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FISH POND WASTEWATER HYDROPONIC TREATMENT POTENTIAL OF *CITRULLUS COLOCYNTHIS*

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ABSTRACT

C.colocyn this' plant hydroponic treatment of fish pond's wastewater (FPWW) was evaluated. The FPWW was collected from the University of Ilorin aquaculture and tested for the dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), electrical conductivity (EC), total dissolved solid (TDS), temperature, pH and bacteriological content. The wastewater under treatment was tested for all the physicochemical parameters on weekly interval for the experimental period, while the bacteriological analysis was done before and after the treatment. The values obtained for the physicochemical parameters were statistically analyzed at $p<0.05$. The physicochemical results observed before application of C.colocynthis treatment technique were 25°C, 540µS/cm, 7.5, 270mg/l, 8.62mg/l, 22.65mg/l and 4.2mg/l for temperature, electrical conductivity, potential hydrogenation, total dissolved solid, 5-day BOD, COD, and the DO respectively. After the fifth week, the analysis of variance of the sample's results showed that the electrical conductivity, total dissolved solid, 5-day BOD and the COD were insignificantly reduced from 539 to 209µS/cm, from 270 to 102mg/l, 8.62 to 4.8mg/l and from 22.65 to 12.01mg/l respectively at $P>0.05$. The treatment efficiencies were observed to be 61.29%, 62.22%, 44.31% and 46.97% respectively. Also, the DO increased from 4.2 to 8.12 having percent increment of 93.33%, while the bacteriological analysis showed that FPWW has 215±35 colonies and $2.15\pm0.35\times10^7$ Cfu/ml before the application of C.colocynthis hydroponic treatment and 83±18 colonies and $8.3\pm0.18\times 10^6$ Cfu/ml after hydroponic treatment. The statistical results were insignificant but were within the limits of comparative standards.

Keywords: Wastewater, treatment plant, water analysis, fishpond

INTRODUCTION

Potable water is becoming one of the rarest and valuable resources in the twenty first century as its supply is limited and its natural source is easily polluted by industries and population increase. Increase in release of nutrient-rich waste water into receiving surface and subsurface water sources results in human health problems and environmental problems such as eutrophication in water bodies that is undesirable growth of aquatic plants and algae (Morrison *et al.*, 2011).

The population growth in developing countries, urbanization and economic development has contributed immensely to the increase in demand for water which consequently has led to the rapid production and discharge of different sources of wastewater including domestic and agricultural wastewater. In contrary there is lack of investment capacity around this part of the world for the construction and operation of adequate treatment facilities, this however threatens the quality of the surface water, groundwater, and soil around the area to which waste water is being discharged. In many parts of Africa, treatment of wastewater is not given necessary attention. Although, lack of awareness, the capacity and cost associated with the construction and operation wastewater treatment plants are all among the reasons for the lack of attention. However, the indiscriminate discharge of wastewater does not only have adverse effect on public health but also on aquatic ecological system (Zainabu and Zerihun, 2002).

Untreated wastewater usually contains numerous pathogenic organisms that may be present in certain industrial waste (Peter *et al.*, 2009). It also contains nutrients, which can stimulate the growth of aquatic plants and may also contain toxic substances. For these reasons, it is necessary to treat wastewater. Since water is also a basic need for human being, increasingly people compete for the same resource, which in turn create problems for the fish farmers. These problems can then be tackled efficiently with the use of recycling aquaculture systems (Hochheimer 2005).

Most fish production takes place in outdoor ponds where production success is often subjected to such natural occurrences as weather, the presence of aquatic weeds and predation by birds and other animals, though to deal with the problem of predators, it is not unusual to see ponds covered with some form of netting material. Four different methods of fishing production are identified by Bardócz, (2009). These are Pond Fish farming – earthen enclosures in which fish live in a natural-like environment; Flow-through systems -water flows through the culture system only once and it is discarded into the environment; Recirculation Aquaculture Systems – land-based systems in which water is reused after mechanical and biological treatment; reduces need for water and discharge of nutrients into the environment; Cage cultures in freshwater lakes and rivers – well designed and carefully managed cages are placed in certain water bodies.

