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Full Length Research Paper

Effect of Fish Pond Wastewater Irrigation on Receiving Soils and Crops in Dry Season Farming

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ABSTRACT: The need to improve soil productivity and elimination of wastewater pollution potential to the soil can be greatly achieved through the application of wastewater from the fish pond. This study evaluates the effect of irrigation with effluent from fish pond on the soil, growth rate and also on the yield of maize and okra. The application of wastewater from fish pond through surface irrigation system improves the physico-chemical properties of the soil in terms of soil electrical conductivity, total soil nitrogen, total organic carbon, total organic matter, soil minerals, exchangeable acidity, cation exchangeable acidity capacity. The statistical analysis shows significance influence of wastewater application on all these physico-chemical properties to the soil at $P < 0.05$ while, the non-significance effect was observed for zinc and iron among the heavy metals investigated. This can be strongly attributed to the low quantity of such metals and their duration in the soil. The Performance of maize and okra plant parameters were greatly influenced by the application of wastewater from fish pond. The result of the experiment shows that the plant height, number of leave, leave area and cob weight, yield of maize and okra yield performs better when compared with the control plot of maize and okra plot respectively. From (Tables 3 and 4) which show the influence of wastewater application on plant parameters gave the highest yield of 5.39 tone/ha for maize through the application of wastewater from fish pond and the lowest yield of 1.04 tone/ha for the control plot which was irrigated with underground water also for okra the same trend was observed, the highest yield of 0.35 tone/ha was obtained from the plot irrigated with wastewater and the lowest yield of 0.15 tone/ha was obtained from control plot. From these results obtained the application of wastewater from fish pond to the soil was found to be satisfactory to improve soil physical-chemical properties as well as yield of maize and okra respectively in the study area.

Keywords: Growth rate, physico-chemical parameters wastewater

INTRODUCTION

Agriculture is the single largest consumer of water of the freshwater on earth, 65 to 75% is used for irrigation (Rosegrant *et al.,* 2005). Worldwide, over 250 million ha of land are irrigated, representing about 20% of the world's arable land, which produces over one-third of global food supply (FAO, 2004). About 79% of irrigated land in developing countries has contributed to the increased crop yields of the Green Revolution (Tucker, 1998). Scarcity of freshwater is becoming an increasing problem primarily in the arid and semi-arid regions of the world. However, majority of the agro-industries are water-based and a considerable volume of wastewater is discharged from different operational units of these industries in the environment either treated or inadequately treated forms which leads to the several problems of surface as well as ground water pollution (Rattan *et al.,* 2005). In much of the world, the increase in crop yield has slowed due to increasing water scarcity and increasing global population, the gap between the supply and demand for water is widening and has reached such alarming levels that in some parts of the world it is posing a threat to human existence. Scientists around the globe are working on new ways of conserving water.

The fertility status of the sandy ultisols common in the semiarid region, of Nigeria, is generally low, and so crop yields are poorer than obtained in most other regions of the country, except where fertility management is well organized. The common technologies taught to farmers for the maintenance of soil fertility have been in the use of inorganic fertilizers, improved crop species/varieties, crop rotation and the role of agro chemicals. These approaches are no more adequate the reasons include excessive degradations of soils by a high rainfall regime which inorganic fertilizers cannot correct; high cost of fertilizer which the soil need for replenishment which many farmers can no more afford, and the desire by many people to eat organically produced foodstuffs (Adeniyan *et al.,* 2011).

It is an opportune time, to refocus on one of the ways to recycle water through the reuse of effluent wastewater from fish pond, for irrigation and other purposes. This could release clean water for use in other sectors that need fresh water and provide water to sectors that can utilize effluent for example irrigation and other ecosystem services.

In this prevailing condition, constant nutrient supply through fertilizer application will be solution or else, soil nutrient decline will be continuous and this will hinder crop production. Inorganic fertilizer has been used for decades on soil amendment for crop production in the world Donava and Casey, (2002). This has resulted to increased demand for inorganic fertilizer to replenish the lost soil nutrient and improve crop production. The resultant effect leads to increased production cost which affects food produced in the world most especially Nigeria. In addition, it was revealed that inorganic fertilizer had adverse effects like nutrient imbalance, soil acidity, increased greenhouse effects on soils (FAO, 2012).

High population is characteristics of many developing countries especially in Nigeria and therefore there is need for intensive and efficient use of land and available water for more food production. Fish farming has being widely developed for food security and income generation Lin and Yi, (2003). The objective of this study therefore, was to evaluate the effect of irrigation with effluent from fish pond on the soil, growth rate and also on the yield of maize (*Zea mays)* and Okra (*Abelmoschus esculentus)* during dry season.

