THE PRELIMINARY STUDY ON THE SUITABILITY OF AFRICAN CATFISH EFFLUENT AS IRRIGATION WATER SOURCE IN SOUTH WEST NIGERIA

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ABSTRACT

The reuse of catfish pond effluent by irrigation can make a significant contribution to the integrated management of our water resources. The study was done to evaluate African catfish (*Clarias gariepinus)* quality pond effluent quality and its suitability for irrigation. Forty (40) samples were collected from five ponds. Physical and chemical parameters of catfish effluent samples from selected earthen ponds were determined in accordance with the American Public Health Association standards. Data were analysed using descriptive statistics. The results showed that there were variations in the chemical constituents of the effluent measured in the selected ponds. The mean values of physical and chemical parameters ranged as pH (6.2 – 8.1), total dissolved solids (140 -307 mg/l); suspended solids (32 – 78 mg/l), electrical conductivity of water (0.21 – 0.48 mmhos/cm), alkalinity (45 – 138 mg/l), total nitrogen (4.5 – 6.9 mg/l), total phosphorus (0.11 – 0.35 mg/l), sodium (11 -31 mg/l), calcium (24.1 – 69.0 mg/l), potassium (0.16 – 0.41 mg/l), magnesium (8.2 -12.0 mg/l), carbonate (8 -40 mg/l), bicarbonate (20 – 95 mg/l), chloride (10.4 – 25.8 mg/l), boron (0.2 – 0.4 mg/l) and biochemical oxygen demand (4.4 – 8.2 mg/l). All were within acceptable limits. The African catfish effluents in the studied earthen ponds are classified as $C_1 – S_1$ water. Hence there are none degree of restriction in the application of catfish effluent for irrigation.

Keywords: Evaluation, irrigation, catfish, effluent, suitability, Lagos-Nigeria.

INTRODUCION

Water is essential to plant growth. Successful farmers have used different methods to supply water to their crops. The artificial addition of water is called irrigation. Irrigation is essentially the artificial application of water to overcome deficiencies in rainfall for growing of crops. It was well known for its protective role of insurance against the vagaries of rainfall and drought. The importance of irrigation was highlighted by Isrelsen and Hansen, [2008]; Srewart and Neilsen, [2009], and Houk, [2006] as follows: (i) it improves water conditions in the soil, increases the water content of plant fibers, dissolves nutrients and makes then available to plants. (ii) it affects temperature conditions by regulating the temperature of the

surface layer of the soil and the ground layer of the air and also makes possible control of the growth and development of plants and improvement of the quality of the harvest (iii) it protects from famine. The reuse of effluent by irrigation can make a significant contribution to the integrated management of our water resources. When the water and nutrients in the effluent are beneficially utilised through irrigation some of the water in our waterways can be reduced. Selecting a suitable site is important for successfully establishing an effluent irrigation system. In relation to effluent quality, effluent contains valuable resources such as water, organic matter and nutrients. However, in excessive amounts these can be detrimental to soils or plant growth [Garg, 2013. [2008] explained that the sustainability of effluent for irrigation system depends on water and nutrient balances. The water balance is calculated to determine the maximum volume of effluent that can be sustainably used which are governed by some parameters such as rainfall, evapotranspiration, runoff and percolation [EPA, 2009]. The nutrients such as nitrogen and phosphorus loading rate can limit the quality of effluent to be used for irrigation in a given area. Researchers such as EPA, [2006, 2007 and 2009]; Garg, [2013]; Jensen, [2011]; Houk, [2006]; Hart, [2004]; Hardie and Haird, [2009]; Srewart and Neilsen, [2009], and Myers et al.,[2005] have highlighted that for effluent utilisation for irrigation water must sustained the following environmental performance objectives.

1.Effluent irrigation system should be located, designed, constructed and operated so that surface water do not become contaminated by any flow from irrigation areas, including effluent, rainfall runoff, contaminated sub-surface flows or contaminated groundwater.

2. Effluent irrigation system should be located, designed, constructed and operated so that the current or future beneficial uses of groundwater do not diminish as a result of contamination by the effluent or runoff from the irrigation scheme or changing water tables.