The recycling aquaculture system removes some of the inefficiencies found in production systems. Water reuse reduces pumping costs and retains energy normally used to heat water. In addition, it enables production to occur in a controlled environment where losses to predators and seasonal drought do not influence production plans. Water reuse also permits a reduction in water consumption and the production of large quantities of fish in a small area (Bucklin *et al*. 1993). It also maintains an excellent cultural environment while providing adequate feed for optimal growth. Maintaining good water quality is of primary importance in aquaculture. Critical water characteristics include concentrations of dissolved oxygen, un-ionized ammonia, nitrogen, nitrate concentration, pH, and chloride levels. The by-products of fish metabolism include carbon dioxide, ammonia-nitrogen, particulate and dissolved faecal solids. Water treatment components are designed to eliminate the adverse effects of these waste products. In wastewater treatment systems, proper water quality is maintained by pumping pond water through special filtration and aeration (oxidation) equipment. Each component is designed to work in conjunction with other components to carry out the reduction of toxic substances in the water before being discharged (Greenberg, 1995).

In hydroponic treatment, plants used are usually from the region where the treatment is to take place. They are resistant to high pollutant load that are changeable in time. The final treatment of the flowing wastewater by means of the adsorption and absorption process is their main role in the treatment plant (Asao, 2012). The use of hydroponic wastewater treatment process has been confirmed in numerous scientific studies that demonstrate that the level of accumulation of nutrient compounds compared to natural nutrients levels in selected plant tissues, ranging from 18.97 to 57.4% for total nitrogen and from 17.60 to 42.54% for total phosphorus (Adrover, 2013; Ebrahim, 2013; Dedska *et.al*, 2015).

This study evaluated wastewater treatment potential of *citrullus colocynthis* for fishpond hydroponic treatment.

MATERIALS AND METHODS

Experimental Location

The field experimental set up on *Citrillus colocynthis* hydroponic treatment of fish pond's wastewater (FPWW) was situated at Araromi, Tanke Ilorin from March 2016 to June 2017. It is located at about 3km from University of Ilorin permanent site which is at latitude and longitude of 8.47°N and 4.68°E respectively.

Planting Materials and Experimental Set-up

Thirty strands of bare rooted *Citrillus colocynthis* plants were carefully uprooted from the garden in Araromi, Tanke which was cultivated for the purpose of this experiment. The uprooted plants were then taken to the fish pond's wastewater

(FPWW) hydroponic treatment experimental set-up where the roots of the *citrillus colocynthis* plants were carefully rinsed with some of the wastewater so as to remove any possible soil particles on them. Twenty-five liters of fish pond's wastewater carried in a twenty-five liters plastic container from University of Ilorin aquaculture was transported to the experimental site.

The fish pond's wastewater was further reassigned to ten three-litre plastic containers. All the three-litre plastic containers containing the waste water were covered with perforated covers. The perforations in the covers were covered with cotton wool in all the ten containers containing FPWW. Three strands of *citrillus colocynthis* plant were inserted in the hole created at the center of the cover (figure 1) such that the roots of the plants submerged into the FPWW completely in five out of the ten wastewater containers leaving the remaining five FPWW containers without plant as control.

Figure 1: *C. collocynthis* hydroponic treatment set-up.

Sample collection for water quality analysis

FPWW samples for analysis were collected before the experiment and during a weekly interval for five weeks and were analyzed for water temperature, potential hydrogenation (pH), electrical conductivity (EC), five-day biochemical oxygen demand (BOD5), chemical oxygen demand (COD), total dissolve solid (TDS), dissolve oxygen (DO), while the bacteriological analysis was done before and after the experiment.

Statistical data analysis.

