220 – 265	160 – 225	200 – 370
Conductivity	545 -867	518 – 645	663 – 1194
NH_3	0.00 – 1.00	0.00 – 1.00	0.00 – 2.0
$S0_4$	1.0 – 2.0	1.0 – 2.0	1.6 – 3.5
Cl^-	2.0 – 4.5	2.4 – 5.0	3.0 – 7.5
pH	5.5 – 7.8	5.2 – 7.8	7.0 – 8.1
T.coliform count	0.7 – 7.2	1.0 – 5.3	1.3 – 9.9
Alkalinity	2.8 – 4.5	2.5 – 6.0	2.6 – 8.5
E coli	Nil	Nil	
Salmonella	Nil	Nil	

4.1.4 Physiochemical Concentration in Vegetables

Table: 4 Range of physiochemical concentration in vegetables sampled from the three locations

Parameters	L1 (Greywater)	L2 (Well water)	L3 (Stream water)
Pb	0.01 – 0.01	0.00 - 0.01	0.00 – 0.02
Co	0.00 – 0.00	0.00 – 0.00	0.00 – 0.02
Cr	0.00 – 0.01	0.00 – 0.02	0.00 – 0.02
Cd	0.00 – 0.01	0.00 – 0.01	0.00 – 0.01
Ni	0.00 – 0.01	0.01 – 0.02	0.00 – 0.02
Fe	0.50 – 1.50	0.50 – 0.70	0.70 – 1.60
Ca	110 -125	45 – 62	50 – 80
K	60 – 80	30 – 36	35 – 40
Zn	0.10 – 0.20	0.14 – 0.10	0.10 – 0.15
Cu	0.03 – 0.06	0.03 – 0.06	0.01 – 0.06
Mn	0.01 – 0.02	0.01 – 0.02	0.00 – 0.02
Mg	10.0 16.0	5.00 – 7.00	3.50 – 8.00
Pas $P0_4^-$	60.0 – 95.0	30.0 – 45.0	30.0 – 50.0
N(mg/l)	1.10 – 2.10	1.10 – 1.50	1.10 – 2.30
Total colif. Count	$(1.10 – 3.80)x\ 10^3$	$(1.00 – 2.60)x\ 10^3$	$(2.2 – 6.20)\ x\ 10^3$
Salmonella	$(0.40 – 1.80)\ x\ 10^2$	$(1.00 – 1.80)x\ 10^2$	$(0.5 – 3.50)\ x\ 10^2$

Heavy Metals

The results of the waters qualities and vegetables analysis showed that heavy metal concentrations (Tables 3 and 4) were within the range of; Pb (0.01 -0.02) L1, (0.01 – 0.03) L2, (0.01 – 0.05) L3, and for chromium (0.00 – 0.00) L1, L2 and L3, cadmium (0.00 – 0.01) L1, L2, and L3, Nickel (0.00 – 0.02) L1 and L3, (0.01 – 0.02) L2, Mn (0.01 – 0.02) L1, L2 and L3 respectively were noticed in water sampled from the three locations. And for vegetables sampled Pb (0.00 – 0.01) L1, (0.00 – 0.01)L2, (0.00 – 0.02) L3, Co (0.00 – 0.00) for the three locations, Cr (0.00 – 0.01) L1, (0.01 – 0.02)L2, (0.00 -0.03) L3 Cd(0.00 – 0.01) L1, L2 and L3, Ni (0.00 – 0.01)L1, (0.01 – 0.02)L2, (0.00 – 0.02)L3 Zn (0.10 – 0.20)L1 (0.04 – 0.10)L2 (0.10 – 0.15)L3, Mn (0.01 – 0.02) L1 and L2 and (0.00 – 0.02)L3.

The concentration of lead in water sample was higher in location 3 (stream water) than the other two locations which could have been as a result of industrial activities intrusions. The effect of chromium was nil and Nickel and manganese had highest value of 0.02. With all these metals uptake in the vegetable sampled, zinc has highest concentration in location 1 and followed by location 2. Hence, the concentration of nickel, chromium, cadmium and lead still fall within the WHO permissible limit which are; 0.20, 0.15, 0.01 and 50mg/l respectively (Appx 1).

