Evaluation of Drainage Wastewater for Irrigation Farms

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Majority of farmers depend solely on rain water for cultivation of crops, because water is an essential criterion for optimum crop growth. Every community produces both liquid and solid wastes. The liquid portion of the waste is essentially the water supply of the community after it has been fouled by a variety of uses. Three different wastewater samples were collected at intervals of one week for two months from a pond-like structure along the wastewater drainage during the peak of dry season within the area of study around 12:00 noon when fresh wastewater was least expected. The effluent samples for trace metal determination were collected in a 2 L plastic bottle and acidified with nitric acid (HNO_3) to maintain a steady state of pH. The electrical conductivity of the samples ranged between 961 and 1,321 ohms/cm.

***Keywords*:** Dry season, Effluent, Farm, Irrigation, Trace metals, Wastewater

Introduction

Africa is currently facing a major food crisis. This situation, if not properly addressed will escalate into famine. Majority of farmers depend solely on rain water for cultivation of crops, because water is an essential criterion for optimum crop growth. Agriculture consumes about 83% of water used from all sources including precipitation (Agunwamba, 2001). Farmers hardly engage in dry season farming because there is an inadequate supply of water for consumption and other domestic duties.

Wastewater may be defined as the combination of liquid water carrying waste products from residences, institutions, commercial and industrial establishments together with such ground, surface and storm water as may be present (Ayotamuno and Akor, 1994). Untreated water usually contains numerous pathogenic and toxic compounds, which constitute environmental risks such as health hazards, in which diseases are caused by pathogenic

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organisms in the wastewater, nuisance in which physical characteristics like scum and odors cause a psychological stress in human, ecological risk in which the discharge of effluent into surface water may exceed the self purification of the receiving water. This is particularly dangerous to the aquatic life and constitutes a risk to agriculture in which toxic compounds in the polluted water can adversely affect plants irrigated with the water from the recipient streams or water bodies (Arthur, 1993). In view of this, the immediate and nuisance free removal of wastewater from its source of generation followed by treatment and disposal is not only desirable but also a necessity.

Most developing countries lack effective collection system for domestic and agro-industrial wastes. This problem will persist as far as the government refuses the desired attentions to afford environmental sanitation and public health (Agunwamba, 2000). There is a need for effective collection system for drainage wastewater and its ultimate disposal in order to prevent the pollution of surface and ground water and reduce the spread of disease caused by pathogenic organisms in the drainage wastewater channel and sewage. These two reasons are interdependent to the extent that the polluted body of water is a potential and frequently an actual source of infection, particularly in hot climate. There is now an increasing awareness that pollution of the environment is most undesirable in itself and that measures to abate pollution should be viewed from an ecological point rather than merely the improvement that should be made to the human condition (Mara and Pearson, 1998).

The treatment of wastewater therefore is to improve its quality for both household and agricultural purposes which must be free of harmful bacteria, sediments, objectionable minerals, taste and odor. Wastewater management is therefore defined as the control of wastewater generation, collection, transfer and transportation, processing and disposal activities based on engineering principles at minimum environmental impact and cost. The ultimate goal of wastewater management is the protection of the environment in a manner commensurate with public health, economic and social concerns.

Irrigation may be defined as the application of water to soil for the purpose of supplying the moisture essential for plant growth. Irrigation plays a vital role in increasing crop yields and stabilizing production. In arid and semi-arid regions, irrigation is essential for economically viable agriculture, while in semi-humid and humid areas, it is often on a supplementary basis (Todd, 2006). Many irrigation methods are used by farmers to apply water to the farm which ranges from watering individual plants from a can of water to highly automated irrigation by a center pivot system. However, from the point of wetting the soil, these methods can be grouped into flood irrigation, furrow irrigation, sprinkler irrigation, subsurface irrigation and localized irrigation methods (Todd, 2006).