The descriptive analysis was done using Microsoft Excel Stat., while the results obtained before and after the experiments were compared with the standards of the NESREA and WHO (1986).

Using Microsoft Excel Stat. one-way ANOVA was used to statistically analyze the results obtained from different parameters tested in the FPWW treatment process using equal time increment series of seven days interval so as to ascertain the effectiveness of the treatment process.

RESULTS

Physicochemical properties

FPWW does not have a definite physicochemical property, because these properties varies from one fish pond to the other depending on the type of fish being reared, their growth level, the source of the water and the type of feed used in such ponds. The physicochemical parameters of the FPWW before the application of *C.colocynthis* for FPWW treatment, samples were collected from the experimental site and analyzed for different parameters. The results obtained from the analysis before application of *C.collocynthis* treatment is compared to some maximum permissible standards as shown in Table 1 below**.**

Table 1: physico-chemical analysis of the sample before treatment

Parameters	Sample	NESREA[1]	WHO[2]	Others[3]
Temperature (°c)	25	27	<35	20-30
Electrical conductivity (µmhos/cm)	540	200		20-1500
pH	7.5	6-9	6.5-8.5	6.5-9
Total Dissolved Solid (mg/l)	270	500		500 (Sarkar, 2002)
Biochemical oxygen demand (mg/l)	8.62	10	10	0.29
Chemical oxidation demand (mg/l)	22.65			
Dissolved oxygen (ppm)	4.2	8-10	8-10	5.0
Water color	Light green			Light green

[1]National Environmental Standard and Regulations Enforcement Agency, [2]World Health Organization, [3]Boyd (1990), Keremahet. *et al*, (2014)

Also, from Table 1, the temperature of the sample is within the NESREA and WHO maximum permissible limit for cultivating fish and within maximum discharge limit, the temperature obtained could be associated to early morning low sunshine as the reading was taken in the morning. The electrical conductivity (EC) of the FPWW before the application of the treatment procedure is 220% above the NESREA maximum possible limit for cultivation of fish, though within the Boyd (1990) specifications for fish cultivations. The electrical conductivity value gotten for this sample could be as a result of pollutions from the fish’s excreta and some dissolved elements from the supplied feed.

The pH of the FPWW before the application of the treatment procedure is within NESREA and WHO standard for maximum possible limit for cultivation of fish and waste discharge. The slightly basic value obtained could be because of uneaten feeds, dead and decaying organic materials. The total dissolved solid (TDS) of the FPWW before the treatment is within the NESREA and Sakar (2002) standard for maximum possible limit for cultivation of fish and wastewater discharge.

Biochemical oxygen demand of the FPWW before the application of the treatment procedure is within both the NESREA and WHO standard for maximum permissible limit for cultivation of fish and wastewater discharge but far below the standard set by Boyd (1990) for the maximum permissible limit for cultivation of fish. More also, the level of biochemical oxygen demand obtained from this analysis could be attributed to the excretion from the fishes and the decaying food not eaten.

The dissolved oxygen of the FPWW before the application of the treatment procedure was 52.5% below the required minimum standard set by both NESREA and WHO for effective cultivation of fishes while it was 84% below the standard set by Boyd (1990). This low value of DO obtained could be as a result of the BOD loading a high level of plankton concentrations.

Bacteriological analysis

Results from the bacteriological analysis are shown on table 2. It could be deduced from the Table that the FPWW sample before the application of *C.colocynthis* treatment contains 215±35 number of colonies with $2.15 \pm 0.35 \times 10^7$ Cfu/ml. These bacteria when subjected to further analysis tested positive for *Escherichia coli* and *Bacillus* spp. The presence of *Escherichia coli* suggests the presence of human faeces which indicates that the source of the pond's water was contaminated since fishes can't be associated with *Escherichia coli*. More also, as shown in Table 2, the control set-up after the fifth week of treatment has 150±43 number of colonies and $1.5 \pm 0.43 \times 10^7$Cfu/ml while the *C. colocynthis* treatment set-up has 83±18 number of colonies and $8.3 \pm 0.18 \times 10^6$Cfu/ml. The *C. colocynthis* treated sample has a treatment reduction of 61.39% while that of the control set-up has a treatment reduction of 30.23%, the higher treatment reduction in the *C. colocynthis* treatment set-up could be associated to the nutrient intake by the *C. colocynthis* plant which results in reduction of the food the bacteria were feeding on.