Wastewater

\Wastewater is liquid waste discharged by domestic residences, commercial properties, industry, agriculture activities which often contains some contaminants that result from the mixing of wastewater from different sources. Based on its origin wastewater can be classed as sanitary, commercial, industrial, agricultural or surface runoff. Term wastewater need to be separated from the term sewage, sewage is subset of wastewater that is contaminated with faeces or urine though many people use term sewage referring to any wastewater. Wastewater mostly consists of pure water (more than 95%), and there are numerous processes that can be used to clean up waste waters depending on the type and extent of contamination.

Agricultural wastewater

Agricultural wastewater may be defined as the combination of the liquid carried wastes from institutions, residences and commercial and industrial establishments. Fish Pond Wastewater is defined as a cloudy fluid arising from pond, containing mineral and organic matter in solution or having particles of solid matter floating, in suspension, or in colloidal and pseudo-colloidal form in a dispersed state.

Physiochemical characteristics of fish pond wastewater

Water is very precious for every living organism on this earth. The available fresh water to man is hardly 0.3 to 0.5% of the total water available on the earth and therefore its judicious use is imperative. In today's scenario, unplanned urbanization, rapid industrialization and indiscriminate use of artificial chemicals causes heavy pollution in aquatic environments leading to deterioration of water quality and depletion of aquatic fauna including fish (Deshmukh and Ambore, 2006). Without the knowledge of water chemistry, it is difficult to understand the biological phenomenon fully, because the chemistry of water reveals much about metabolism of the ecosystem and explains the general hydro-biological interrelationship (Ptil *et al.,* 2009). Physico-chemical characteristics are highly important with regard to the occurrence and abundance of species. Discharge of urban, industrial and agricultural wastes have increased the quantum of various chemicals that enter the receiving water, which considerably alter their physico-chemical characteristics.

Effect of wastewater irrigation on soil and crops

The reuse of wastewater, in particular for irrigation, is an increasingly common practice, encouraged by governments and official entities worldwide. Irrigation with wastewater may have implications at two different levels: alter the physic-chemical properties and microbiological content of the soil and/or introduce and contribute to the accumulation of chemical and biological contaminants in soil. The first may affect soil productivity and fertility; the second may pose serious risks to the human and environmental health. The sustainable wastewater reuse in agriculture should prevent both types of effects, requiring a holistic and integrated risk assessment. They also found that the profitability from using wastewater was negatively affected by the presence of heavy metals such as Lead and Mercury that are carried through untreated wastewater and get deposited in the soil. Of the two opposing effects of wastewater irrigation, the negative effect of heavy metal toxicity outweighs the positive effects of organic nutrients. Ambika, (2010) and Darvishi, (2010) showed that wastewater increases soil salinity, organic carbon, N, K, Ca and Mg cations to a great extent. Soil is a biofilter that can reduce a large part of domestic wastewater pollutants, but the filtering increases EC, SAR, Na, Ca and Mg of soil. Studies by Aghtape *et al.* (2011) showed that irrigation with wastewater significantly increased the macro elements (N,P and K) contents in corn forage. This increase could be related to the amount of nutritious (such as N, P and K) in wastewater. Tunc and Sahin (2015) in their studies observed that the soil physical (bulk density, particle density, total porosity, pore size distribution and aggregate stability) and hydraulic (water retention and infiltration) properties get significantly affected from wastewater irrigation to cauliflower and red cabbage plantings. The studies further showed that soil electrical conductivity and organic carbon content in wastewater irrigated soil were higher than in freshwater irrigated soil. Wastewater application can result in a number of problems such as pathogenic infection and heavy metal accumulation in soil, underground water and crops to toxic levels Amiri *et al.* (2008).

METHODOLOGY

Study area

The experiment was conducted during the 2018 dry season in Agricultural and Bio-Environmental Engineering Departmental farm, The Federal Polytechnic, Bida, which lies between Lat. $9^{o}05^{I}$N and 9.083^{o}N and Log. $6^{o}01^{I}$E and 6.071^{o}E has an average temperature of 26.5^{o}C and about 481mm of precipitation annually. Bida has a steeped climate so therefore the major soil found in this area are the sandy clay type of soil and has characteristic red colour enriched with a clay sub-soil noticeable in the landscape. There are two climatic regimes in the area; the distinct dry season, which occurs from November to March and wet season which occurs from April to October. The dry season usually get to its peak in the month of March which is also the period for highest evapotranspiration, while the wet season usually get to its peak between the months of July and September which also records highest precipitation. The area belongs to guinea savannah vegetation with short grasses that grows rapidly during rainy season and dry up during dry season because of the intense heat associated with high evapotranspiration. The map and experimental plots are shown (Figures 1 and 2).

Collection of soil sample and wastewater sample

Soil samples were collected randomly from plot 2, 6, 9 and 11 for maize plots and okra plots before application and after application of wastewater at a depth of 20 cm. Land clearing was carried out before the collection of soil sample into the polyten bags which was before application of wastewater. Plots 1 and 11 are the control plots that is, plot not irrigated with wastewater while two samples of wastewater were collected at interval of three and seven days respectively. Borehole water sample were also collected. Both soil samples, borehole water and wastewater sample were taken to National Cereal Research Institute Baddegi (NCRI) Central Laboratory for physico-chemical analysis. Plots layouts are shown in (Figure 2). Figure 2 Experimental Plots at Agricultural & Bio-Environmental Engineering Department at Experimental Farm, Federal Polytechnic Bida.

