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Phytoremediation of Cassava Wastewater by Water Hyacinth

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ABSTRACT

Background and Objective: Wastewater produced from the cassava processing industry contains a high level of a toxic chemical called cyanide, which when discharged without proper treatment creates serious environmental risks. The study aimed to investigate the possibility of water hyacinth as sustainable means of reducing the level of toxicity in cassava wastewater. **Materials and Methods:** Cassava wastewater was collected from fermented cassava tubers. Water hyacinth was grown on the fermented wastewater and decanted for 7, 14, 21 and 28 days. The treated samples were collected and analyzed for Cyanide (CN), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Electrical Conductivity (EC), Total Soluble Solids (TSS) and pH using standard methods. **Results:** The water hyacinth used as phytoremediators had positive effects on the wastewaters by increasing the pH and dissolved oxygen to an acceptable standard and decreasing the electrical conductivity, total dissolved solids, total suspended solids, cyanide, biological oxygen demand and chemical oxygen demand when compared to their initial concentrations, though, the values recorded for all the tested parameters were far higher than that recommended for water but not up the recommended standards after 28 days. **Conclusion:** The wastewater from cassava is more polluted. Water hyacinth as a phytoremediator performed importantly physicochemical parameters of the cassava wastewater.

KEYWORDS

Wastewater, bioremediation, cyanide, phytoremediation, aquatic plants, dissolved oxygen

INTRODUCTION

The unprecedented upsurge in industrialization, urbanization, and population has contributed immensely to huge pollutants in the water resources. Phytoremediation is a plant-based approach, to the reduction of harmful contaminants such as oil, domestic and industrial wastewater, insecticides, metals, and pesticides in the environments to safer concentration[1-5]. Although, their performance in cleaning up is dependent on the pollution levels. The convectional remediation techniques involve biological, chemical, and physical treatment. Traditionally, remediation techniques used comprise containment, pump-and-treat, extraction, stabilization/solidification, soil washing, air stripping, precipitation, vitrification, thermal desorption and biological remediation[6-8]. The massive quantities of harmful water and organic Large

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quantities of effluents from industrial growth and current agricultural technologies discharged to various water bodies and groundwater portend grave danger to health and ecological risk. This challenge needed urgent attention by treating effluents before discharge. Many researchers found that lack of funds, frail implementation of environmental policies and dearth of technical know-how have been major contention[5,6,8].

Water hyacinth is an aquatic and productive weed that creates serious challenges to humanity and the environment. Water hyacinth grows extremely rapidly and its production is approximately double in 5-15 days. The harvest frequency for aquatic plants tends to be in the order of days. In contrast, the frequency for trees and crops is years and months, given the enormity of the menace related to the growth and spread of the plant and the difficulty in arriving at a generally acceptable control method. Some of the problems faced on water infested with water hyacinths include environmental nuisance, choking other aquatic lives, harbouring mosquitoes breeding, obstructing navigation and fishing activities, threat to Eco diversity and economic depression in areas invaded by the plant.

Srivastava *et al*.[9] and Dhote and Dixit[10] have reported that a phytoremediation is a viable option for the remediation of petroleum hydrocarbon polluted sites. It was found that the use of phytoremediation as a clean-up option accrues benefits such as being very cheap compared to other techniques, environmentally friendly, degrading pollutants and enhancing habitat recovery through the stimulation of vigorous vegetative plant growth.

It was reported that aquatic plants have the potential to hyper accumulate heavy metal removal and this enables them to be used for the treatment of industrial effluents and sewage wastewater[11-17]. Presently, cassava production has doubled in the past three decades and is expected to increase geometrically in the nearest future. Cassava is one of the most important staple food crops in tropical parts of the world and also plays a significant role in maintaining food security this can be ascribed to its ease of cultivation and tolerance of poor soils, low rainfall and high temperatures[18-23]. Production of this crop plays a role in maintaining food security in most of the developing world, including Africa, the Asian Pacific and South America[22,23].

Cassava may be made into various traditional Nigerian delicacies, including gari, fufu, lafun flour and other fermented goods[24]. In Nigeria, gari is the most popular of all cassava-based goods. Garri is produced on three scales: Small, medium and huge[19]. Cassava (Manihot esculenta Crantz) processing into gari involves several unit operations, involving peeling, washing, grating, pressing, frying and packaging.