Table 2: Results from the bacteriological analysis.

Sample Identification	No of colonies	Cfu/ml
Sample before treatment	215±35	$2.15 \pm 0.35 \times 10^7$
Control set-up	150±43	$1.5 \pm 0.43 \times 10^7$
After *C.colocynthis* treatment	83±18	$8.3 \pm 0.18 \times 10^6$

Effect of C.colocythis on the physico-chemical characteristics of FPWW

The possibility of *C.colocythis* plant to treat FPWW using hydroponic procedure was evaluated by collecting samples at weekly interval for five weeks and examined for some physicochemical and bacteriological parameters.

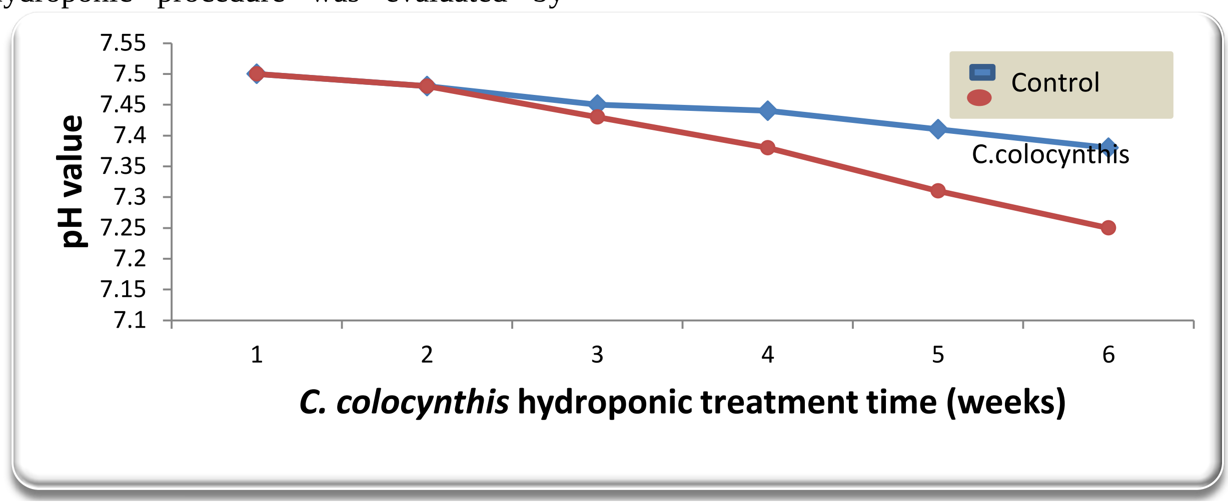

Figure 2: Graphical representation of pH values with treatment time.

Figure 2 shows graphical representation of pH values with treatment time. The results represented shows that the time series of pH measurements during the experimental period had the minimum value of 7.25 and a maximum value of 7.5. The pH values of *C.colocynthis* hydroponic treatments sets were discovered to be lower than that of the control set in the treatment time. This could have been as a result of the high organic decomposition rate in the *C.colocynthis* treatment sets which can also be ascertained from BOD5 and COD removal rate resulting in CO_2 and acid production which subsequently results in lower pH value of the *C. colocynthis* treatment set.