3. An effluent irrigation system should be ecologically sustainable. It should maintain or improve the capacity of the land to grow plants, and should result in no deterioration of land quality through soil structure degradation, salinization, water logging, chemical contamination or soil erosion.

4. Design and management of effluent irrigation systems should not compromise the health and productivity of plants, domestic animals, wildlife and the aquatic ecosystem. Risk management procedures should avoid or manage the impacts of pathogenic micro-organisms, biologically active chemicals, nutrients and oxygen depleting substances

5. The effluent irrigation scheme should be sited, designed, constructed and operated so as not to compromise public health. In this regard, special consideration should be given to the provision of barriers that prevent human exposure to pathogens and contaminants.

6. Potential resources in effluent, such as water, plant nutrients and organic matter, should be identified, and agronomic systems developed and implemented for their effective use.

7. The effluent irrigation system should be located, designed, constructed and operated to avoid unreasonable interference with any commercial activity or the comfortable enjoyment of life and property off-site. In this regard, special consideration should be given to odour, dust, in-

sects and noise. The parameters that determined the suitability of effluent for irrigation were reported by EPA, [2006, 2007. 2009]; Hart,[2004]; Garg,[2013] and Bryan, [2007] include the concentration of pH, electrical conductivity, total dissolved solids (TDS), total solids (TS), sodium, calcium, magnesium, boron, chloride. Carbonate, bicarbonate, total nitrogen and total phosphorus. The quality of suitable irrigation water is very mush influenced by the constituents of the soil which to be irrigated include texture, depth, concentration of pH, electrical conductivity, total dissolved solids (TDS), total solids (TS), sodium, calcium, magnesium, boron, chloride. Carbonate, bicarbonate, total nitrogen and total phosphorus.

The quality of suitable irrigation water is very much influenced by the constituents of the soil which to be irrigated. Water containing impurities, which are injurious to plant growth, are not satisfactory for irrigation and it is called the unsatisfactory water. The various types of impurities, which make the water unfit for irrigation are classified by [EPA, 2006, 2007, 2009; Garg, 2013; Hart, 2004; Srewart and Neilsen, 2009; Myers et al., 2005, and, Haird, 2009] as follows:

1. Sediment concentration in water
2. Total concentration of soluble salts in water and salinity (TDS and EC). Salts of calcium, magnesium, sodium and potassium, present in the irrigation water may prove injurious to plants when they are in excess.
3. Proportion of sodium ions to other cations. The proportion of sodium ions in the water or soils was generally measured by a factor called Sodium Absorption Ratio (SAR) and represents the hazards of water.
4. Concentration of potentially toxic elements present in water such as boron, selenium and other elements.
5. Bicarbonate concentration as related to the concentration of calcium plus magnesium. High concentration of bicarbonate ions may result in precipitation of calcium and magnesium bicarbonates from the soil-solution, increasing the relative oroportion of sodium ions and causing sodium hazards.
6. Bacterial contamination. Bacterial contamination of irrigation water is not a serious problem, unless the crops irrigated with highly contaminated water are directly eaten, without being cooked.

The salinity parameter is used to characterize salt tolerance in most studies and caused by sodium, calcium, magnesium, chloride and sulphate together with alkalinity , resulting from bicarbonate and carbonate have direct toxic effects on plant physiology and / or affect plant growth through osmotic effects and loss of nutrients availability [Reboll, et al., 2007)].

The quality of African catfish (*Clarias gariepinus*) effluent had been examined by various researchers. Researchers likes [Boyd, 2001; 2003; Tucker et al., 2002; Tucker, 2000 and Tucker and Robinson, 1990] reported that concentrated aquatic animal production (CAAP) facilities produce a variety of pollutants that may be harmful to the aquatic environment when discharged in significant quantities such as total suspended solids (TSS), and nutrients. Boyd, et al, [2000] and Boyd, [2003] reported that, water in catfish ponds usually has higher concentrations of nitrogen, phosphorus, total suspended solids, organic matter, and biochemical oxygen de-

mand than natural surface waters in the vicinity, it affects the texture and mineral composition of the soil in intermediate vicinity. There are others publications on the subject of catfish pond effluents but it is difficult to draw conclusions from these studies because the characteristics of catfish pond effluents are unique, a function of feeding, water source, location, season, farm management practice. Presently there is no legislative frame for irrigation water reuse in Nigeria. No literature on the quality of catfish effluent in relationship to irrigation system rather than application as source for irrigation in the study area.

