An Experimental Study of Phytoremediation of Greywater Using Water Hyacinth (*Eichhornia crassipes*)

KIRIDI, E. A

Department of Agricultural and Environmental Engineering, Niger Delta University, Wilberforce Island, Bayelsa State

Abstract-* This study investigates the potential of water hyacinth (Eichhornia crassipes) in the phytoremediation of greywater. Greywater samples were treated using water hyacinth in a controlled environment over a 5-day period. The physicochemical parameters considered were pH, electrical conductivity (EC), total dissolved solids TDS, and salinity. Three replicates of ten (10) liters of greywater in a plastic trough, each containing roughly 150 g of water hyacinth, were observed every day for five days. The electrical conductivity (EC), pH, total dissolved solids (TDS), and salinity treatment parameters were measured in the experiment. The treatment means were then computed. The results indicated that after three days of the study, the majority of the water parameters had decreased to their maximum. A 57% decrease in both EC and TDS and a 15% decrease in salinity were recorded. Also, a phytoremediation rates of +0.15 g/day for EC, +0.097g/day for TDS and +5.5 x 10 $^{-5}$ g/day for salinity were observed. After three days, the water hyacinth began to exhibit symptoms of nutritional deficiency and later, re-introduction of absorbed pollutant. At 95 percent confidence level for EC and TDS, an Anova indicates that there was no significant difference between the control and water hyacinth treatment means. This implies that water hyacinth should be removed and another one re-introduction of new plants for phytoremediation of greywater is to be achieved.

***Keywords:* Phytoremediation, Greywater, Water Hyacinth, Wastewater Treatment.**

I. INTRODUCTION

Water is important due to its many roles in life. It is required for various purposes, such as for daily consumption, agricultural, industries, and fisheries. Nowadays it is becoming accessible due to increasing water pollution as a consequence of accelerated industrial and urban growth. Hence, an appropriate system is required to save and prevent water degradation. Most countries are concerned about river water quality hence the awareness to investigate outflows from all pollution sources has been increased [1]. Stream-water quality is degraded due to pollutants from point and nonpoint sources. Recent concerns over long-term river water quality objectives have led to a growing awareness to investigate discharges from all pollution sources. Grey-water is one of the important point pollution sources, which come from residential and commercial areas into the rivers without prior treatment. Grey-water is considered to be the major volume of domestic wastewater [2]. Therefore, it is important to control the discharge of grey-water into the river.

The world is becoming increasingly concerned about environmental pollution and water scarcity, which calls for the creation of sustainable and alternative wastewater management techniques. Between 50 to 80 percent of wastewater in homes is grey water, which comes from sources like sinks, showers, and washing machines [3]. Even while grey water is less polluted than black water, it can still be harmful to the environment if it is released improperly. In rural and low-income areas, traditional treatment systems can be expensive and energy-intensive. Phytoremediation provides a green solution, as it utilizes the natural capabilities of plants to purify water. Of these plants, water hyacinth (*Eichhornia crassipes*), is one of the known plants considered due to its rapid growth rate, and proven potency in nutrients uptake.

Removal of heavy metals achieved through various techniques such as reverse osmosis [4]. ion exchange [5]. chemical precipitation [6]. adsorption and solvent extraction [7] include enormous operational and maintenance costs and are usually not environmentally friendly [6], [7], [8]. These conventional techniques for the remediation of heavy metals are generally costly and time-consuming. These treatment technologies require high capital investment and, in the end, generate the problem of sludge disposal [9]. For the remediation of

wastewater polluted with heavy metals contaminants, an environmentally friendly and economical treatment technology is needed [10], [11].
Wastewater carrying soaring concentrations of pollutants is immensely noxious for aquatic ecosystem and human health [12], [13], [14]. Reclamation of wastewater has been the only option left to meet the increasing demand of water in growing industrial and agricultural sectors [15].

Industrial and domestic untreated wastewater contains pesticides, oils, dyes, phenol, cyanides, toxic organics, phosphorous, suspended solids, and heavy metals (HMs) [16]. Heavy metals among these toxic substances can easily be accumulated in the surrounding environment [17]. Commercial activities such as metal processing, mining, geothermal energy plants, automotive, paper, pesticide manufacturing, tanning, dying and plating are held responsible for global contamination of heavy metals [18], [19]. Removal of heavy metals from the wastewater is diffcult because they exist in different chemical forms. Most metals are not biodegradable, and they can easily pass through different trophic levels to persistently accumulate in the biota [20].

