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BIOTREATMENT OF WASTEWATER STABILIZATION POND USING WATER HYACINTH FOR AGRICULTURAL APPLICATIONS

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Abstract

Biofiltration of wastewater bodies has recently gained popularity in many countries, not only for domestic and municipal applications but also for agricultural purposes. Water quality is a critical factor of consideration for optimum growth, nutrient utilization, and survival of aquatic animals and plants. High concentrations of heavy elements in a pathogenic-laden water environment have led to many deaths and stunted growth of animals and plants. Using water hyacinth - a biofilter is one way of removing pollutants from a water body. This is one method by which rivers and streams are naturally purified of pollutants and contaminants. The technology of water hyacinth biofiltration of wastewater bodies was applied to treat the wastewater of the University of Nigeria Nsukka (UNN) waste stabilization pond (WSP) in the southeastern state of Nigeria. The study investigated the physicochemical properties of the UNN wastewater stabilization pond effluent using water hyacinth as a biofilter. The aim was to determine the effect of water hyacinth on the treatment of wastewater of the UNN waste stabilization pond and whether the filtrate can support farming activities around the WSP environs. The physicochemical properties of the wastewater investigated were the ammonia (NH_3), Nitrate (NO_3), Chlorine (CL), pH, and Copper (CU) concentration levels respectively. Wastewater from the pond was collected and subjected to laboratory analysis before and after the biofiltration processes. The results of the experimental investigation showed that the ammonia (NH_3), nitrate (NO_3), chlorine (CL), PH, and copper (Cu) concentrations were reduced from 1.2 mg/l - 0.80 mg/l; 2.5 mg/l - 2.1 mg/l; 99mg/l - 90mg/l; 6.8 - 6.7 and 0.011 mg/l - 0.00 mg/l respectively under 45 days of biofiltration process using water hyacinth in three replicates. Observation showed that the filtrates (treated water) could be useful in many applications like fish farming, and dry season irrigation of crops and plants around the wastewater stabilization pond environs. Useful applications of the WSP would enhance and boost economic activities within the University of Nigeria, Nsukka campus community. The use of water hyacinth biofiltration is a sine qua non recommendation for freshwater recovery from wastewater bodies, especially in areas where water is scarce for agricultural practices.

Keywords: *Biotreatment, wastewater, UNN, water, hyacinth, Fish, farming*

Introduction

Biofiltration is a natural method by which rivers, streams, and seas are naturally purified of pollutants and contaminants. Biotreatment technology has proven a good conversion of otherwise harmful substances into less harmless products of economic value. The use of natural methods in municipal sewage treatment has shown to be a cost-effective and eco-friendly method for removing contaminants from polluted water bodies compared to physical or chemical approaches. Water hyacinth (*Eichhornia*) is a free-growing floating aquatic plant that drives its nutrients for growth from wastewater bodies. Water hyacinth has been a natural way by which rivers and streams are naturally purified due to its ability to absorb nutrients from contaminated water bodies. The technology of the water hyacinth purification method has gained significant attention as an aquatic plant that can absorb pollutants from aquatic environments with rapid proliferation (Shahabaldin et al 2015). As attempts to control the rapid

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growth have not been completely successful, the best management strategy is finding some plant usage (Patel, 2012). Applications of water hyacinth include formulation of animal fodder/fish feed (Aboud et al, 2005), biosorbent for the removal of toxic metals (Malik, 2007), production of biogas and bioethanol (Mshandete et al, 2004), compost making (Szczeck, 1999), paper manufacturing (Groote et al, 2003) and also as phytoremediation agent (Sajn-Slak et al 2005). Water hyacinth has been found useful in the medicine formulations and treatment of diseases. Einarsdotirr and Nilssen (1996) reported on the effect of water quality on the survival, growth, and behavior of different fish species while the impact of water quality and level fluctuations on the species communities has been widely studied in rivers, lakes, and reservoirs (Ogwan and Molo, 2004, Thomson et al, 2002). An increase in industrialization, and urbanization coupled with population explosion has led to an increased quantity of wastewater discharge. Management of industrial and municipal effluents has become a major problem for towns and cities. A better management could be treating the effluent for other useful applications for agricultural practices. Waste recycling and treatment are often costly and not environmentally friendly due to the health implications and method of the conversion process. Despite several studies (Echiegu et al. and Agunwamba et al., 2015), there is a paucity of information on wastewater treatment of the UNN WSP using water hyacinth.