In recent times, industrial development and the growth of cities in the country has led to increased rate of pollutant discharges into water courses (El-Arby and Elbordiny, 2006). The major use of the water courses (river and stream) in Nigeria include agricultural activities and human consumption. Most towns, villages and industries in Nigeria and most developing countries consider treating wastewater as a wasteful venture. Hence, it is very convenient to dispose wastewater from communal premises without paying any attention to its toxic effect on agricultural land and level of pollution. However, some higher institutions in Nigeria, over the years have been involved in establishing or constructing wastewater treatment plants which are being improved upon. Some of these higher institutions are: Ahmadu Bello University (ABU), Zaria, University of Nigeria Nsukka (UNN) and Obafemi Awolowo University (OAU) Ile-Ife (Agunwamba, 2001).

This study is aimed at proffering water supply problem to the university community for dry season irrigation farm and proffering the best treatment method of wastewater from the major drainage that passes through the Bosso campus of the Federal University of Technology (FUT), Minna, Nigeria. The objectives of this study are to evaluate the compositions of drainage wastewater within the study area, to determine the bacteriological pathogenic parameters in the effluent domestic wastewater and to make recommendations on the types of crops that can be planted using the wastewater from the drainage channel.

Materials and Methods

Three different wastewater samples were collected at intervals of one week for two months from a pond-like structure along the wastewater drainage during the peak of dry season within the area of study around 12:00 noon when fresh wastewater was least expected. The effluent samples for trace metal determination were collected in a 2 L plastic bottle and acidified with nitric acid (HNO_3) to maintain a steady state of pH. Plastic containers were used to prevent sample contamination from metallic containers. The effluent samples for determination of physicochemical parameters were also collected in a separate 2 L plastic bottle. The plastic containers were thoroughly washed and rinsed three times with the effluents to be sampled before the actual samples were collected. Effluent samples for trace metal determination and other parameters were preserved in a refrigerator at a temperature of 27 °C to allow the samples to maintain its natural state for 24 h before its arrival to the laboratory.

To identify and locate samples easily, all samples carried self adhesive labels. These were affixed on the sample bottles instead of the cover to prevent loss or misplacement. The information carried on the sample label includes location, date and time. Standard procedures as stated by (AOAC, 1990) were followed to determine various parameters (physical, inorganic and organic) of the samples collected. The physical parameters determined are pH, electrical conductivity, turbidity, total dissolved solids, total suspended solids, total hardness, calcium hardness and total alkalinity. The inorganic parameters determined included are chloride ion, phosphate ion, sulphate ion, nitrates and trace metals. The organic parameters determined included are Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC) and Theoretical Oxygen Demand (TOD).

Results and Discussion

The results obtained were compared with those of (WHO, 1968 and 1973; and FAO, 2002). The results of laboratory analysis of the domestic wastewater collected from the main drainage that passes through FUT, Minna Bosso campus are presented in Tables 1, 2 and 3, while World Health Organization (WHO) and Food and Agriculture Organization (FAO) standards for irrigation of water are presented in Table 4. The measured temperature for the samples was 27 °C.

The electrical conductivity is used to measure salt concentration in any water, it measures the ability of any water to conduct electricity and this is expressed in mhos/cm. When the electrical conductivity and salt concentration of water samples were compared with WHO and FAO Standards, it was discovered that the electrical conductivity of the

Table 1: Physical Parameters of the Wastewater

Parameters	Sample 1	Sample 2	Sample 3	Mean
pH	8.5	8.5	8.9	8.6
Conductivity (ohms/cm)	967	981	1,321	1,090
Turbidity (NTU)	49	47	38	45
Total Suspended Solids (TSS)	38	28	27	31
Total Dissolved Solids (TDS)	1,009	1,240	1,006	1,085
Total Solids (TS)	1,047	1,268	1,033	1,116
Appearance	Not Clear	Unobjectionable	Clear	–
Color	230	230	89	183
Odor	Objectionable	Odorless	Odorless	–
Taste	Sipid	Insipid	Insipid	–

Table 2: Inorganic Parameters of the Wastewater

Parameters	Sample 1	Sample 2	Sample 3	Mean
Total Iron Units?	0.72	0.77	0.70	0.73
Sulphate (SO_4^{2-}) Units?	544.00	703.00	190.00	479.00
Chloride (Cl^-) Units?	512.00	338.00	412.00	420.00
Lead (mg/L)	0.15	0.18	0.14	0.16
Sodium Units?	315.00	325.00	209.00	283.00
Manganese Units?	0.71	0.63	0.33	0.56
Phosphate Units?	65.00	79.00	88.00	77.00
Nitrate Units?	25.00	33.00	65.00	41.00
Potassium Units?	654.00	502.00	234.00	463.00