Removal of toxic pollutants is extremely important to minimize the threat to human health and the surrounding environment
The treatment of greywater before it is discharge into the stream will minimized the oxygen demand from the stream; this is important for the well-being of aquatic fauna, and flora.
It may also have the positive impact on humans because it will lead to the reduction of toxic substance accumulation in the soil which could have affected the health of the crops and humans indirectly.
The objective of this research is to ascertain the potentials water hyacinth in pollutant load reduction in greywater in experimental conditions.

II. MATERIALS AND METHODS

2.1 Experimental site

The experimental site was the Department of Agricultural and Environmental Engineering laboratory of Niger Delta University, on Wilberforce Island in Bayelsa State, Nigeria. Located in a vegetative mangrove swamp, the university has a tropical environment with two distinct seasons: the wet season, which lasts from March to October, and the dry season, which lasts from November to April.

2.2 Experimental Setup and procedure

The experiment was carried out as described by [21]. The grey water was collected from a domestic kitchen and bathroom in Niger Delta University, Amassoma student hostel and cafeteria. A homogenous grey water was then prepared and samples were collected and analyzed immediately to determine baseline values which are presented in Table 1. Healthy specimens of water hyacinth were collected from the banks of River Nun and their roots were washed to remove debris and acclimatized in clean water for 48 hours. Then, three replicates of the plastic trough with ten liters of grey water and a control were filled with about 150 g of the water hyacinth plant. The phytoremediation of the water hyacinth on the chosen water parameters of pH, electrical conductivity (EC), total dissolved solids (TDS), and salinity were examined at 24-hour intervals for 5 days using standard test kits

2.3 Parameters Measured

Parameters measured included:

- pH
- Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)
- Salinity
- Temperature

III. RESULTS AND DISCUSSIONS

Results show that the pH of the water hyacinth treatment means ranged from 7.55 to 9.55 and water hyacinth was able to gradually reduce the concentrations of EC and TDS within the first three days of its introduction, thereafter, an increase in concentration levels was observed which indicated re-introduction of the EC and TDS (Table 2). but a continuous reduction of the concentration levels of salinity. Comparisons of the effects of the water hyacinth treatment with the chosen water conditions and control are shown in Figures 1 through 4.

Table 1. Some physico-chemical characteristics of the grey water

Parameter	Value
pH	9.55
Temperature (ºC)	30
Conductivity (S/m)	960.73
TDS (ppt)	615
Salinity (ppt)	1.3

Table 2. Mean effects of the water hyacinth treatment on some physicochemical characteristics of the grey water for the 5 days intervals

Grey water Parameters	Phytoremediation Period (Days)				
	1	2	3	4	5
pH	9.55	7.90	7.81	7.57	7.55
Temperature (^{O}C)	30	29	27	29	27
Electrical Conductivity (S/m)	960.73	809.58	415.23	826.55	873.32
TDS (ppt)	615	518	266	529	559
Salinity (ppt)	1.3	1.1	1.1	1.2	1.2