According to Echiegu et al, (2016), the University of Nigeria, Nsukka (UNN), sewage treatment facility provides a good source of marginal water, which is employed by some members of the university community for the production of vegetables. Although this practice has been on for over 30 years, not much is known about the suitability of this marginal water for irrigation purposes. Phytoremediation using water hyacinth could be an alternative measure of treating the effluent. The characterization of the water quality would be useful and further determine the proper usage. Agunwamba et al., (2015) used solar-enhanced radiation in the effluent treatment of the wastewater, but in this study, water hyacinth was used for the treatment of the UNN wastewater stabilization pond.

The treatment of the wastewater stabilization pond at the University of Nigeria, Nsukka, using water hyacinth, is an opportunity aimed at boosting the socio-economic activities within the university community through agricultural practices in a benign environment. With high-quality water, dry season agriculture, and fish farming could be boasted around the wastewater treatment plant.

Materials and Methods

Description of the experimental site

This experiment was conducted at the Department of Agricultural and Bioresources Engineering, University of Nigeria, Nsukka, Nigeria. The University of Nigeria, Nsukka (UNN) has a waste stabilization pond (WSP) that collects all wastewater from the staff residential quarters, student hostels, laboratories, and workshops in the university community. The pond is an open-air one for wastewater collection from the nooks and crannies of the university. All wastewater is discharged into the pond. There was no plan either to improve or enhance the collection process or the treatment of the wastewater for other purposeful applications such as irrigation and fish farming applications. Many farmlands surround the UNN WSP. The treatment of the wastewater of the WSP could support many agricultural activities around the pond if and when properly managed. Fig. 1 shows the UNN wastewater stabilization pond (A) and a prototype of a wastewater stabilization pond (WSP) developed for this experimental study. The structure is made of solid blockwork with three compartments, each measuring 61 x 61 x 5 cm designed in the similitude of a shallow retention pond. A retention basin similar to a pond of the same dimension was provided for a control experiment placed side by side. The size of the structure was chosen to avoid temperature stratification, easy management, reduce water usage, and minimize harvesting efforts. This was to achieve the main objective of the study – the biotreatment of wastewater from the UNN wastewater stabilization pond using water hyacinth as a biofilter. The first compartment of the structure is a typical wastewater stabilization pond. The second apartment is the wastewater treatment section where biofiltration takes place probably with water hyacinth, while the third section serves as the point where the treated water gathers for further usage Fig. 1 (B).

Fig.1: (a) UNN wastewater stabilization pond and (B) Constructed water hyacinth wastewater treatment pond

Experimental Procedure

A water sample wastewater from the UNN wastewater stabilization pond was collected and aerated using an electronic spectrophotometer machine (model GF 9900). This was introduced and filled into the First compartment of the WSP (B) and allowed to flow into the second compartment of the pond through a channel. Water hyacinth (biofilter) collected from the bank of River Niger; Nigeria was introduced on the wastewater treatment pond compartment 2 for filtration of the contaminated/polluted wastewater. The Water hyacinth feeds and extracts/absorbs nutrients from the wastewater acting as a purifier. Laboratory analyses of the wastewater samples were conducted before and after the introduction of the biofilter (water hyacinth) and experimentally analyzed at the National Soil Testing Laboratory, Federal Ministry of Agriculture and Rural Development, Kilometer 2, Abuja Road Gonigora Kaduna for water quality assurance. The following elements/parameters Temperature, Dissolve oxygen, pH, Chloride (Cl), Ammonia (NH_3), Nitrate (NO_3), Nitrite (NO_2), Sulphates (SO_4), Iron (Fe), Lead (Pb), Chromium (Cr), Cadmium (Cd), Mercury

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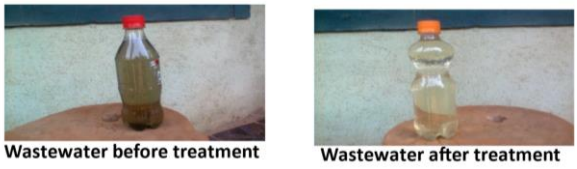
(Hg), Zinc (Zn), Copper (Cu)) was conducted before and after treatment for quality assurance at intervals to ascertain the rate of growth of water hyacinth.

Fig 2 shows the wastewater samples before and after the treatment with water hyacinth while Table 1 shows the results of the wastewater before and after the treatment and analyses were conducted.