Analytical methods

pH was measured using digital pH meter (Metrohm, Swiss-made). EC was measured using digital conductivity meter (Remi, India). Organic carbon was determined using Walkley and Black's rapid titration method Sodium, potassium and calcium were estimated using flame photometer after extraction with ammonium acetate buffer. Phosphorus and nitrogen was analyzed using spectrophometer by following standard methods. The Fe, Mg and Zn level was determined by using Atomic absorption spectrophotometer (Thermo Fisher. Model CE 3000 Series AA System). The soil samples were dried at 70° C and then digested with a HNO_3 and H_2SO_4 solution mixture accordingly. Digested samples were diluted with Millipore water and filtered with Whatman no.42 filter paper. Then the sample was made up to 20 ml. The ready sample was then analyzed using AAS. Wastewater was collected from the fish pond at various level of contamination, that is, at three days and seven-day interval.

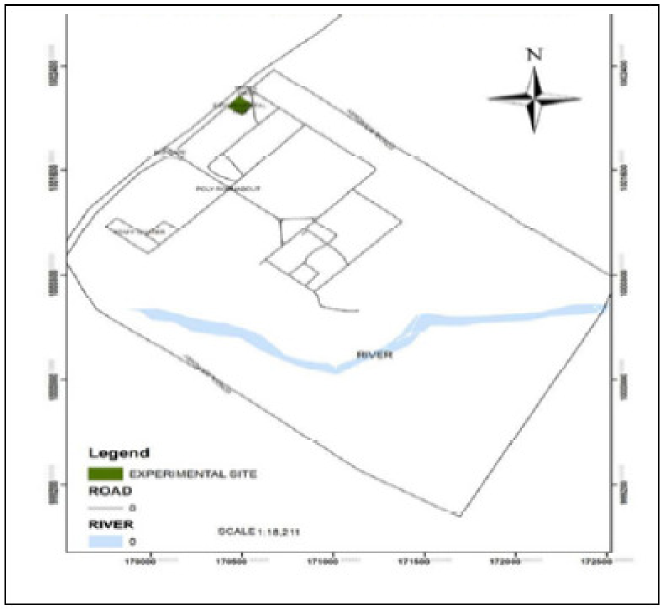

Figure 1: Map of Federal Polytechnic Bida, Niger State.

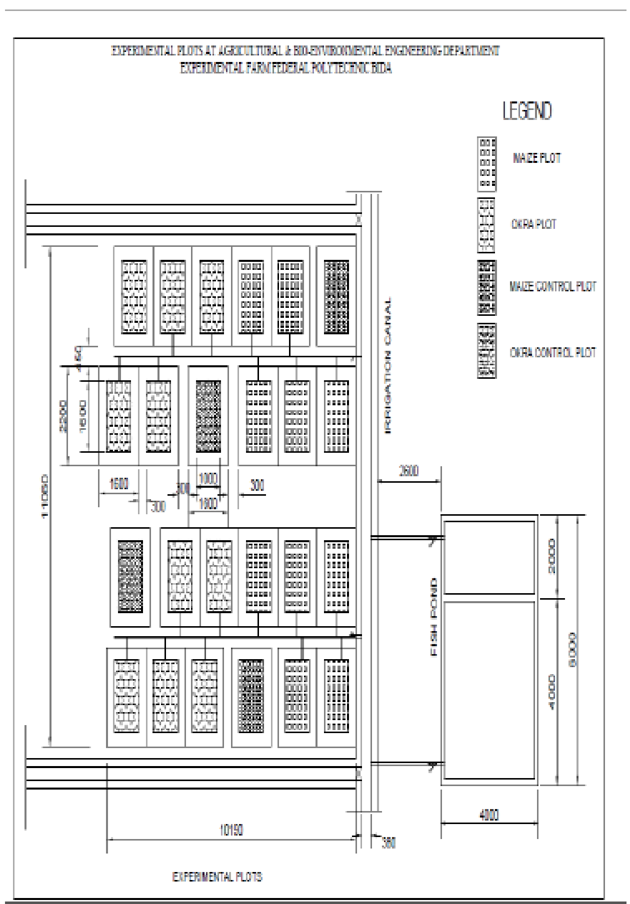

Figure 2: Experimental plots.

Size of plots and crops cultivated

The total length and breath for the two crop plots are 10.19.m and 11.06 m with total field surface area 112.7014 m^2. Each plots surface irrigated area was 2.56 m^2 and the total surface irrigated area for both maize and okra was 61.44 m^2 respectively. The inter row spacing for the maize and okra was 30 cm while intra row spacing was 75 cm respectively.