The waste products of traditional gari production include considerable amounts of water, hydrocyanic acid, organic materials in peels and sieves from the pulp. The ecology and biodiversities are severely harmed by the continuous discharge of these contaminants[20-23]. When these waste materials are incorrectly disposed of, disagreeable odours and unattractive situations result[19, 20]. The most common component of cassava processing industry effluent is cyanide, which is channelled into pits. It collects and sinks gradually into the surrounding soils, causing substantial health and environmental risks[20-25]. This study aims to assess the use of water hyacinth to bioremediate cyanide in cassava wastewater generated by the local cassava processing industries. Also, the potential of water hyacinth to clean wastewater to a standard that will meet the environmental water quality figures mandated by the World Health Organization before being discharged the wastewater to the environment.

MATERIALS AND METHODS

Preparation of fermented cassava wastewater: Fresh cassava tubers were harvested from a farm at Amarata-Epie farm in Yenagoa, Bayelsa State, Nigeria. The experiment was carried out in the Environmental Engineering Laboratory of the Niger Delta University in April to October, 2019.

Fresh cassava tubers were harvested from the crop science department, Niger Delta University. The cassava tubers were washed and then peeled with a sharp knife and washed properly to be sparkling white. It was then soaked with 120 L portable or clean water and left for four days to ferment. The fermented cassava was then removed from the bow where the cassava was soaked. The water left is the fermented cassava wastewater.

Water hyacinth: Water hyacinths were harvested from the Amassoma river, plastic bows were filled with cassava wastewater to a capacity of 6 L and then water hyacinths of 50, 75 and 100 g were planted in the various wastewater for 7, 14, 21 and 28 days.

Parameters: The parameters to be determined in these studies are pH, Electrical Conductivity (COND), Total Dissolved Solids (TDS), Total Suspended Solid (TSS), Cyanide (CN^-), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD).

Determination of pH: The pH of the wastewater samples was determined with the help of a pH meter. The meter was calibrated (standardized with two buffer solutions, pH 4 and 9) before being used. After that, the electrode was rinsed completely in distilled water before being dipped in the water sample. The pH of the water sample is recorded as a continuous pH readout.

Determination of electrical conductivity (us cm^{-1}): The electrical conductivity of the water sample was measured with the conductivity meter, which also has the salinity meter attached. The meter probe is dipped into the water sample, the control switch is turned to the conductivity mode and a steady readout is recorded as the electrical conductivity of the water sample.

Determination of total dissolved solids (mg L^{-1}): An evaporating dish was washed, oven-dried and weighed to obtain a constant weight. The 100 mL of water sample was transferred to an evaporating container and evaporated to dryness in a six-hole water bath. The dish and its contents were dried to a consistent weight in an oven at 105°C. The obtained residue weight is a proportion of the volume of sample used. The dissolved solids are measured in parts per million (ppm) or milligrams per litre (mg L^{-1}).

Dissolved oxygen (DO): The dissolved oxygen meter (the DO meter) is commonly called to determine dissolved oxygen in water bodies. In the determination of pH, The DO meter probe was standardized, zeroed and then dipped into the water body. A continuous readout or displayed DO record as the dissolved oxygen in the sample.

RESULTS AND DISCUSSION

The increasing order of daily mean pH is Day 1<7<21<28 for cassava wastewater treated with water hyacinth in Table 1. Mean pH across the 28 days ranged between 3.01±0.00 (Day 1) to 6.44±0.13 (Day 28). The above results of the phytoremediation indicated that treatment on Day 28 met the recommended values of pH (6.0-9.0) specified by the Environmental Protection Agency for effluent discharge. The pH was increased close to neutral at the end of 28 days of cultivation. It can be interpreted that the rise in pH might be due to the absorption of pollutants by the plant[25] Water hyacinth increased the pH value of the cassava wastewater with the treatment residence time. Haryanto *et al.*[25] opined that water hyacinth as a phytoremediator in cassava wastewater treatment increased pH value from 7.0-7.2 after 53 days of retention time.

The rise in pH enhanced microbial action to degrade BOD and COD in the wastewater[5,21]. A similar observation was reported on the progressive increase in pH value at various residence times after water hyacinth was introduced into the cassava wastewater treatment. It was found that cassava waste without water hyacinth treatment recorded a pH value of 6.86 on day 0 to 7.84 on day 28[29]. This observation could be attributed to the decomposition of organic matter in the wastewater by microorganisms and also a photosynthetic activity that takes CO_2 dissolved in form[5] H_2CO_3. Water hyacinth as phytoremediation has the potential to reduce the value of BOD and COD in cassava wastewater[5,20,25]. Daily mean values for Electrical Conductivity recorded the highest value (7453.00±0.00 μS cm^{-1}) on Day 1 and the lowest value (6624.33±34.15 μS cm^{-1}) on Day 28 with decreasing order of Day 1>7>14>21>28 (Table 1).