This study was to evaluate catfish pond effluent quality and its suitability for irrigation in Southern West Nigeria. Besides, to encourage the beneficial use of catfish pond effluent and show how this might accomplished in an ecologically sustainable manner.

MATERIALS AND METHODS
Site Description
Lagos State is geographically situated in the South Western part of Nigeria. It spans the Guinea Coast of the Atlantic Ocean for over 180km on the South, from the Republic of Benin on the West to its boundary with Ogun State in the North and East of Nigeria. It falls within longitudes 030 50`E and 030 38`E and latitudes 060 20`N and 060 18`N.The total territorial area of 3,577sq km, about 787sq km or twenty-two percent (22%) is wetland area. The altitude of the State is approximately 4.6m above the sea level. The state is divided into twenty Local Government Areas (Fig. 1)

Figure 1: Map of Lagos State showing the study area.

Collection of Water samples
Five earthen fish ponds stocked with the African catfish (*Clarias gariepinus*) sited at different locations were selected based on the environmental (swampy and inter-land) and highest stocking density. Water samples were taken on 24th and 25th of April, 2014. Water samples were collected from top and bottom at a depth ranges from 10 cm to 25 cm at 5 cm intervals for each catfish pond in the morning (10.00 am). 250 ml glass bottles of the samples were collected and analyzed

for BOD_5, and other samples were collected in sterilized ten (10) of 1-litre plastic bottles for other physiochemical parameters. The required quality parametric analyses were done next 24 hours. Measured physical and chemical parameters were pH, Total solids (TS), Total dissolved solids (TDS), Electrical conductivity (EC), Sodium, Calcium, Magnesium, potassium, Boron, Chloride, Carbonate (CO_3), Bicarbonate (HCO_3), Total nitrogen (TN), and Total phosphorus (TP), and Biochemical oxygen demand (BOD5). The analyses were conducted according to standard method (APHA, 2005). All measurements were replicated four times.

Determination of water quality parameters.

pH: The pH (Hydrogen ion concentration) values were measured directly by a pH meter by dipping the electrode into the pond water.

Suspended solids (SS) and Total dissolved solids (TDS) (mg/l): 50 ml of samples through pre – weighted glass fibre paper dried for 30 minutes and weighed again. The suspended solid content of the sample is the difference in the weight of filters. For a given sample location, the experiments were repeated three times and average reading were taken

Volume of water taken in each test
$\qquad$ = 50 ml
Mass of empty dish $\quad$ = M_1 mg
Mass of dish + dry residue = M_2 mg
Mass of filter paper $\quad$ = M_3 mg
Mass of filter paper + dry residue
$\qquad$ = M_4 mg
Concentration of suspended solids = (M_4 – M_1 /50) X 1000 $\qquad$ = x mg/l
Concentration of total solids = (M_2 –

M_1 /50) x 1000 $\qquad$ = y mg/l
Concentration of dissolved solids = (y – x) mg/l

Electrical Conductivity: 20 ml of water sample was put into Erlenmeyer flask and 80 ml of distilled water was added. The mixture was placed on shaker for one hour and then filter through Whatman No.1 filter paper. The conductivity electrode was washed with distilled water and rinsed with standard KCL solution. EC was determined by dipped the conductivity meter into the solution. The conductance is expressed in mmhos / cm.

Alkalinity (mg/l): 100 mml of water sample was put into conical flask.3 drops of phenolphthalein indicator was added. Alkalinity of water sample was measured by titrated with 0.02 N of Sulphuric acids.

Alkalinity (mg/l): 0. 02 of H_2SO_4 used X 1000/ ml of water sample.

Chloride (mg/l): 20 ml of water sample was put into a porcelain dish by pipette and same amount of distilled water into a second dish for a colour comparison. 1 ml of potassium chromate indicator was added to each dish. Standard silver nitrate solution was added to the sample by burette drops by drops by drop with simultaneous gentle stirring with a glass rod till the color changed reddish

Chloride (mg/l): (ml of $AgNO_3$ used – 0.02) X 500 / ml of sample {2}.