Nitrogen: Is a necessary macronutrient for plants that stimulate plant growth and usually added as a fertilizer, but can also be found in wastewater as nitrate, ammonia, organic nitrogen. Excessive nitrogen application to the crop can result in; over stimulation and excessive growth which attracts pests, delayed maturity or a reduction in the quality of the crop. The accumulation of nitrogen in waters for all the three locations were within the range of (0.20 – 0.80) L1, (0.2 – 1.0) L2, (0.30 – 1.00) L3 (Table 3) in comparison with vegetables uptake which fell within the range of (1.10 – 2.10) L1, (1.10 – 1.50) L2 and (1.10 – 2.30) L3 (Table 4). The higher concentration of nitrogen in vegetables sampled was due to leachate which could have taken place in both locations 2 and 3 while the points were still used as a refuse dumping points. The level of nitrogen in all the three locations were far below World Health Organization save limit which is $30mgl^{-1}$ which mean the vegetables are relatively unaffected until it exceeds this limit.

Iron: Excessive Iron in waters can reduce the dissolved phosphorus component through precipitation: therefore, phosphorus might not be readily available for plant uptake in the presence of excessive Iron. The concentration of iron ranged from (0.2-0.5) L1, (0.2- 0.5) L2, (0.3- 0.6) L3 in water sampled (Table 3), while (0.5 – 1.5) L1, (0.50 – 0.70) L2 and (0.70 - 1.60) L3 (Table 4), were in vegetables sampled, for all the locations, more Iron accumulation was found in vegetables

sampled which could have been as a result of slight reduction in phosphorus component through precipitation. The WHO recommended maximum concentration of Iron for crop production is 5mgl^{-1}, hence, the vegetables sampled were still within the permissible maximum level for human consumption.

Phosphorus: Phosphorus is also a primary macronutrient that is essential to the growth of plants and other biological organism but if its concentrations in wastewater for instance are too high, noxious algal blooms can occur. From the waters sampled (Table 3) phosphorus were within the range of (1.0 – 2.5)L1, (1.0 – 2.5)L2 and (1.2 – 4.0) L3 and for vegetables sampled, were (60.0 – 95.0)L1, (30.0 – 45.0)L2 and (30.0 – 50.0)L3 (Table 4). High concentrations of phosphate were found in all the three points of vegetables sampled, meaning that, the soil had already contained excessive amount of phosphate regardless of what had applied as irrigation water. The values obtained in the entire sampling points of vegetables under study were higher than the WHO limit of 5mgl^{-1}. The levels obtained can cause eutrophication and may pose a problems for other uses. Thus, there is a need to develop awareness in the local livelihood not to consume such contaminated vegetables.

Calcium and Magnesium: Minerals such as calcium and magnesium cause water hardness which is an aesthetic quality of irrigation water. How hardness is classified is based on the following scale. Calcium carbonate concentration of 0-60 milligram per liter is considered softwater, 61-120 mg/l moderately hard, 121-180mg/l is hard and above 181mg/l or above is considered to be very hard.

Calcium concentrations in soil sampled were in the range (65-78)L1, (78-95)L2, (70-95)L3 and in vegetables sampled, calcium concentration were in the range (110-125)L1, (45-62)L2, (50-80)L3 and magnesium were in the range (10.0-16.0)L1, (5.0-7.0)L2, and (3.50-8.0) (Table 3 and 4). Calcium concentration in location 1 of vegetable sampled is considered hard, location 2 is said to be moderately hard. The accumulation of calcium in vegetables sampled were still bellow WHO permissible limit which is in the range (75-200) mg/l.

Electrical conductivity: EC of water is a useful indication of its salinity and is also a measure of the ions present in water and effectively a surrogate for total dissolved solids (TDS). It also has an impact on crop physiology and yield with visible injury at high salinity levels.

Guidelines developed for the evaluation of water quality for irrigation suggest that there need be: No restrictions on the use of irrigation water concentration with an EC of 700uscm^{-1}, slight to moderate restriction for irrigation water with an EC of between 700 – 3000uscm^{-1}, and severe restrictions for irrigation water with and EC of greater than 3000uscm^{-1}. The concentration of EC in the waters sampled was in the range (545 – 867) uscm^{-1}, L1, (518 – 645) uscm^{-1} L2 and (667 – 1194) ucm^{-1}L3. According to the literature, no restriction on the use of irrigation water in location 2 and there was slight to moderate restrictions for the use of water in both location one and three.