Irrigation system employed for the experiment

Surface irrigation was employed during investigation. The surface irrigation system adopted consists of PVC pipe of 6 cm in diameter which is connected to the canals from the fish pond of 0.75 m depth while the canal outlet is 0.65 m with a discharge valve of 3 cm in diameter. The canals also consist of two valves which discharge the wastewater to the 2.54 cm pipe through a reducer as the main line and discharge to individual plot by 1.27 cm PVC pipe. The maize plot was irrigated at two days' interval in 8 minute for each plot excluding the control plot which was irrigated using borehole water. Average depth of effluent water used in the main pond was 0.9 m

RESULTS AND DISCUSSION

Physico-chemical properties of wastewater and borehole water

The pysico-chemical properties investigated are as follows; Wastewater collected at seven-day show low pH value of 6.3 when compare to that of three days which gave pH 6.6 and borehole water which gave pH of neutral value that is 7.0. The electrical conductivity shows the same trend in wastewater sample as that of pH while borehole water has very low value of electrical conductivity (EC). The EC value of wastewater at seven, three days and borehole water are 180, 130 and 20 S/m respectively. The turbidity of three samples shows wastewater collected at seven days was found to be more turbid when compare to the other samples. The value of turbidity of the three samples are 1.3, 0.94 and 0.9 for waste water collected at seven days, three days and borehole water respectively. The dissolve oxygen and biochemical oxygen demand both shows the same trend that is, wastewater at seven days was found to be higher than others though the wastewater at three - day show value of dissolve oxygen higher than borehole water sample. Values obtained from laboratory analysis of the three samples for dissolve oxygen and biological oxygen demand are 0.3, 0.1 0.32 mg/L and 0.3, 0.1, 0.22 at seven, three and borehole water respectively. The result of chemical oxygen demand was found to be relatively the same for three samples while total dissolved solids shows that wastewater at seven days has more dissolved solid than wastewater at three days and borehole water respectively which is due to dissolution of the feed with the value 118.8 mg/L while wastewater at three days and borehole water are 85.8 and 13.2 mg/L respectively. The amount of nitrogen N was found to be high in wastewater from fish pond with wastewater at seven days having high concentration of nitrogen, phosphorus P and these agree with result of Ambika, and Darvishi, (2010). Furthermore, the result show that the borehole water contains more phosphorus` than the wastewater while potassium was high at seven - day wastewater than the borehole water but at the three - day wastewater the potassium was found to less than borehole water from the result obtained. Lead was found to be more presence in borehole water while other show less heavy metals when compare to borehole water. Iron and manganese were the same in all the three sample investigated. The laboratory results are presented in (Tables 1 to 5).

Statistical analysis of soil for maize plot after application of wastewater from fish pond

The statistical analysis of maize plot shows that the following physio-chemical properties of soil were significantly affected while some were not affected. Some of the significantly affected properties are electrical conductivity, nitrogen and phosphorus with exception of control plot while (P) Sodium (Na), Potassium (P), Calcium (Ca), Exchangeable Acidity (EA) and Cation Exchangeable Capacity (CEC) Organic Carbon (OC) and Organic Mater (OM) were found to be significant including the control plot. Meanwhile, among the heavy metal investigated Lead and Manganese were found to be statistically significant in all the plots investigate and iron was not statistically significant in all the plots. Lastly zinc was also found no significant with exception of control plot which show significant level. The statistical analyses for maize plots are presented in (Table 4).

Statistical analysis of soil for okra plot after application of wastewater from fish pond

The statistical analyses of okra plot show that the following physio-chemical properties of soil were significantly affected at $P < 0.05$ while some were not affected. Some of the significantly affected properties are Electrical Conductivity (EC), with exception of control plot while Nitrogen (N) and Phosphorus (P) Sodium (Na), Potassium (P), Calcium (Ca), Exchangeable Acidity (EA) and Cation Exchangeable Capacity (CEC), Organic Carbon (OC) and Organic Mater (OM) were found to be significant including the control plot and this agree with the report of (Mojiri et al. 2013). Meanwhile, among the

Table 1: Physico-chemical properties of fish pond wastewater and borehole water.

Samples Description	pH	E.C	TEMP ºC	COLOUR	TUR NTU	DO mg/L	BOD mg/L	COD mg/L	TDS mg/L	N mg/L	P mg/L	Pb mg/L	Zn mg/L	Fe mg/L	Mn mg/L	Na mg/L	K mg/L	Ca mg/L
WW_7	6.3	180	28.2	Colourless	1.3	0.3	0.3	60	118.8	4.03	1.52	1.21	1	1.07	0.39	0.4	0.22	3.5
WW_3	6.6	130	28.1	Colourless	0.94	0.1	0.1	60.5	85.8	1.43	1.44	1.16	1.28	1.07	0.39	0.33	0.06	3.1
BW	7.0	20	28.1	Colourless	0.9	0.32	0.22	59	13.2	0.93	3.02	1.63	1.21	1.07	0.39	0.24	0.09	2.63

Note: WW_7: Wastewater at seven day, WW_3: Wastewater at three day and BW: Borehole Water

Table 2: Physico-chemical properties of the Soil before application of Fish Pond Wastewater for Maize plot.