Total Nitrogen: 100 ml of filtered water sample was collected in Kjeldahl flask fitted with distillation unit. 5 ml of Magnesium oxide (MgO) was added and distillation started; 25 ml of distilled was collected. 1g of devards alloy was added to the remaining vol-

ume of the flask and distillation started again. 25 ml of distilled was taken into two separate Nessler tubes and 0.5ml Nessler reagent was added to each tube. The mixed solution started developing colour. This colour after 10-15 minutes was matched against colour discs of a Nesslenizer (BDH Nesslenizer). Nitrogen content (mg/l) is expressed as follows:

N, NO_2, NO_3 and NH_3 (mg/l) = umber of matchng division of the standard dics × 100

Total Phosphorus (mg/l): 50 ml of filtered water sample was put in a nessler tube. 2 ml of sulphomolybdic acid and 5 drops of stannous chloride solution were added. The mixtures were mixed thoroughly. The developed blue colour after 3-4 minutes was compared with nesslenizer standard colour discs. The phosphate content (P_2O_5) in ppm is expressed as follows:
    Phosphate (mg/l) = disc reading for 50mm × 2 × 0.01.

Sodium (mg/l): 50 ml of filtered water sample was put in a tube and diluted to make up to 1 litre (1000 μg Na/ml) solution. 100 mL was taken from solution and diluted to 1 litre to make 100 μg Na. ml stock solution.5, 10, 15 and μg Na/ml of stock solution were fed on the flame photometer one by one to obtain a standard curve on Y-axis against the concentrations of Na on X-axis.
NA (mg/l) = A
Where**,**
A= absorbance reading (μg/ml) from the standard curve

Calcium and Magnesium (mg/l): 50 ml of filtered water sample was put in 150 ml conical flask and 25 ml of ammonium acetate was added. The mixture was shaken on

mechanical shaker for 5 minutes and then filtered through Whatman filter paper No. 1. 5 crystals of carbamate and 5 ml of ammonium chloride-ammonium hydroxide buffer solution. 4 drops of Eriochrome black T indicator was added to the mixture and then titrated with 0.01N versenate (EDTA) till colour changed from orange red to purple and green to wine red respectively.

Potassium (mg/l): .50 ml of filtered water sample and diluted to make up 20 μg K/ml solution. 100 mL of the ammonium acetate was added to the solution
 Potassium (ppm): 10A
Where,
A = content of K (μg) in the sample was
     read from the standard curve

Boron (mg/l): 5 ml of filtered water sample in 25 ml volumetric flask and 2 ml buffer solution was added (2 ml EDTA solution and 2 ml azomethine-H solution). The content was thoroughly mixed. The solution was allowed to stand for 1 hour to allow colour developed. Then, the volume was noted. The intensity of colour was measured at 420 nm. The colour was found to be stable upto 3-4 hours. The standard curve was prepared using 0.25, 0.50, 1.0, 2.0, 4.0 mlof 4μg B/ml solution (working standard) to the series of 25 ml volumetric flasks. 2 ml each of buffer reagent was added and mixed and allowed to stand at room temperature for 30 minutes. The absorbance measured at 420 nm. C value is reading from the standard curve.
Boron (mg/l): C x Dilution factor (10)

Carbonate and Bicarbonate: Rinse the burette with 0.02N Sulphuric acid (H_2SO_4) and discard the solution. Fill the burette with 0.02 N sulphuric acids and adjust it to zero. Using a measuring cylinder exactly measure 100 ml filtered water sample and poured it

into 250 ml conical flasks.

(a) 3 to 4 drops of phenolphtalein indicator were added to the flaks and pink colour developed.

Carbonate (mg/l): T - 2P

(b) The pick colour in the flash was titrated with0.02 N of H$_2$SO4 from the burette, until the pick colour disappeared. 3 drops of methyl orange indicator was added to the same flask and titrated with 0.02N of H$_2$SO4. The colour changed from red to yellow.