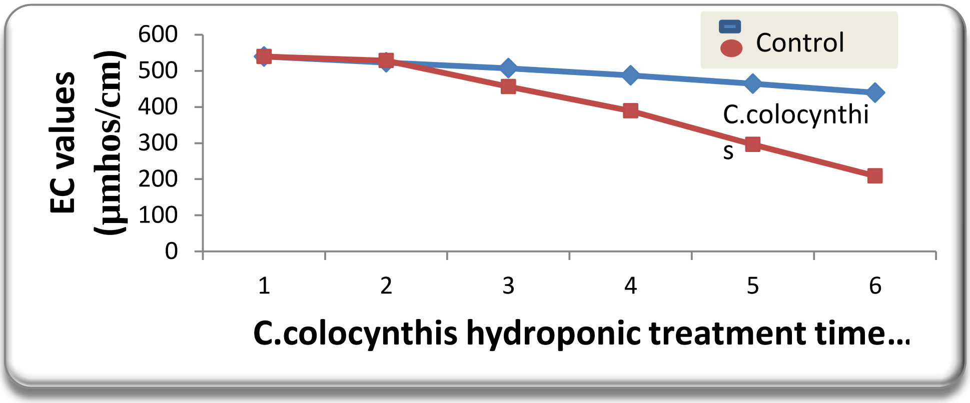

Figure 3: Graphical representation of EC conc. Of treatment with treatment time

Figure 3 shows the graphical representation of EC treatment with time. It was observed from the result that during the first week of the treatment, the percent reduction value of EC obtained for the control is slightly greater than that of the treatment set up as the EC reduction value of the control was 3.0% while that of the treatment set up was 2.0%. By the second week the treatment set-up shows a great percent reduction of 15.4% in the EC value compared to the percent reduction of 5.94% in the EC value of the control set up. More also, by the third, fourth and fifth week, it was found that the percent reduction for the treatment set up were 27.29%, 45.08% and 61.22% respectively, while the percent reduction of the control was 9.65%, 13.91% and 18.55% respectively.

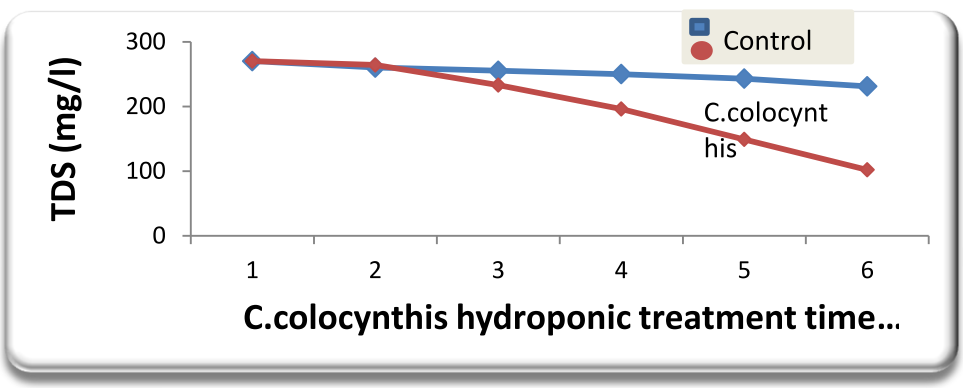

Figure 4: Graphical representations of TDS with treatment time

Figure 4 shows the graphical representation of TDS with treatment time. From the result, the TDS of both the treatment set up and the control set up follow almost the same pattern as the result of the EC concentration values. The treatment set up have reduction percent of 2.22%, 13.7%, 27.4%, 44.8% and 59.63% for week 1, 2, 3, 4 and 5 respectively. While the control set up has a reduction percent of 3.7%, 5.56%, 7.41%, 10% and 14.44% respectively. The TDS follows the same pattern as the result obtained from the EC, this confirms the fact that the EC and TDS has some level of proportionality.

