Kitchen Wastewater Treatment with Constructed Wetland Using Water Hyacinth

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Abstract

A laboratory scale constructed wetland, with dimension of 0.9m in length, 0.9m in width, and 0.3m in depth, was constructed at the department of civil engineering, lautech Ogbomoso. The experiment was carried out to investigate the enhanced removal efficiency for water hyacinth with constructed wetland in treating kitchen wastewater. Wastewater from Alata milk and honey was selected for the treatment plant. Influent and effluent were analyzed for pH, B.O.D, Turbidity, Nitrate, Sulphate, Magnesium, Chloride, Conductivity, D.O., Color, for continuous 10 days. From the result obtained, there was a maximum of 60.5% increase in pH, 77.5% reduction in D.O., 66.7% reduction in nitrate, 93.3% reduction in sulphate, 80% reduction in turbidity, 43.6% reduction in color, 34.6% reduction in chloride and 70% reduction in magnesium. This study emphasizes that water hyacinth plant could provide an alternative aquatic plant system for wastewater treatment.

Keywords: constructed wetland, aquatic plant, water hyacinth, kitchen wastewater, laboratory scale, removal efficiency

1. INTRODUCTION

Constructed wetlands known as an artificial wetland is one of the technology treatment system that have been used internationally and effectively to improve water quality and to treat various kinds of wastewater. The constructed wetlands act as a biological filter by removing contaminant or pollutants such as heavy metals, organic materials, and also nutrients from the wastewater which involved several physical, chemical and biological process in the transformation and consumption of organic matter within the wetland [1], [2].

Usually the constructed wetland system consists of three elements which are water or wastewater that needs to be treated; aquatic plants act as a filter or absorber, and also microorganism that can degrade all the contaminant or pollutant in the wastewater [8].

There are several advantages by applying the constructed wetlands system compared to the other conventional treatment. It is very economical and cost effectively, simple and easy to operate, and no complex technology is needed [3]. In designing the good wetland, the main biological component in the constructed wetland is the aquatic plants (macrophytes). However, it is important in determining the appropriate macrophytes species that can survive in the wastewater environment, because only suitable macrophytes can treat a high concentration of pollutant in the waste water [7].

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Recently, floating aquatic macrophytes systems are much better to use compared to the emergent macrophytes treatment system in term of nutrient uptake efficiency, especially macrophytes that has a large roots system.

Several study documented that floating macrophytes such as Pistia Stratiotes (water lettuce) and Eichhornia crassipes (water hyacinth) have the capability to remove a large amount of pollutant, capability to survive at any wastewater environment and also has the highest growth rate [4], [5].

Wastewater pollution has always been a major problem throughout the world. One of the main sources of the pollution is from municipal wastewater. Usually, municipal wastewater comes from residential area, restaurant, and cafeteria, industrial or agricultural effluent. This municipal waste consists of organic and inorganic waste includes food scraps, waste oils and detergent [1], [6]. This waste is sometime very toxic to the certain aquatic life.

Basically, municipal wastewater contains high level of Chemical Oxygen Demand (COD) and Total Suspended Solid (TSS). This high level of Chemical Oxygen Demand (COD) results low Dissolve Oxygen (DO) in water and this can lead to mortality of aquatic live. In addition, suspended solid such as organic and inorganic material can cause dirt and odor to the water. Usually, municipal wastewater will undergo pretreatment before it will be discharge into the river. The conventional sewage treatment involve physical, chemical and biological process which are very complex process, required highly cost and still contribute to pollution because it use chemical reagent to treat the wastewater. This conventional treatment system is not environmental friendly. At the same time, some premise such as restaurant or cafeteria are preferred to discharge all their waste directly into the drain or river without any pretreatment. That waste usually contains mixture of waste oil, waste powder, chemical reagent such as detergent and many more. As a result, this waste can cause water pollution and can affect our water quality after it enters the waterway. Besides that, this wastewater also can cause odor or bad smell to our environment.