Samples Description	pH	EC	TEMP ºC	N %	OC %	OM %	P mg/L	Na mg/L	K mg/L	Ca mg/L	EA mg/L	CEC mg/L	Pb mg/L	Zn mg/L	Fe mg/L	Mn mg/L
Plot 2	5.3	40	27.1	0.13	0.356	0.538	1.687	0.34	0.28	2.22	0.16	3.00	0.450	1.016	1.072	0.336
Plot 6	5.5	50	27.2	0.12	0.306	0.527	1.747	0.41	0.29	2.11	0.16	3.01	0.519	1.019	1.07	0.338
Plot 9	5.5	40	27.1	0.13	0.405	0.652	1.755	0.39	0.30	2.23	0.15	3.07	0.487	1.02	1.07	0.336
Control plot	5.4	40	27.3	0.08	0.522	0.899	1.717	0.45	0.43	2.8	0.07	3.62	0.872	1.089	1.07	0.386

Table 3: Physico-chemical properties of the soil after application fish pond wastewater for maize plot.

Samples	PH	EC	Temp. ºC	N %	OC %	OM %	P mg/L	Na mg/L	K mg/L	Ca mg/L	EA mg/L	CEC mg/L	Pb mg/L	Zn mg/L	Fe mg/L	Mn mg/L
Plot 2	5.6	60	27.3	0.13	1.035	1.756	1.60	0.42	0.32	2.74	0.10	3.58	0.710	0.980	1.070	0.380
Plot 6	5.7	80	27.3	0.14	1.03	1.77	1.61	0.45	0.32	2.7	0.12	3.59	0.824	0.97	1.07	0.387
Plot 9	5.6	70	27.3	0.14	1.1	1.82	1.658	0.49	0.55	2.66	0.09	3.79	0.723	0.98	1.07	0.379
Control Plot	5.4	40	27.1	0.13	0.300	0.753	1.706	0.34	0.28	2.26	0.14	3.02	0.520	1.018	1.074	0.337

Table 4: Physico-chemical properties of the soil before application of fish pond wastewater for okra plot.

Samples	pH	EC	TEMP °C	N %	OC %	OM %	P mg/L	Na mg/L	K mg/L	Ca mg/L	EA mg/L	CEC mg/L	Pb mg/L	Zn mg/L	Fe mg/L	Mn mg/L
Plot 2	5.6	50	27	0.16	0.542	0.921	1.756	0.37	0.31	2.13	0.13	2.94	0.561	1.07	1.068	0.339
Plot 6	5.5	30	27	0.18	0.864	1.489	1.71	0.48	0.43	2.73	0.14	2.95	0.84	1.02	1.074	0.39
Plot 9	5.5	50	27	0.14	0.65 0	0.870	1.740	0.40	0.30	2.21	0.16	3.07	0.70	1.019	1.074	0.346
Control plot	5.7	20	27.1	0.05	0.864	1.489	1.74	0.44	0.3 1	2.8	0.12	7.19	0.842	1.02	1.071	0.39

Table 5: Physico-chemical properties of the soil after application of fish pond wastewater for okra plot.

Samples	PH	EC	Temp. ºC	N %	OC %	OM %	P mg/L	Na mg/L	K mg/L	Ca mg/L	EA mg/L	CEC mg/L	Pb mg/L	Zn mg/L	Fe mg/L	Mn mg/L
Plot 2	5.7	70	27.1	0.2	0.761	1.647	1.674	0.40	0.38	2.42	0.08	3.28	0.732	0.962	1.057	0.347
Plot 6	5.5	50	27.1	0.2	0.414	0.714	1.7	0.43	0.3	2.8	0.12	3.76	0.84	0.995	1.073	0.388
Plot 9	5.7	60	27.1	0.15	1.020	1.541	1.623	0.42	0.41	2.51	0.13	3.47	0.910	0.998	1.069	0.352
Control plot	5.6	40	27.1	0.07	0.562	1.134	1.652	0.41	0.29	2.53	0.11	3.34	0.842	0.997	1.063	0.351

heavy metal investigated Lead (Pb) and Manganese (Mn) were found to be statistically significant in all the plots investigate and Iron (Fe) was not statistically significant in the entire plot. Lastly Zinc (Zn) was also found no significant with exception of control plot which show significant level. The statistical analysis for Okra plots are presented in (Tables 6 and 7).

Maize and okra crop growth parameters and yield

The wastewater from fish pond has great influence on the leave and height of maize crop 3^{rd} to 8^{th} weeks after planting. The maximum height of maize crop measured at plot 6 gave 1.78 m at 16^{th} weeks and minimum height was also observed at control plot which gave 0.68 m and

Table 6: Statistical analysis for maize plot.