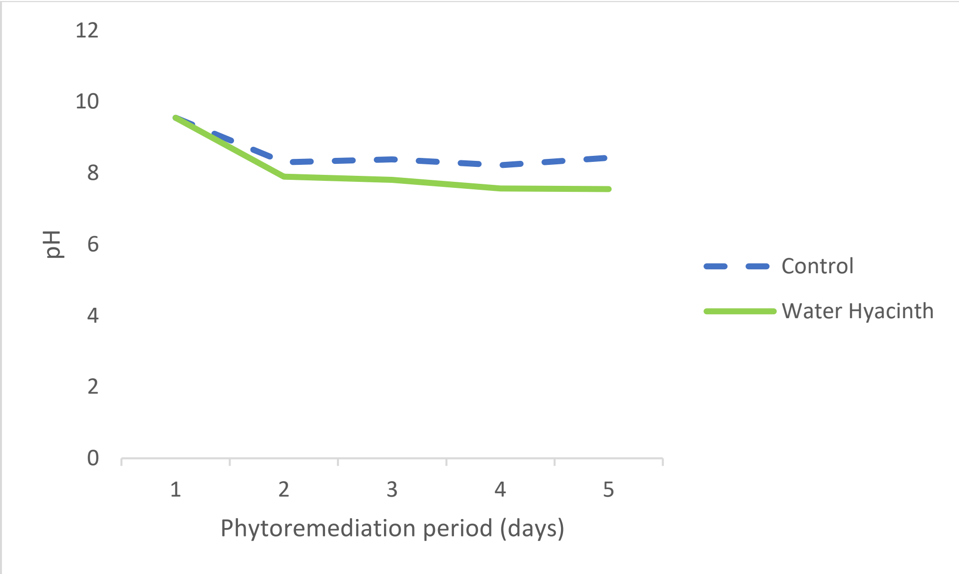

Figure 1. Comparison between control and water hyacinth treatment means with respect to pH

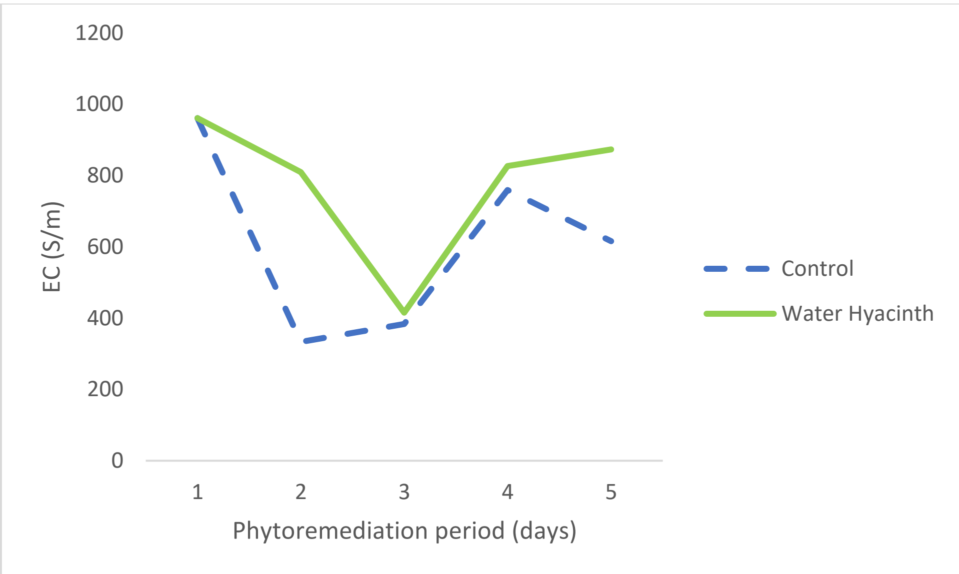

Figure 2. Comparison between control and water hyacinth treatment means with respect to EC

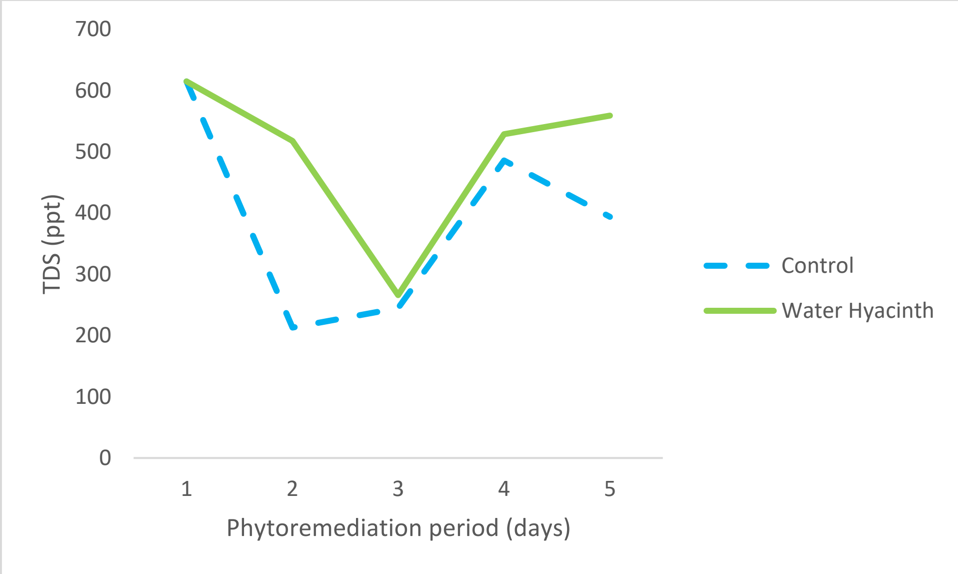

Figure 3. Comparison between control and water hyacinth treatment means with respect to TDS