In this research study, an alternative method is suggested by using the constructed wetland system for treating the municipal wastewater. This constructed wetland system also has a potential to be developed as one of the wastewater treatment technology. This is because the constructed wetland system provides various advantages which are cost effectively, where it is easy to operate and environmental friendly to other wildlife and ecosystem.

Constructed wetlands (CWs) are also described as engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and the associated microbial assemblages to assist in treating wastewaters [10]. They are designed to take advantage of many of the same processes that occur in natural wetlands, but do so within a more controlled environment. CWs for wastewater treatment may be classified according to the life form of the dominating macrophytes, into systems with free-floating, floating leaved, rooted emergent and submerged macrophytes. Further division could be made according to the wetland hydrology (free water surface and subsurface systems) and subsurface flow CWs could be classified according to the flow direction (horizontal and vertical) [9]

2. MATERIALS AND METHODS

The experiment was carried out at the civil engineering department of the faculty of engineering and technology, ladoke Akintola University of technology Ogbomosho, Nigeria. Wastewater samples were collected from kitchen at Alata milk and honey on the 14th of March 2014 in the evening. Specimen were filled by funnel into a 25 liters keg and corked immediately to prevent them from turning septic before the commencement of the experiment. Water hyacinth plants of the same age group were collected from the treatment plant of university of Ibadan where water hyacinth is being used to treat wastewater coming from Awo, Idia and Abu-Bakr halls.

2.1 Study Site

Laboratory scale surface vertical flow constructed wetland (CW) was used in this research; a plastic sided rectangular shape is constructed as wetland with a wooden stand to support and also to prevent the constructed wetland from sinking into the ground. The wastewater was poured directly in to the constructed wetland. The dimension of the constructed wetland is 900mm by 900mm by 300mm which was erected at Civil Engineering Department.

2.2 Lining of the basin

Lining of the basin was required to increase water tightness at various edges so as to prevent possible leakage at the edges. A thick white Polyethylene nylon was used.

2.3 Substrate filling

The layer of different size of substrate to be filled was properly marked inside the basin before filling the substrate in the vertical flow wetland. The substrates were washed to eliminate the unwanted particles such as dust and were sieved to obtain the desire aggregate size (granite 13.5mm and 8mm, sharp sand and humus less than 2mm). An outlet tap was fixed for at the base of the basin to collect the treated wastewater, and was covered with screen to prevent the passage of sand with the water.

The height of the basin is 300mm and the quantity of the substrate is listed below.

The first layer is the 13.5mm granite size which is arranged up to a height of 50mm

The second layer is the sharp sand which is also arranged to a height of 50mm

The last layer which is the humus soil is also arranged to a height of 50mm

The remaining 150mm is the free board

2.4 Vegetation Plantation

Live plant transplant was used in this project set up. The specimen was nurtured for two weeks in a plastic bowl before transplanted to the basin. The plant can be transplanted through the seedlings or directly transplanted by uprooting the whole plant.

2.5 Starting of the experiment

After the preparation of the bed for the constructed wetland, the actual performance of the bed was started. The raw wastewater from Alata milk and honey was collected and screened through fine mesh before putting the wastewater in to the influent container. The raw wastewater characteristics like PH, DO, COD, BOD, e.t.c were determined using the procedure mentioned in the standard methods.

2.6 Performance Operation

The performance of the wetland was accessed from time to time as samples were collected and analyzed at predetermined interval to determine the effect of detention time on the treatment efficiency of the set up. The treated

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water was collected for a continuous ten days from the effluent of the constructed wetland and analyzed.

3. RESULTS AND DISCUSSION

The raw wastewater collected from Alata milk and honey kitchen, near LAUTECH Ogbomoso Campus, and analysed in the Civil Engineering Department Water laboratory. The results of the Physico-chemical analyses carried out on the samples daily for a retention time of ten (10) days were presented as shown in Table 1, Table 2 showed Parameters with Percentage Reduction and Increase.

From the Table 1, it was observed that the water was moderate in strength and needs treatment before discharging in to the stream or for any other use or purpose.