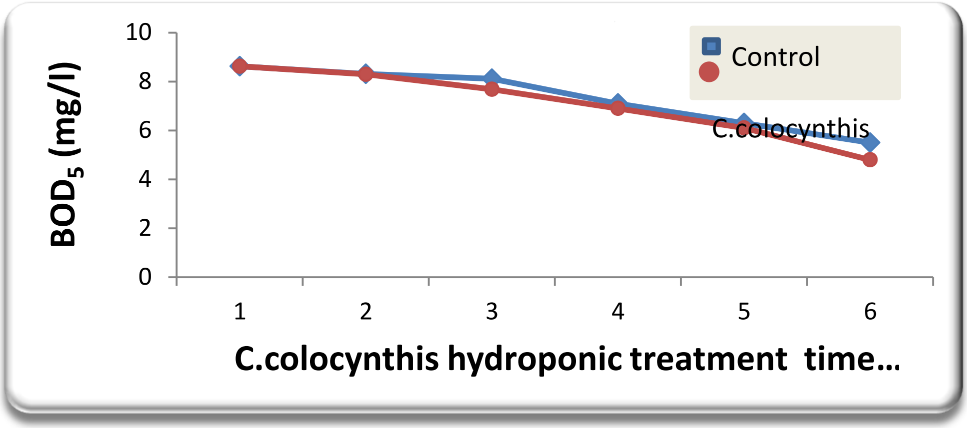

Figure 5: Graphical representation of BOD5 concentration treatment with treatment time

In the hydroponic treatment set-up, the concentration of the BOD5 (figure 5) was decreased from 8.62 mg/l by 3.8% in the first week, 10.9% in the second week, 25.75% in the third week, 33.87% in the fourth week and 51.28% in the fifth week. While in the control experiment set up the BOD5 was decreased by 3.589% in the first week, 5.92% in the second week, 17.63% in the third week, 26.91% in the fourth week and 36.19% in the fifth week. The 4.2mg/l obtained as the final BOD5 after the fifth week in the hydroponic treatment set up is absolutely within the WHO (1986) and NESREA requirement for both wastewater discharge requirement and BOD limit for fish cultivations.

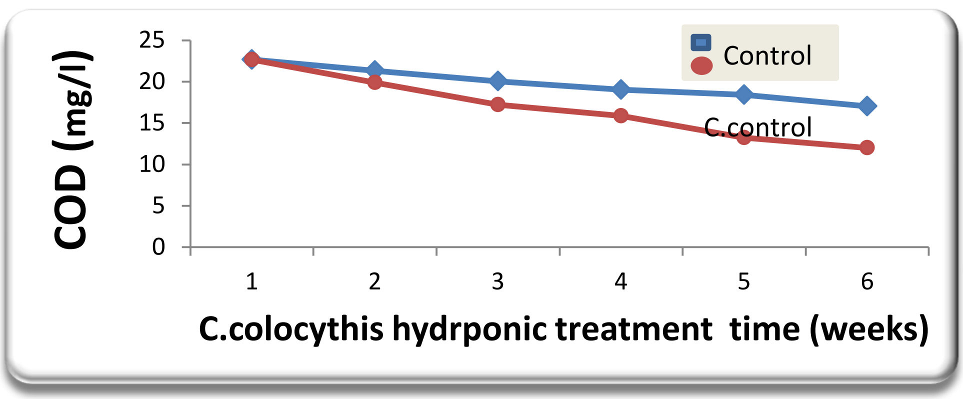

Figure 6: Graphical representation COD conc. treatment with treatment time

Figure 6 shows the graphical representation of COD concentration treatment with time. It could be observed from the result that the COD of the hydroponic treatment set up was much more decreased from the original 21.35mg/l by 12.19% in the first week, 24.02% in the second week, 29.98% in the third week, 45.59% in the fourth week and 46.96 in the fifth week, while in the control set up the COD was reduced by 5.7% in the first week, 5.9% in the second week, 11.48% in the third week, 16.03% in the fourth week and 24.86% in the fifth week.