Mean values of total dissolved solids decreased across the days (from Day 1 to 28, respectively) with a recorded maximum value of 6578.00±0.00 mg L^{-1} (Day 1) and a minimum of 4677.33±237.48 mg L^{-1} (Day 28) for the treated cassava wastewater (Table 1). Daily mean values for total suspended solids ranged between 2309.33±90.57 mg L^{-1} (Day 28) and 3321.00±0.00 (Day 1) as a recorded decrease across the days was observed as Day 0>7>14>21>28 for the cassava wastewater (Table 1).

Mean values of cyanide decreased as the residence time progressed. The average CN content in the treatment decreased with residence time[29]. The reduction could also be related to the activities of some species of bacteria, algae, fungi and some aquatic plants that oxidize cyanide[29]. Cyanide is toxic and harmful to the health of anyone exposed to it over short and long periods[5,25,27]. The majority of the conventional curative technologies for the removal of heavy metals are very exorbitant, not environmentally friendly and detrimental to health[5,25,27].

Dissolved oxygen recorded a range of mean values between 4.87±0.00 mg L^{-1} (Day 1) to 5.75±0.24 mg L^{-1} (Day 28) with decreasing order of daily mean values as Day 1>7>14>21>28 for the cassava wastewater (Table 1). Biological oxygen demand decreased across the 28 days progressively with its highest mean value (2253±8.27 mg L^{-1}) on Day 1 and its lowest mean value (1446±7.88 mg L^{-1}) on Day 28 for the treated cassava wastewater (Table 1). The introduction of water hyacinth into chromite mines wastewater reduced the level of BOD concentration by 50% BOD[5]. Mahmood *et al.*[28] observed BOD dropped between 40-70% in textile wastewater after the introduction of water hyacinth at a residence time of 96 hrs. Chemical oxygen demand ranged between 1470.00±7.64 mg L^{-1} (Day 28) and 2310.00±9.87 mg L^{-1} (Day 1) with a progressing order of decreasing mean values as Day 1>7>14>28>21 for the treated cassava wastewater (Table 1). If this poison substance cyanide is not properly treated before being discharged into water bodies, it prevents the body's cells from using oxygen. When this happens, the cells die. Cyanide is more harmful to the heart and brain than other organs[25,26]. Water hyacinth has been found to have the ability to reduce TDS, BOD, COD, TSS and electrical conductivity and improve DO and pH in the wastewater[5].

The water hyacinth used to phytoremediation these cassava wastewaters had positive effects on this wastewater by increasing the pH and dissolved oxygen and decreasing the electric conductivity, total dissolved solids, total suspended solids, cyanide, biological oxygen demand and chemical oxygen demand.

Table 1: Daily mean variations in physicochemical parameters of cassava waste water treated with water hyacinth

	Days				
Parameters	1	7	14	21	28
pH	3.01±0.00	3.20±0.21	4.51±0.31	5.47±0.45	6.44±0.13
Ec (μS cm^{-1})	7453.00±0.00	7387.33±111.79	7223.00±142.62	6824.66±71.23	6624.33±34.15
TDS (mg L^{-1})	6578.00±0.00	6413.33±161.28	6081.33±87.84	5247.66±359.98	4677.33±237.48
TSS (mg L^{-1})	3321.00±0.00	3214.66±72.41	3041.00±43.86	2624.00±179.80	2309.33±90.57
CN- (ppm)	23.32±0.00	20.98±0.50	20.03±0.14	18.31±0.98	15.22±0.89
DO (mg L^{-1})	4.87±0.00	4.45±0.05	4.68±0.23	5.27±0.18	5.75±0.24
BOD (mg L^{-1})	2253.00±8.27	1981.00±0.46	1908.00±7.41	1577.00±9.62	1446.00±7.88
COD (mg L^{-1})	2310.00±9.87	1950.00±5.00	1783.03±6.65	1616.00±5.03	1470.00±7.64

Data are Mean±SD, Ec: Electrical conductivity, TDS: Total dissolved solids, TSS: Total suspended solids, CN-: Cyanide, DO: Dissolved oxygen, BOD: Biological oxygen demand and COD: Chemical oxygen demand

CONCLUSION

The water hyacinth was found to be effective and efficient in reducing the concentrations of TSS, TDS, BOD, COD, EC, CN^- and DO of cassava wastewater within 28 days of treatment. The experimental results revealed that water hyacinths remediate cassava wastewater to a greater extent during 28 days of the experimental period. This aquatic plant was also effective in increasing the DO and pH of cassava wastewater.

SIGNIFICANCE STATEMENT

There are four conventional methods of treating wastewater which include: Physical water treatment, biological water treatment, chemical treatment and sludge treatment. This study discovered the potentiality of water lettuce as a bio-remediator in removing some organic and inorganic pollutants in cassava wastewater.

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