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Table 3: Chemical Parameters of the Wastewater				
Parameters	**Sample 1**	**Sample 2**	**Sample 3**	**Mean**
Total Alkalinity Units?	1,020	941	843	934
Total Hardness Units?	350	418	602	456
Calcium Hardness Units?	223	109	66	132
Free CO_2	80	85	143	102

Table 4: WHO and FAO Standards			
S. No.	**Parameters**	**Maximum Allowable Limits**	
		WHO	**FAO**
1.	pH	6.85-8.5	7.0-7.5
2.	Electrical Conductivity (ohms/cm)	30	15
3.	Dissolved Oxygen (mg/L)	1.3	4
4.	Chloride (Cl^{-}) (mg/L)	200	220
5.	Sulphate (SO_4^{2-}) (mg/L)	200	200
6.	Total Hardness (mg/L)	500	–
7.	Iron (Fe^{2+}) (mg/L)	0.3	0.3
8.	Total Alkalinity (mg/L)	150	100
9.	Potassium (K^{+}) (mg/L)	0.001-100	200
10.	Manganese (Mn^{2+}) (mg/L)	0.3	0.3
11.	Total Solids (TS) (mg/L)	–	100
12.	Total Dissolved Solids (TDS) (mg/L)	–	100
13.	Suspended Solids (SS) (mg/L)	–	100
14.	Nitrates Units?	45	40
15.	Sodium (Na^{+}) Units?	200	–
16.	Lead (Pb^{2+}) Units?	0.14	–
17.	Total Alkalinity ($CaCO_3$) (mg/L)	150	200
18.	Turbidity Units?	10	15
19.	Total Calcium Hardness Units?	200	150
20.	Total Magnesium Hardness Units?	200	150
21.	Phosphate (mg/L)	50	50
22.	Free CO_2 (mg/L)	–	–
23.	Total Bacterial Count (CFU/mL)	0	100

samples ranged between 961 and 1,321 ohms/cm. This clearly shows that the water cannot be used for any form of irrigation practice since the soil of the area is sandy-clay which will not allow easy movement of water.

The pH value indicates the degree of acidity or alkalinity which represents the value of hydrogen ion (H^+) concentrations in water. The results of water analysis indicate a mean pH value of 8.6 which is slightly above WHO limit of 8.5 and FAO limit of 7.5. Therefore the water needs to be treated to reduce the pH value before using it for dry season farming.

The suspended solid concentration influences the level of turbidity. The effluent had mean turbidity value of 45 NTU. Turbidity in natural water reduces light transmittance and affects the species that may survive in the water and the nature of the solids causing the turbidity may have other implications which may affect the crops if used directly for dry season farming. To reduce the turbidity of the effluent, screens of different diameters should be used along the flow channel before the collection point.

Sodium has the ability to destroy soil structure and it is capable of building up sodium salts in the soil. Therefore, it is an undesirable element in the irrigation of crops particularly in large quantities. The mean sodium content in the wastewater sample is 283 mg/L, which exceeds the 200 mg/L, recommended by WHO, as a result, the wastewater should not be used for irrigation purposes unless treated to reduce sodium concentration.

Calcium is a very common environmental pollutant. It causes calcium hardness in water. The calcium content of the wastewater which is 132 mg/L falls within the permissible limit (75-200 mg/L) of WHO suggesting that the wastewater could be used for dry season farming.

Magnesium is another common water pollutant which results to temporary hardness of water. The WHO permissible limit is 30-150 mg/L. The mean value of magnesium content of the wastewater is 92 mg/L suggesting that the wastewater could be used for dry season farming.

Chlorine is an important element in water because its concentration determines the susceptibility of water to pathogens that cause some water-borne diseases in man and lower animals that consume it. The permissible limits of chloride according to WHO and FAO for irrigation purposes are 200 mg/L and 220 mg/L, respectively. Since the mean value (420 mg/L) of chloride concentration in the samples exceeds the set standards, there is a need for the wastewater to be treated of chloride before use for irrigation.