Bicarbonate (mg/l): = 2P - T

Where,

T = Total Alkalinity

P = Phenolphtalein

Biochemical oxygen demand (BOD$_5$): The BOD was determined by Winkler's method. Water sample for BOD were collected at each location in 100 ml BOD bottles without agitating. The initial DO content is determined as stated; stopper was carefully removed. 1ml each of sodium iodide (Nal) solution and magnesium Sulphate (MgSO$_4$) solution were added with aid of 1ml pipette, the stopper was replaced and the content was thoroughly mixed, 2.0 ml of concentrated Sulphuric acid (H$_2$SO$_4$) was added mixture, 50 ml of the solution was titrated with 0.025N of Sodium thiosulphate (Na$_2$S$_2$O$_3$) with starch solution as indicator of the colorless end point. After 5 days, incubated bottles, DO was determined using the above procedure.

The BOD$_5$ (ppm): Initial DO of sample – DO of sample after 5 day / ml of percentage of sample added

Data Analysis. Data were analysed using descriptive statistics. The following equations were used to evaluate the suitability of catfish effluent as irrigation water.

(a) The risk of sodicity (% Na$^+$) is expressed as:

% Na$^+$ = (Na$^+$ + K$^+$) / (Ca^{2+} + Mg^{+2} + Na$^+$ + K$^+$)

(b) Sodium adsorption ratio (SAR) is used to evaluate sodium hazard and is expressed as follows:

SAR = Na+ / [(Ca^{2+} + Mg^{+2})]$^{0.5}$

(c) Residual Sodium Carbonate (RSC)

Residual sodium carbonate is expressed as follows:

RSC=(CO$_3^{-2}$ + HCO$_3^-$) - (Ca^{+2} + Mg^{+2}) meg/l

Where,

% Na$^+$ =Sodium concentration in meg/l

Ca^{2+} =Calcium concentration in meg/l

Mg^{+2} =Magnesium concentration in meg/l

K$^+$ =Potassium concentration in meg/l

CO$_3^{-2}$ =Carbonate concentration in meg/l

HCO$_3^-$ =Bicarbonate concentration in meg/l

RESULTS AND DISCUSSION

Physical and chemical properties of catfish effluent.

The mean values of water quality on the selected catfish earthen pond are presented in the Table 1. The mean values of the pH of the effluent ranged from 6.2 - 8.1. The variation in the values of pH from pond to pond may be due to the variation in cations concentrations (Calcium, Magnesium, Potassium and Sodium). All the values indicated slightly alkaline conditions, but fell within the recommended standards range of 6.0 – 8.5 (FAO, 1994). However, continuous application of this effluent to the soils may be harmful.

The mean values of the electrical conductivi-

ty concentrations (EC) of the effluent ranged from 0.21 – 0.48 (mmhos/cm). The mean values of the total dissolved solids concentrations ranged from 140 – 307 (mg/L). The mean values of the suspended solids (SS) ranged from (32 – 78) mg/L. The values below 100 mg/l pose no restriction to irrigation. General consensus says that suspended solids (SS) level below 50 mg/L, is safe for a drip irrigation system while values above 100 mg/l will cause plugging , but the complexity and variability of irrigation waters and systems make effective filtration the most sensible approach to controlling hazard posed by suspended solids. Total alkalinity concentrations of the effluent ranged from 45 – 138 (mg/L). The mean values of total nitrogen and total phosphorus concentrations ranged from (4.9 – 7.5 and 0.11 – 0.35) mg/L respectively. The mean values of sodium, calcium, potassium and magnesium concentrations in the effluent ranged from (11 – 31, 24.1 – 69.0, 0.16 – 0.41 and 8.2 – 12.0) mg/L respectively. The mean values of Carbonate and bicarbonate concentrations in the effluent ranged from (8 – 40 and 20 – 95) mg/L respectively. The mean values of Chloride and boron concentrations ranged from (10.4 – 25.8 and 0.1 – 0.4) mg/L respectively. Biochemical oxygen demand (BOD_5) of water is an important criterion for judging the suitability of wastewaters (effluents) for irrigation. The mean values of catfish effluent ranged from (4.4 – 8.2) mg/l. The value was below the 100 mg/l safe limit (FAO, 1994, Bryan, 2007). The means values of the various chemical constituents when compared with the FAO (1994) water standard for irrigation were fall within the ranges values recommended as suitable for irrigation (Table 1).