Physico-chemical properties	Control plot before	Control plot after	Plot 2 before	Plot 2 after	Plot 6 before	Plot 6 after	Plot 9 before	Plot 9 after
pH	5.4± 0.1^{b}	5.4 ± 0.1^{b}	5.3 ± 0.1^{a}	5.6 ± 0.1^{c}	5.5 ± 0.1^{b}	5.7 ± 0.1^{d}	5.5 ± 0.1^{b}	5.6 ± 0.1^{c}
EC	40 ± 10^{a}	40 ± 10^{a}	40 ± 10^{a}	60 ± 5^{b}	50 ± 10^{a}	80 ± 5^{d}	40 ± 10^{a}	70 ± 5^{c}
N %	0.08 ± 0.01^{a}	0.08 ± 0.01^{a}	0.13 ± 0.01^{b}	0.13 ± 0.05^{b}	0.12 ± 0.01^{b}	0.14 ± 0.01^{c}	0.13 ± 0.01^{b}	0.14 ± 0.01^{c}
OC %	0.52 ± 0.01^{d}	0.30 ± 0.01^{a}	0.36 ± 0.00^{b}	1.04 ± 0.00^{e}	0.31 ± 0.01^{a}	1.03 ± 0.01^{e}	0.41 ± 0.01^{c}	1.10 ± 0.02^{f}
OM %	0.90 ± 0.01^{d}	0.75 ± 0.00^{c}	0.54 ± 0.00^{a}	1.76 ± 0.00^{e}	0.54 ± 0.00^{a}	1.77 ± 0.01^{f}	0.65 ± 0.01^{b}	1.82 ± 0.01^{g}
P mg/L	1.72 ± 0.00^{d}	1.71 ± 0.00^{d}	1.69 ± 0.00^{c}	1.60 ± 0.01^{a}	1.75 ± 0.00^{e}	1.61 ± 0.01^{a}	1.75 ± 0.01^{e}	1.66 ± 0.01^{b}
Na mg/L	0.45 ± 0.01^{d}	0.34 ± 0.01^{a}	0.34 ± 0.01^{a}	0.42 ± 0.01^{c}	0.41 ± 0.01^{c}	0.45 ± 0.01^{d}	0.39 ± 0.01^{b}	0.49 ± 0.01^{e}
K mg/L	0.43 ± 0.01^{d}	0.28 ± 0.01^{a}	0.28 ± 0.01^{a}	0.32 ± 0.01^{c}	0.29 ± 0.01^{a}	0.32 ± 0.01^{c}	0.30 ± 0.01^{b}	0.55 ± 0.01^{e}
Ca mg/L	2.80 ± 0.01^{e}	2.26 ± 0.01^{b}	2.22 ± 0.01^{b}	2.74 ± 0.01^{d}	2.11 ± 0.01^{a}	2.70 ± 0.10^{c}	2.23 ± 0.01^{b}	2.66 ± 0.01^{c}
EA mg/L	0.07 ± 0.01^{a}	0.14 ± 0.01^{d}	0.16 ± 0.01^{e}	0.10 ± 0.01^{b}	0.16 ± 0.01^{e}	0.12 ± 0.01^{c}	0.15 ± 0.01^{d}	0.09 ± 0.01^{b}
CEC mg/L	3.71 ± 0.08^{d}	3.02 ± 0.04^{a}	3.00 ± 0.03^{a}	3.58 ± 0.01^{c}	2.98 ± 0.02^{a}	3.59 ± 0.01^{c}	3.07 ± 0.02^{b}	3.79 ± 0.02^{e}
Pb mg/L	0.87 ± 0.00^{g}	0.52 ± 0.01^{c}	0.45 ± 0.00^{a}	0.71 ± 0.01^{d}	0.52 ± 0.00^{c}	0.82 ± 0.00^{f}	0.49 ± 0.00^{b}	0.72 ± 0.00^{e}
Zn mg/L	1.09 ± 0.00^{b}	0.68 ± 0.58^{a}	1.02 ± 0.00^{a}	0.98 ± 0.01^{a}	1.02 ± 0.00^{a}	0.97 ± 0.01^{a}	1.02 ± 0.01^{a}	0.98 ± 0.01^{a}
Fe mg/L	1.07 ± 0.00^{a}	1.07 ± 0.00^{a}	1.07 ± 0.00^{a}	1.07 ± 0.00^{a}	1.07 ± 0.01^{a}	1.07 ± 0.01^{a}	1.07 ± 0.01^{a}	1.07 ± 0.01^{a}
Mn mg/L	0.39 ± 0.00^{c}	0.34 ± 0.00^{a}	0.34 ± 0.00^{a}	0.38 ± 0.01^{c}	0.34 ± 0.00^{a}	0.38 ± 0.01^{c}	0.34 ± 0.00^{a}	0.37 ± 0.02^{b}

NOTE: The same alphabet show no significant at $p < 0.05$ within the same raw

Table 7: Statistical analysis for okra plot.