As the retention time increases, there was generally a continuous decrease in values of all the parameters that is been checked for. The quality of the effluent from the water hyacinth culture after 10 days showed that it is suitable for non – drinking purposes like crop irrigations and fishing when compared with WHO stream standards WHO (2000a and 2004b). It was observed that increase in the detention time increase the percentage removal of the pollutant.

Figure 1: the constructed wetland setup

Figure 2: the constructed wetland with water hyacinth

Table 1: Results for the treated wastewater

parameters	Effluents										
	Raw water sample	day1	day2	day3	day4	day5	day6	day7	day8	day9	day10
Ph	4.28	6.49	6.15	6.87	6.86	6.19	6.45	6.53	6.98	6.81	7.05
D. O.	5.64	10.25	6.77	5.22	1.27	30.7	14.0	10.2	6.64	6.23	8.87
Nitrate	30	10	10	10	20	10	10	20	20	20	20
Sulphate	120	100	60	90	70	10	80	60	80	20	16
Turbidity	58.5	31.81	11.7	19.46	70	14.91	34.17	13.36	37	35.80	14.76
Temperature	27.6	27.4	28.2	26.9	30.2	28.1	28.8	29.7	26.2	28.3	28.3
D. O.	550	550	480	310	340	440	470	550	370	550	550
Chloride	520	350	340	450	350	340	390	450	380	450	450
Conductivity	11.4	21.8	16.6	23.6	13.5	23.1	13.9	26.3	25.8	24.4	25.5
Magnesium	243	243	243	165.24	170.1	72.9	109.35	85.05	135.65	243	72.9
B.O.D	_	10.75	19.36	30.83	40.14	48.03	56.99	61.65	67.38	73.84	79.57

Table 2: showed Parameters with Percentage Reduction and Increase

Parameters	EFFLUENT (Day)										Range (%)
	1	2	3	4	5	6	7	8	9	10	
Colour	0	12.7	43.6	38.2	20	17.02	0	32.7	0	0	12.7-43.6
Turbidity	45.6	80	39.04	0	74.5	41.6	77.2	36.8	38.8	74.	36.8-80
Ph	51.64	43.69	60.5	60.3	44.6	50.7	52.6	63.1	59.1	64.	44.6-64.7
Chloride	32.7	34.6	13.5	32.7	34.6	25	13.5	26.9	13.5	13.	13.5-34.6
Sulphate	16.6	50	25	41.7	91.7	33.3	50	93.3	83.3	86.	16.6-91.7
Magnesium	0	0	32	30	70	55	65.8	44.2	0	70	32-70
Nitrate	66.7	66.7	66.7	33.3	66.7	66.7	33.3	33.3	33.3	33.	33.3-66.7
D.O	45	16.7	0	0	81.6	59.7	44.7	15.1	9.5	36.	9.5-81.6
BOD	10.75	19.35	30.82	40.14	48.03	56.99	61.65	67.38	73.84	79.5	10.75-79.57