Total dissolved solid: The range of Total Dissolved Solid (TDS) in waters sampled from the three locations were within the range (220 – 265)L1, (160 – 225)L2 and (200 – 370)L3 (Table 3). These values obtained for TDS in all the sampling points were far below the WHO standard of 2000mg/l and will not contribute adverse effect on vegetable propagated for human consumption.

Dissolved oxygen (DO): DO values obtained for L1, L2 and L3 of waters sampled varied between (4.3 – 7.2), (5.0 – 6.8) and (4.5 – 6.8) shown in Table 2. The DO is a measure of the degree of pollution by organic matter, the destruction of organic substance as well as the self purification capacity of the water body. The standard for sustaining aquatic life is stipulated at 5mgl^{-1} a concentration below this value adversely affects aquatic biological life. The DO level at all points was above this level.

BOD: Biological Oxygen Demand (BOD) is the measure of the oxygen required by micro-organism whilst breaking down organic matter. The concentration of BOD in all the sampling points was as a result of the use of chemicals, which are organic that are oxygen demand in nature. The accumulation of BOD (Table 3) are in the range of (3.5 – 12.0)L1, (5.0 – 15.0)L2 and (6.0 – 27.5) L3 with location 3 having the highest range, but all still fell below WHO values of 50mg/l.

The following enteropathogenic bacteria; *Pseudomonas Sp., Salmonella Sp., Proteus Sp., Aeromonas Sp., Enterocbacter Sp., Klebsiella Sp., Staphylococcus Sp., E-coli*, were isolated in the three samples taken from each location (Table 3 and 4). Meaning that, the vegetables under the study areas are not safe for human consumption.

The concentration of metals in vegetables sampled from the three locations are in the following order; location 1; Ca> P> K>Mg>N> Fe> Zn>Cu> Mn>Pb, Cr, Cd, Ni> Co, Location 2; Ca >P>K> Mg >N> Fe> Zn> Cu> Mn> Cr, Ni> Pb, Cd, and Location 3 is in order; Ca> P> K> Mg> N> Fe> Zn> Cu> Mn, Ni, Pb, Co, Cr. From the results of this study, vegetable irrigated with domestic sewage (Greywater) was found to have highest accumulation of physio-chemical parameters and followed by location 3 (Stream water) with location 2 having the least concentration.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Encouraging wastewater reuse in agriculture has important economic and environmental benefits, such as conserving water and utilizing nutrients. However, using untreated wastewater poses certain environmental and health risks, to direct users and agricultural produced using wastewater.

There is a need to pre-treat the effluent of industrial cities/areas before their disposal in the sewage system and also to continuously monitor the status of these elements in soils, waters as well as in crops to prevent any health hazard to human/animals consuming food grown on such soils and with those waters. Since microbial contamination is the main problem, on farm practices and post-harvest activities could reduce the risk for farmers, their families and consumers of the vegetables produce.

The water under the study areas contained excessive amounts of certain heavy metals with the positive indication of enteropathogenic bacteria thereby rendering the water unsafe for irrigating the vegetables, which are consumed by human beings. These sources of water should not be used for drinking

purpose of livestock as the heavy metals present in it may cause a number of abnormalities in animals.

5.2 RECOMMENDATIONS

1. Appropriate risk analysis should be performed to clarify the risks associated with the reuse of graywater for irrigation. Based on the results of the risk analysis, new standards for graywater reuse (specific to greywater) should be developed.
2. The use of the traditional indicator organisms (e.g. Fecal coliforms, *E.coli*) should be reviewed since they do not truly represent the existence of pathogens in graywater (both in number and in persistence to disinfection). Proper indicator organisms should be used for graywater.
3. Domestic sewage water should be properly disposed and or recycled. Relevant agencies should make continuous effort to control, regulate and educate populace on indiscriminate waste disposal from domestic and industrial areas within the study area.

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