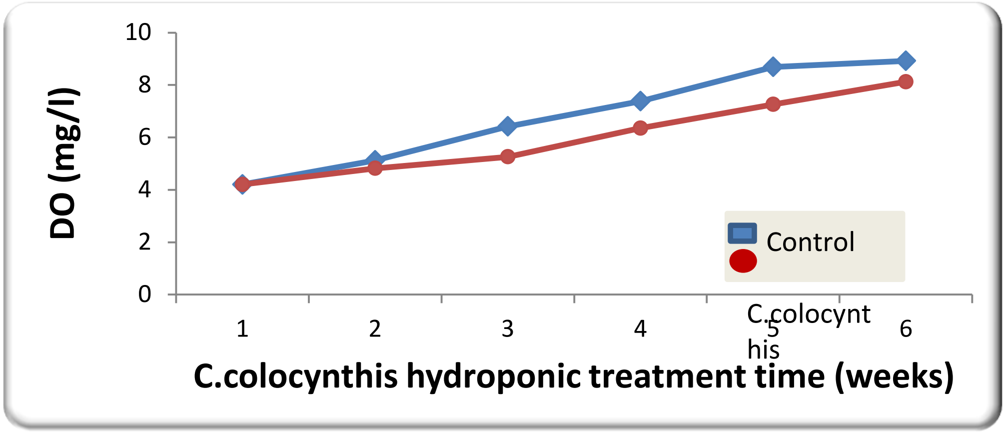

Figure 7: Graphical representation of DO concentration treatment with treatment time

Figure 7 shows the graphical representation of DO concentration treatment with time. From the result, the DO has appreciated considerably well in the control set up from the original 4.2mg/l by 21.9% in the first week, 52.86% in the second week, 75.71% in the third week, 106.9% in the fourth week and 112.38% in the fifth week while the hydroponic treatment set up was increased by 14.76% in the first week, 25.23% in the second week, 51.19% in the third week, 72.86% in the fourth week and 93.33% in the fifth week. However, in both cases the final results obtained (8.92mg/l and 8.12mg/l respectively) were within the WHO (1986), NESREA and Boyd (1986) standard limit for fish cultivation.

Judging by the overall results, the effectiveness of *C. colocynthis* for FPWW treatment in present experiment was not that apparent in the first week hydroponic treatment but was much more substantial for the rest of the weeks after the first week control set-up.

Table 3: Final values of treated FPWW and their treatment efficiencies.

Parameters	**C.colocynthis**	**Control**	**FEPA[1]**	**WHO[2]**	**Others[3]**	**Treatment efficiency of C.colocynthis**	**Treatment efficiency of the control.**
Temperature(°C)	26	26	27	<35	20-30		
Electrical conductivity (µmhos/cm)	209	439	200		20-1500	61.29%	18.70%
Ph	7.25	7.38	6-9	6.5-8.5	6.5-9		
Total Dissolved Solid (mg/l)	102	231			500 (Sakar, 2002)	62.22%	14%
Biochemical oxygen demand (mg/l)	4.8	5.5	10	10	0.29	44.31%	36.19%
Chemical oxidation demand (mg/l)	12.01	17.02				46.97%	24.36%
Dissolved oxygen (ppm)	8.12	8.92	8-10	8-10	>5.0	93.33%*	112.38%*

*percent increment.

Table 3 shows the final values of treated FPWW and their treatment efficiencies. It was observed that the treatment efficiency of the Electrical conductivity was 61.29% while that of the corresponding control set-up was 18.70%, the treatment efficiency of the Total dissolve solid, the 5-day biochemical oxygen demand and the chemical oxygen demand are 62.22%, 44.31% and 46.97 respectively while their corresponding control values are 14%, 36.19% and 24.36% respectively. The percentage efficiencies presented above revealed the fact that the *C. coloynthis* treatment set-up has an average treatment efficiency of 53.7%, which is very much more, compared to the control set-up's average treatment efficiency of 18.64%. It could also be observed that the final values obtained after the *C. colocynthis* hydroponic treatment for all the physicochemical parameters are within the WHO and NESREA standards.