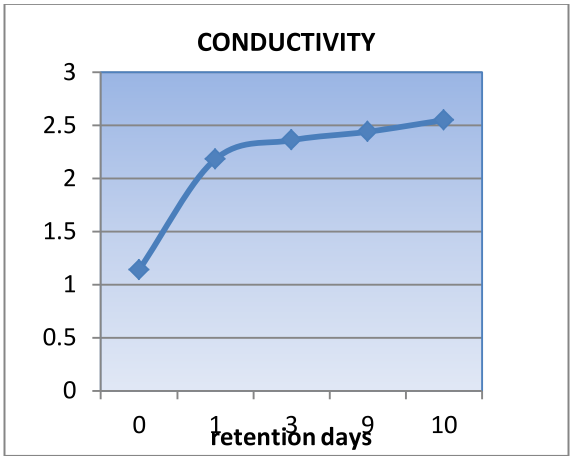

Figure 3: Graph of conductivity against retention

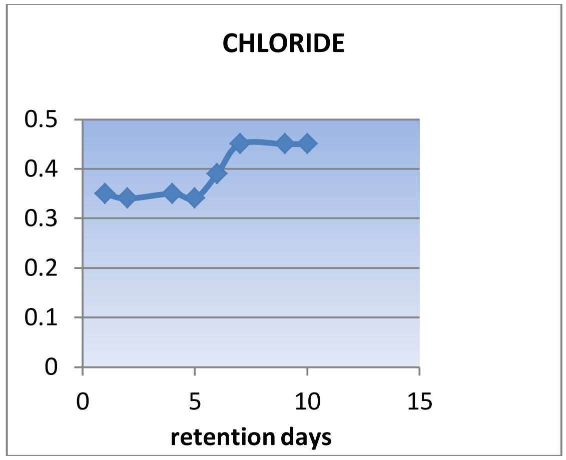

Figure 4: Graph of Chloride against retention

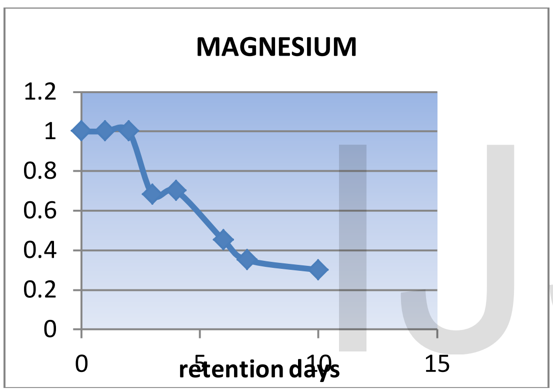

Figure 5: Graph of Magnesium against retention

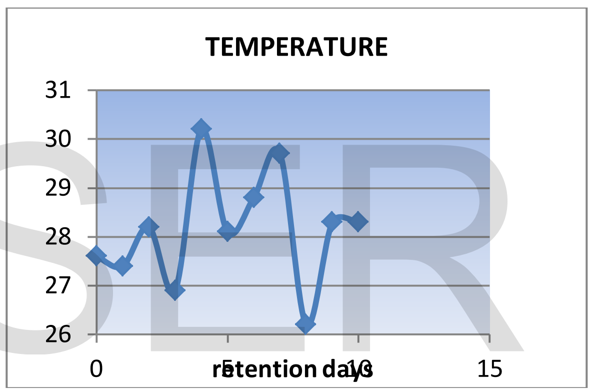

Figure 6: Graph of Temperature against retention

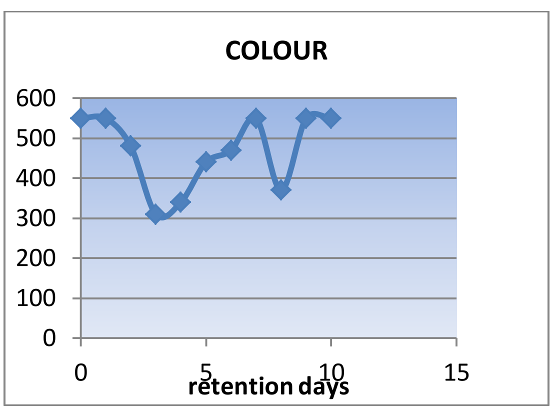

Figure 7: Graph of Color against retention

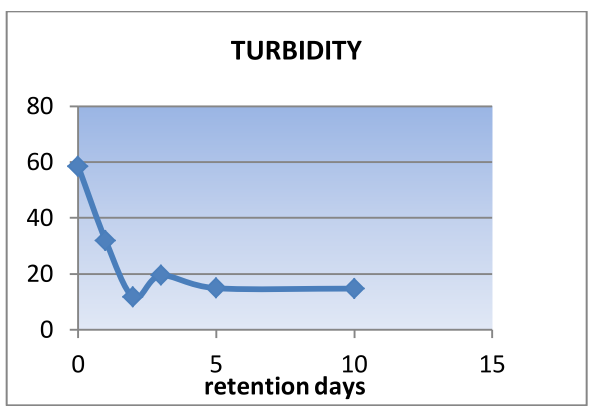

Figure 8: Graph of Turbidity against retention

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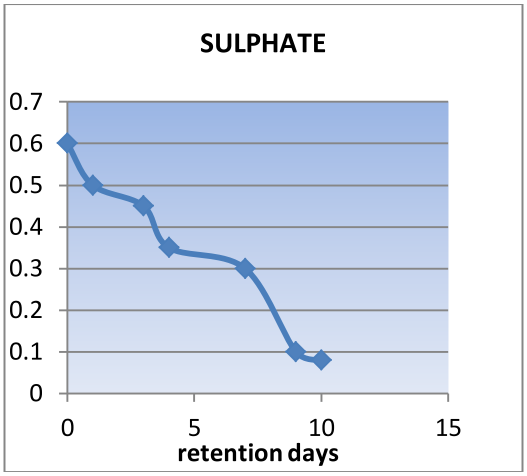

Figure 9: Graph of Sulphate against retention

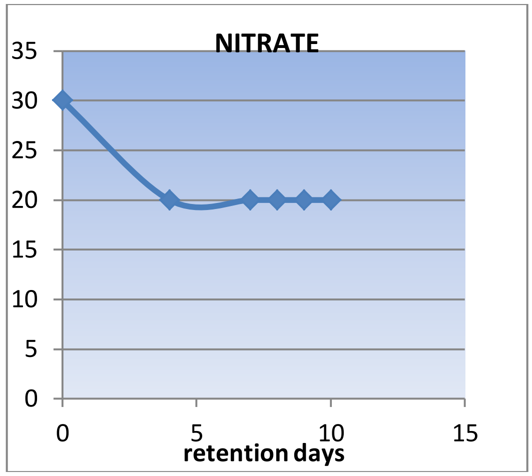

Figure 10: Graph of Nitrate against retention

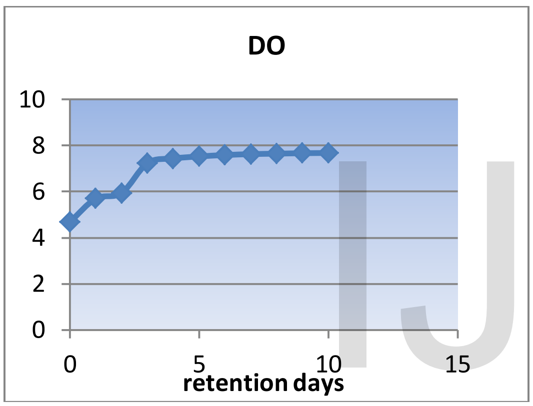

Figure 11: Graph of DO against retention

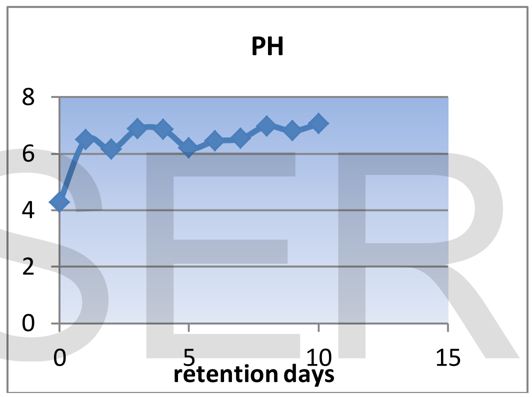

Figure 12: Graph of pH against retention

4. CONCLUSION

The percentage removal for increasing the detention time was not linear but for the detention time of five days it was found that the overall percentage removal of all the pollutants was best. It is also clear that water hyacinth is suitable and efficient for the treatment of kitchen wastewater. There is a remarkable improvement on pH control and removal efficiency in BOD, Turbidity and Sulphate and Nitrate. The treated water was fit enough to be let out directly into a receiving water body as the concentration are below allowable limits. Thus constructed wetland treatment can be used independently or in combination to conventional treatment so as to make the final output of better quality suitable enough for discharge into a natural water body.

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