Wastewater before treatment Wastewater after treatment

Fig.2: Wastewater before and after treatment with water hyacinth

Table 1: Laboratory test results of the University of Nigeria Nsukka stabilization pond wastewater before and after the introduction of water hyacinth (Treatment) on the water

Wastewater before treatment with water hyacinth	Wastewater after treatment with water hyacinth
Temperature 28.2^{o}C	27^{o}C
Dissolve oxygen 1.2 mg/l	1.2 mg/l
Acid level (pH) 6.8 mg/l	6.7
Chloride (Cl) 99 mg/l	90 mg/l
Ammonia (NH_3) 1.2 mg/l	0.80 mg/l
Nitrate (NO_3) 2.5 mg/l	2.1 mg/l
Nitrite (NO_2) 0.5 mg/l	0.5 mg/l
Sulphates (SO_4) 118 mg/l	110 mg/l
Iron (Fe) 0.110 mg/l	0.110 mg/l
Lead (Pb) 0.00 mg/l	0.00 mg/l
Chromium (Cr) 0.00 mg/l	0.00 mg/l
Cadmium (Cd) 0.00 mg/l	0.00 mg/l
Mercury (Hg) 0.00 mg/l	0.00 mg/l
Zinc (Zn) 0.010 mg/l	0.001mg/l
Copper (Cu) 0.110 mg/l	0.00 mg/l

Results and Discussion

Observation (Fig 2) shows that the wastewater (treated) left after 45 days of growth of the water hyacinth on the wastewater looks purified and purer than the original indicating nutrient extraction from the wastewater by the water hyacinth. This was further confirmed by the laboratory analyses (Table 1). The concentrations of the elements and compounds Chloride (CL), Ammonia (NH_3), Nitrate (NO_3), and Sulphate (SO_4), and Sulphate (SO_4), Zinc (Zn), and Copper (Cu) were reduced after the introduction and growth of the water hyacinth in the wastewater from 99 – 90 mg/l, 1.2 – 0.80 mg/l, 1.5 – 2.1 mg/l, 118 – 110 mg/l, 0.010 – 0.001 mg/l, and 0.110 – 0.00 mg/l respectively. The decrease in concentrations shows that the water hyacinth must have used the compounds and elements in the process of growing. This further strengthened the capability of water hyacinth as a biofilter for wastewater treatment in a typical waste stabilization pond. The roots of water hyacinth contain some micro-organisms acting like living substrates that help break down the wastewater nutrients the plant absorbs to grow.

The process of reduction of nitrogen in the wastewater can further be explained by the ammonification and nitrification process. This process of the nitrogen cycle involves the formation of ammonium compounds from dead and decaying plants and animals. By nitrification, ammonium compounds are converted into nitrite by nitrifying bacteria called Nitrosomonas. The nitrite (NO_2) is then converted by oxidation to nitrate (NO_3) by Nitrobacter. The plant (water hyacinth) can only absorb nitrates from the wastewater through its root noodles for growth, thereby reducing the nitrates concentration in the wastewater by detoxification, which can be of useful applications. The treated water could be used to support aquatic life - fish farming and crop growth. Alkalinity and pH are two important factors in determining the suitability of water for irrigation plants. pH between 5.0 and 7.0 are recommended for crop irrigation while pH 6.5 to 8.5 are suitable for fish farming according to the standard water quality index. The wastewater at the stabilization pond has a pH range of 6.8 – 6.7 after being treated. This makes it suitable both for fish farming and crop production.

Conclusion

Water hyacinth as a biofilter was used to treat wastewater from the waste stabilization pond located at the University of Nigeria, southeastern Nigeria. The was conducted using a prototype treatment plant developed for the purpose. The wastewater was analyzed before and after the treatment with water hyacinth for 45 days in three replicates. The result of the experimental studies showed that the concentrations of the elements and compounds Chloride (CL), Ammonia (NH_3), Nitrate (NO_3), and Sulphate (SO_4), and Sulphate (SO_4), Zinc (Zn), and Copper (Cu) were reduced after the introduction and growth of the water hyacinth in the wastewater from 99 – 90 mg/l, 1.2 – 0.80 mg/l, 1.5 – 2.1 mg/l, 118 – 110 mg/l, 0.010 – 0.001 mg/l, and 0.110 – 0.00 mg/l respectively. The indication

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is that water hyacinth could be a useful tool for the treatment of wastewater of typical WSP and sewage facilities in towns and industries. Treated wastewater of WSP could find more useful applications in fish farming and irrigation of crops and plants.

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