Physico-chemical properties	Control plot before	Control plot after	Plot 2 before	Plot 2 after	Plot 6 before	Plot 6 after	Plot 9 before	Plot 9 after
pH	5.70 ± 0.10^{a}	5.60 ± 0.10^{a}	5.60 ± 0.10^{a}	5.60 ± 0.10^{a}	5.53 ± 0.15^{a}	5.50 ± 0.10^{a}	5.50 ± 0.10^{a}	5.70 ± 0.10^{a}
EC	40 ± 10^{a}	40 ± 10^{a}	50 ± 10^{b}	70 ± 10^{c}	30 ± 10^{a}	50 ± 10^{b}	50 ± 10^{b}	50 ± 10^{b}
N %	0.05 ± 0.01^{a}	0.07 ± 0.01^{b}	0.16 ± 0.01^{a}	0.20 ± 0.10^{c}	0.18 ± 0.01^{b}	0.20 ± 0.1^{c}	0.14 ± 0.01^{a}	0.20 ± 0.10^{c}
OC %	0.86 ± 0.01^{f}	0.56 ± 0.00^{c}	0.54 ± 0.00^{b}	0.76 ± 0.00^{e}	0.85 ± 0.08^{a}	0.41 ± 0.01^{f}	0.65 ± 0.01^{d}	1.02 ± 0.00^{f}
OM %	1.49 ± 0.01^{e}	1.13 ± 0.00^{d}	0.92 ± 0.01^{c}	1.65 ± 0.01^{f}	0.71 ± 0.01^{a}	1.49 ± 0.01^{e}	0.87 ± 0.01^{b}	1.65 ± 0.01^{f}
P mg/L	1.74 ± 0.00^{g}	1.65 ± 0.00^{c}	1.76 ± 0.00^{h}	1.67 ± 0.00^{d}	1.71 ± 0.00^{f}	1.70 ± 0.00^{e}	0.87 ± 0.01^{a}	1.62 ± 0.00^{b}
Na mg/L	0.44 ± 0.00^{g}	1.65 ± 0.00^{c}	0.37 ± 0.01^{a}	0.40 ± 0.10^{a}	1.71 ± 0.00^{f}	1.70 ± 0.00^{e}	0.87 ± 0.01^{a}	1.62 ± 0.00^{b}
K mg/L	0.31 ± 0.01^{a}	0.29 ± 0.01^{a}	0.31 ± 0.01^{a}	0.38 ± 0.01^{b}	0.43 ± 0.01^{b}	0.30 ± 0.10^{a}	0.30 ± 0.01^{a}	0.41 ± 0.01^{b}
Ca mg/L	2.80 ± 0.10^{d}	2.53 ± 0.01^{c}	2.13 ± 0.01^{a}	2.42 ± 0.01^{b}	2.73 ± 0.01^{d}	2.80 ± 0.01^{d}	2.21 ± 0.01^{a}	2.51 ± 0.01^{b}
EA mg/L	0.12 ± 0.01^{b}	0.11 ± 0.01^{b}	0.13 ± 0.01^{c}	0.08 ± 0.01^{a}	0.14 ± 0.01^{c}	0.12 ± 0.01^{b}	0.16 ± 0.01^{d}	0.13 ± 0.01^{c}
CEC mg/L	3.67 ± 0.09^{d}	3.34 ± 0.00^{b}	2.94 ± 0.00^{a}	3.28 ± 0.07^{b}	3.84 ± 0.11^{d}	3.84 ± 0.23^{d}	3.07 ± 0.0^{a}	3.47 ± 0.04^{c}
Pb mg/L	0.84 ± 0.00^{d}	0.84 ± 0.00^{d}	0.56 ± 0.00^{a}	0.73 ± 0.00^{c}	0.84 ± 0.01^{d}	0.84 ± 0.01^{d}	0.70 ± 0.01^{b}	0.91 ± 0.01^{e}
Zn mg/L	1.02 ± 0.01^{a}	1.00 ± 0.00^{a}	1.07 ± 0.01^{b}	0.96 ± 0.00^{a}	1.02 ± 0.01^{a}	1.00 ± 0.10^{a}	1.02 ± 0.00^{a}	1.00 ± 0.00^{a}
Fe mg/L	1.10 ± 0.01^{a}	1.10 ± 0.00^{a}	1.07 ± 0.00^{a}	1.06 ± 0.00^{a}	1.07 ± 0.01^{a}	1.07 ± 0.01^{a}	1.07 ± 0.00^{b}	1.06 ± 0.11^{a}
Mn mg/L	0.39 ± 0.00^{e}	0.35 ± 0.00^{c}	0.34 ± 0.00^{a}	0.35 ± 0.00^{b}	0.39 ± 0.00^{d}	0.39 ± 0.00^{e}	0.35 ± 0.00^{b}	0.35 ± 0.00^{e}

NOTE: The same superscript alphabet show no significant at $p < 0.05$ within the same

Table 8: Effect of fish pond wastewater on the crop parameters and yield of maize.