The limit of 200 mg/L is also desired for sulphates according to WHO and FAO standards. The mean value of 479 mg/L obtained for sulphate in this study shows that the wastewater is not suitable for irrigation purposes and must be treated to reduce the sulphate content to permissible limit if it is to be used for irrigation.

Iron concentration of 0.5 mg/L may be severe and may need to be corrected. The highest desirable level of iron is 0.1 mg/L while the maximum permissible level is 1.0 mg/L but not all crops will survive. Iron has a chemical effect that could become a problem at the concentration of 1.0 mg/L. It has the ability to cause rusting most especially in some sprinklers or overhead irrigation system. The mean value of 0.7 mg/L was obtained for iron in this study. There is a need to treat the wastewater for use to irrigate crops.

The permissible level of total hardness in any water is 500 mg/L, which in most cases comprise calcium carbonate ($CaCO_3$) or magnesium carbonate ($MgCO_3$) and hydrogen carbonate (HCO_3). The mean total hardness of the wastewater is 456 mg/L which is close to the 500 mg/L limit. Nevertheless, the wastewater should be treated to reduce the total carbonates if it to be used for dry season farming.

The acceptability and suitability of water resources for irrigation purposes is guided by the amount of Total Dissolved Solids (TDS) present in the water. The osmotic pressure of the soil solute increases when the TDS are present in large quantities thereby, causing high soil moisture stress in the root zone which, in turn, hinders plant growth and subsequently affects crop yield. The acceptable limit of TDS and pH value for suitability indicates that water containing TDS up to 400 mg/L or less and pH value below eight is generally suitable for irrigations purposes. However, the result of the wastewater analysis shows a high mean value for TDS of 1,085 mg/L, thereby making the wastewater unsuitable for irrigation purposes.

Nitrate is the chemical form in which nitrogen is absorbed or taken up by plants from the soil. From the results of the wastewater analysis, the mean value of nitrate was 41 mg/L and this is within the WHO standard of 45 mg/L for irrigation purpose.

Phosphate is the chemical form of phosphorus when in solute. Phosphorus is one of the three primary nutrients largely required by plants for growth. The wastewater analysis shows a very high rate of phosphorus content of 77 mg/L mean value which exceeded the permissible limit of 50 mg/L according to WHO and FAO standards.

Potassium is one of the primary nutrient elements required by plants for morphological performance in the field. However, it is considered to be toxic simply because, in the elemental state, it reacts violently with moisture to liberate hydrogen and form potassium hydroxide which is extremely caustic in nature. From the results of the wastewater analysis, the mean value of 463 mg/L far exceeded WHO and FAO standards values of 0.0001-100 mg/L and 150 mg/L.

The appearance of water is closely related to color of water. The color of potable water is colorless and the appearance of potable water has to be clear and attractive (WHO, 1973). This was done by the close observation of the samples collected at different sampling points. The samples collected at S_1 and S_2 did not show clear appearance but sample S_3 was observed to be clear and attractive. The appearance of this sample conformed to the recommended standards by WHO.

Color in water may originate from impurities such as vegetables, humus, iron, management and industrial wastes such as dyes. They are capable of impacting color to the water supply. The color of water might not have any effect on the quality of water for irrigation purposes. It can be determined by visual comparison using properly calibrated glass disc and standard color solution with low concentrations. The method adopted was visual comparison.

Taste and odor depend on the actual contact of the stimulating substance with the appropriate human reception cell. The sense of odor is closely related to that of the taster, in fact, it is normally correct to suggest that most taste in water is really a sensation of smell.

Conclusion

The water analysis from tables 1, 2 and 3 show a high level of pollution. When compared with the WHO and FAO guidelines and standards, it was observed that the effluents contain several pollutants far exceeding the WHO and FAO limits. The effluents are therefore not fit or suitable for use in dry season farming (irrigation) because the crops will be adversely affected due to high concentrations of most of the elements found in the wastewater, except if necessary treatment of the wastewater is carried out.

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The drainage wastewater flows from outside of the university community into the school drainage, refuse and other forms of waste are dumped along the flow channel, shows the reason why the wastewater is highly polluted. The wastewater must be treated to meet the WHO and FAO standards for irrigation.

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