When the pH values were subjected to the analysis of variance, the P-value was 0.265706 which is far more than the critical value of 0.05, this shows that it is statistically insignificant. Also, the electrical conductivity, the total dissolve solid, the 5-day biochemical oxygen demand, the dissolved oxygen and the chemical oxygen demand have p-values of 0.13618, 0.107463, 0.746168 and 0.141023 respectively, these values are all very much greater than the 0.05 P-value which indicates that all values obtained for all the physicochemical parameters investigated for, were not significant.

In other words, for all the physicochemical parameters considered, the null hypothesis cannot be rejected i.e. it could be statistically proven that the means of all the groups are equal and that they are from the same population distribution. More also, from the description above, it could be concluded that the differences in the means obtained from the parameters above could have been due to sampling error.

CONCLUSION

The study evaluated the physicochemical and bacteriological analysis of Fish Pond Wastewater's (FPWW) quality obtained from University of Ilorin Aquaculture center, after which *C.colocynthis* hydroponic treatment without any medium was then applied to assess its effect on the FPWW.

The physicochemical results observed before application of the hydroponic treatment plant were 25°C, 540µS/cm, 7.5, 270mg/l, 8.62mg/l, 22.65mg/l and 4.2mg/l for temperature, electrical conductivity, potential hydrogenation, total dissolve solid, 5-day biochemical oxygen demand, chemical oxygen demand, and the dissolve oxygen respectively. These results were a great risk to aquatic life except for the temperature and the pH based on the standards of both NESREA and WHO. More also, if such kind of wastewater is discharged into the environment it could lead to both ground water and surface water contaminations which will in turn affect the public health.

After the fifth week of experiment the analysis of variance of the sample's results showed that the electrical conductivity, total dissolve solid, 5-day biochemical oxygen demand and the chemical oxygen demand were insignificantly reduced from 539 to 209µS/cm, from 270 to 102mg/l, 8.62 to 4.8mg/l and from 22.65 to 12.01mg/l respectively. The treatment efficiencies were observed to be 61.29%, 62.22, 44.31% and 46.97% respectively for the electrical conductivity, total dissolve solid, 5-day biochemical oxygen demand and chemical oxygen demand. The dissolved oxygen was increased from 4.2 to 8.12 having percent increment of 93.33%, however, the control set-up have more percent increment (112.38%), indicating that *C.colocynthis* slightly interfered negatively with the normal extent at which oxygen dissolves in the FPWW. More also, the bacteriological analysis showed that FPWW has 215±35 colonies and $2.15 \pm 0.35 \times 10^7$ Cfu/ml before the application of *C.colocynthis* hydroponic treatment and 83±18 colonies and $8.3 \pm 0.18 \times 10^6$ Cfu/ml after hydroponic treatment.

Although, the statistical analysis of the results was not significant, the percentage efficiency of treatment shows substantial increment in the treatment level of the FPWW by the *C.colocynthis* as compared to the control set-up. More also, these results are within the standards of NESREA and WHO, which indicates that the *C.colocynthis* hydroponic treatment of FPWW can still be observed where situation favors the usage as the null hypothesis is not a hundred percent criteria for showing practical significance.

Finally, it could be established that *C.colocynthis* treatment system was gradual with treatment time. This indeed could be attributed to the gradual adaptation, growth and development of the plant. In other words, it could be deduced that the possibility of *C.colocynthis* treatment of the *C.colocynthis* treatment will increase as the plant grows.

Recommendations

1. This study is limited to the treatment effect of *C.colocynthis* on FPWW, further research should be conducted on the nutrient accumulations in the *C.colocynthis* plant and the edibility of the fruits from it.
2. Further studies should be conducted on effect of the FPWW on the *C.colocynthis* plant growth and development.

3. Studies could be carried out on the use of C.colocynthis treated FPWW in agriculture.

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