Evaluation of the catfish effluent quality for irrigation.

The suitability of irrigation water (SIW) is expressed as:

$$SIW = f (Q, S, P, C, D)$$

Where,
Q = Quality of irrigation water
S = Soil type
P = Salt tolerance characteristics of plant
C = Climate and
D = Drainage characteristics of the soil.

This study was restricted to only the quality of irrigation water.

The suitability of irrigation water are based on the following evaluations which include: Risk of sodicity, Salt problem, Residual sodium carbonate (RSC) and potentially toxic elements

Risk of Sodicity Evaluation
This was based on the concentration of sodium in irrigation water due to high solubility and the negative effects associated with sodium in irrigation water. Excess sodium content in irrigation water can affect plant growth, soil permeability and damaging soil structure. The risk of sodicity ($\% Na^+$) is expressed as:

$$\% Na^+ = (Na^+ + K^+) / (Ca^{2+} + Mg^{+2} + Na^+ + K^+)$$

The percentage sodium values ranged from (0.20 – 0.23) meg/L which were below 3 meg/L (Table 2) which means that sodicity problem is not expected. Sodicity causes swelling and dispersion of clay particles, surface crusting and pore plugging [Bryan, 2007] both of which aggravate infiltration problem. This condition makes it difficult for plants to get enough water.

Salt Problem Evaluation
Catfish effluent as irrigation water source

contains a mixture of natural and artificial occurring salts. There are two types of salt problems namely; (a) total salinity and (b) sodium.

(a) Total Alkalinity
Water salinity is usually measured by the total dissolved solids (TDS) or electrical conductivity of water (EC_W). Total dissolved solids are sometimes referred to as the total salinity (mg/L). Electrical conductivity and total dissolved solids concentrations ranged from (0.21 – 0.48) ds/m and (140 – 307) mg/L respectively. Both total dissolved solids and electrical conductivity values were low as compared to recommended standard values (see Table 2).

(b) Sodium
Sodium salts are of particular concern, an excessive sodium levels relative to calcium and magnesium can adversely affect plant growth, soil structure and permeability. Sodium adsorption ratio (SAR) is used to evaluate sodium hazard and is expressed as follows:

$$SAR = Na+ / [(Ca^{2+} + Mg^{+2})]^{0.5}$$

Sodium adsorption ratio (SAR) was evaluated and values ranged from (0.49 – 0.9) meg/l which below recommended value (see Table 2). The effluent qualities in the five ponds are, therefore, good quality for irrigation. This is significant because saline water increases the osmotic exertion required for plants to absorb water from soil. Hence as salinity increases, less water becomes available to plant uptake even when there is adequate water in the soil. It can also further cause reduction in plant yield, burn plant leaves and discolouration of fruits and resulted to reduce in market value.

Residual Sodium Carbonate (RSC)
Residual sodium carbonate is expressed as follows:

$$RSC = (CO_3^{-2} + HCO_3^-) - (Ca^{+2} + Mg^{+2})\ meg/l$$

The estimated values ranged from (- 1.28 to – 1.61) meg/l (see Table 2). RSC values below zero are considered safe for irrigation (Bryan, 2007). High concentration of bicarbonate in effluent can lead to a high concentration of bicarbonate in the soil water where it may be concentrated through the process of evapotranspiration. There is then an increased tendency for calcium and magnesium to precipitate as insoluble salts. Overtime, this reduction in available calcium and magnesium will result in an adversely affect soil structure and could cause a sodium hazard. RSC values above zero render soil susceptible to structural problems which can be resulted to calcium loss from soil by precipitation. Lime deposition reduces the crops market value, plugs irrigation systems and reduces nutrients available to plants by reduced solubility

Specific ion toxic
The miscellaneous hazards (specific ion toxic) are the concentration of potentially toxic elements such as chloride and boron. The most common toxicity problem is chloride in irrigation water. This is because is not adsorbed or held back by soil. The concentration of chloride values ranged from (0.30 – 0.83) meg/l. Generally, chloride was below the 30 meg/l safe limit (FAO, 1994, Bryan, 2007) for both ponds. High chloride concentration corrodes plant leaves and fruits. This can be prevented by dilution and by avoiding contact between the leaves and water during irrigation. Boron concentration values ranged from (0.02 – 0.07) meg/l (see Table

2). The value was below the 0.37 meg/l safe limit (Ayers and Westcot, 1994, Bryan, 2007). Boron is toxic to many crops at levels only slightly above those required for growth. Boron concentration in water of 0.4meg/l can damage sensitive fruits.