Plot Number	Plant height (cm)	No. of leave	K coefficient	Leave Area m^2	Cob weight (g)	Cob Weight (tone/ha)
1	0.676	13	0.56	0.04164	242	1.04
2	1.391	14	0.54	0.03682	528	2.48
3	1.235	12	0.55	0.03987	452	2.12
4	1.1245	14	0.54	0.03077	579	2.71
5	1.326	12	0.53	0.02167	437	2.05
6	1.781	16	0.55	0.04043	1379	5.39
7	1.099	10	0.53	0.03167	325	1.52
8	1.047	12	0.56	0.05615	464	2.18
9	1.573	14	0.57	0.06840	837	3.92
10	0.975	10	0.55	0.03892	320	1.50
11	0.7345	10	0.55	0.04531	273	1.07
12	1.586	12	0.54	0.03846	595	2.79

the same trend was observed for the okra crop which had fast growth rate at 2nd and 3rd weeks during the planting season more than the control plots. The maximum height of the okra crop was 0.35 m while the lowest height was 0.22 m which occurs in the control plot. The maize cob weight from the result shown in (Tables 8 and **9**) show

Table 9: Effect of fish pond wastewater on the crop parameters and yield of okra.

Plot Number	Plant height (m)	No. of leave	K coefficient	Leave Area m^2	Yield weight (g)	Yield Weight (tone/ha)
1	0.24	5	0.30	0.0088	32	0.13
2	0.30	6	0.32	0.0261	92	0.36
3	0.30	6	0.32	0.0210	65	0.25
4	0.32	6	0.30	0.0133	75	0.29
5	0.35	6	0.31	0.0226	67	0.26
6	0.32	5	0.32	0.0279	82	0.32
7	0.29	6	0.33	0.0482	90	0.35
8	0.24	5	0.31	0.0289	65	0.25
9	0.33	7	0.32	0.0323	60	0.23
10	0.28	6	0.31	0.0217	61	0.24
11	0.22	5	0.29	0.0064	39	0.15
12	0.34	8	0.30	0.0087	60	0.23

that the wastewater application influences the yield of the maize crop which gave the highest yield of 5.39 ton/ha at plot 6 while the control plot gave the lowest values which are plot 1 and plot 11 (1.04 and 1.07 tone/ha respectively) and these shows similar trend with result obtained by Hussein and Al-Jaloud, (1995). The same trend was also observed for Okra plots which gave the highest yield of 0.35 tone/ha at plot 7 and lowest yield at control plots that is, plot 1 and 11 (0.13 and 0.15 tone/ha respectively).

Conclusion

The application of wastewater from the fish pond improved the physico-chemical properties of the soil in term of soil electrical conductivity, total soil nitrogen, total organic carbon, total organic matter, soil minerals, exchangeable acidity, cation exchangeable acidity capacity, lead and manganese. The statistical analysis shows significance influence of wastewater application on all these physico-chemical properties to the soil at $P < 0.05$ while, the non-significance effect was observed in zinc and iron among the heavy metals investigated and this can be strongly attributed to the low quantity of such metals and its duration in the soil. Iron among the heavy metals investigated was found to be the highest (1.074 mg/L for maize and 1.073 mg/L for okra) while Manganese was found to be the lowest (0.337mg/L for maize and 0.347 mg/L for okra). Performances of maize and okra plants were greatly influence by the application of wastewater from fish pond. The result of the experiment shows that plant height, number of leave, leave area and cob weight, yield of maize and okra yield perform better when compared with the control plot of maize and okra plot respectively. From (Tables 7 and 8) show the influence of wastewater application on the yield of maize plot which gave the highest yield of 5.39 tone/ha and the lowest yield of 1.04 tone/ha for the control plot which was irrigated with underground water also for okra the same trend was observed, the highest yield of 0.35 tone/ha was obtained from the plot irrigated with wastewater and the lowest yield of 0.15 tone/ha was obtained from control plot and these was found to be satisfactory to improve maize and okra yield respectively in the study.

Recommendations

From result and statistical analysis, it shows that wastewater from fish pond have the potentials to improve the physico-chemical properties of soil and increase maize and okra yield and it also contributed less to the heavy metals presence in the soil. So therefore it is important to note the following recommendations;

(i) Wastewater from fish pond utilization through Integrated agricultural practice should be encourage at all level and this will eliminate the pollution potential to the environment
(ii) More research should focus on daily utilization of fish pond wastewater in other to ascertain the daily pollution potential of the wastewater.
(iii) Physico-chemical properties of the crop obtained from wastewater irrigation should be carry out to investigate the concentration of wastewater from fish pond.

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