Classification of catfish effluent as irrigation water

Irrigation water is classified based on the sodium adsorption ratio (SAR) and electrical conductivity of water (EC_W). Both the values SAR and EC_W in the Table 2 were lower than 1 meg/l and 1 mmhos/cm respectively. The catfish effluents in the earthen ponds are classified as C1 – S1 water. This implied that there is none degree of restriction in the application of catfish effluent as irrigation water source.

However, for a continuous application of this effluent for irrigation to the soils may be harmful and resulted to salinization (accumulation of salts soil, eventually to toxic levels for plants).Besides, poorly drained and shallow depth soil could be enhanced water rises to the surface by capillary action, rather than percolating down through the entire soil profile and then evaporates from the soil surface which may promote increases in salt concentrations of the soil. It is advisable that salt concentration of soil should be determined especially in poorly drained soils when the groundwater was within 3 metres or less from the surface before applied this effluent for irrigation in next planting season.

Table 1: The mean values of water quality on the selected catfish earthen ponds.

Parameter	Unit			Ponds			Recommended Standard values
		A	B	C	D	E	
pH		7.5	6.6	6.2	7.9	8.1	6.0 – 8.5
Electrical Conductivity (mmhos/cm)		0.38	0.25	0.21	0.36	0.48	0 – 3.0
Total dissolved solids	(mg/L)	243	167	140	230	307	0 – 2000
Suspended solids	(mg/L)	54	38	32	56	78	0 -100
Total alkalinity	(mg/L)	110	68	45	121	138	0 - 200
Total nitrogen	(mg/L)	4.9	5.1	7.5	5.9	6.9	0– 10
Total phosphorus	(mg/L)	0.18	0.11	0.35	0.25	0.30	0 – 2
Sodium	(mg/L)	18	11	20	15	31	0 - 50
Calcium	(mg/L)	64.0	24.1	36.0	57.5	69.0	0 – 120
Potassium	(mg/L)	0.25	0.42	0.16	0.26	0.41	0 – 2
Magnesium	(mg/L)	12.0	8.2	9.0	9.5	10.0	0 – 30
Carbonate	(mg/L)	31	15	8	34	40	0 - 50
Bicarbonate	(mg/L)	73	38	20	82	95	0 - 120
Boron	(mg/L)	0.1	0.3	0.2	0.1	0.4	0 – 2
Chloride	mg/L)	19.5	10.4	20.1	23.1	25.8	0 – 30
BOD5	(mg/L)	6.2	5.3	4.4	5.9	8.2	0 – 100

Table 2: Evaluation of the catfish effluent quality for irrigation

Parameter	Unit	Estimated value	Standard value
Risk of sodicity			
% Na$^+$	meg/l	0.20 – 0.23	0 - 3
Total alkalinity			
EC$_W$	mmhos/cm	0.21 – 0.48	0 - 3
TDS	mg/l	140 – 307	0 – 2000
Sodium Hazard			
SAR	meg/l	0.49 – 0.90	0 – 3
Residual sodium carbonate			
RSC	meg/l	- 1.28	< 0
Specific ion toxic			
Chlorine	meg/l	0.30 – 0.83	0 – 10
Boron	meg/l	0.02 – 0.07	0 - 3
Classification			
Class		SAR (S)	EC$_W$ (C)
1		0 -1	0 – 1
2		1 -2	1 -2
3		2 – 3	2 – 3
4		>3	>3

CONCLUSION

An investigation on catfish earthen ponds at some selected locations was assessed to determine the suitability of its effluent as irrigation water. Results showed that the catfish effluent was found to be suitable for irrigation systems as, toxicity, salinity, and chemical constituents fell within the tolerance limit. The catfish effluents in the earthen ponds are classified as C1 – S1 water. This implied that there is none degree of restriction in the application of catfish effluent for irrigation in the studied area.

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