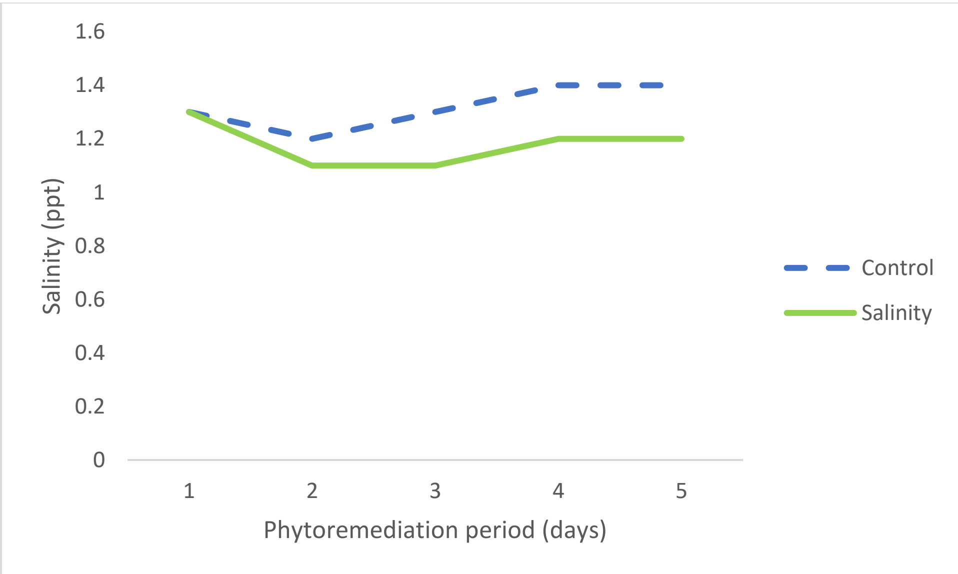

Figure 4. Comparison between control and water hyacinth treatment means with respect to salinity

Table 3. Phytoremediation rates by water hyacinth treatment of the brackish water after 3 days

Parameters	*PI (days)	Treatment	Influent	Effluent	Reduction	%	Phytoremediation rate/day	Phytoremediation rate/g/day
pH	3	**WH	9.55	7.81	1.74	18	0.0725	0.0116
EC	3	WH	960.73	415.23	545.5	57	22.73	0.15
TDS	3	WH	615	266	349	57	14.54	0.097
Salinity	3	WY	1.3	1.1	0.2	15	0.008	5.5×10^{-5}

*PI = Phytodesalination interval; **WH = Water Hyacinth

Table 4. Anova summary between the control and water hyacinth treatment on the grey water

Parameter	Control Mean	Treatment Mean	Control Variance	Treatment Variance	F (Cal)	F (Crit)	P value	*Treatment Remark
pH	8.58	8.08	0.301	0.702	0.43	0.157	0.013	S
EC	610.4	777.08	68364.51	44357.1	1.54	6.39	0.06	NS
TDS	610.4	777.08	68364.51	44357.1	1.54	6.39	0.06	NS

Salinity	1.32	1.18	0.007	0.007	1.0	0.5	0.012	S

*Treatment Remarks: S = Significant; NS = Not significant

It was observed that there was an increase in concentration levels after 3 days for pH, EC, TDS and salinity.

Table 3 show the physicochemical reduction by water hyacinth of the grey water after 3 days of the research. A phytoremediation rates of +0.15 g/day for EC, +0.097g/day for TDS and +5.5 x 10^{-5} g/day for salinity were observed. The water hyacinth started showing signs of nutrient starvation and a reduced rate of remediation. This is because the essential nutrients for plant survival in greywater are limited.

A summary of the analysis of variance (Anova) between the control and water hyacinth treatment on the brackish water show that with the exception of pH and salinity, F (cal) is less than F (crit) and the P value is > 0.05, therefore it can be concluded statistically that there was no significant difference between water hyacinth treatment and the control for EC, TDS (Table 4).

IV. CONCLUSIONS AND RECOMMENDATIONS

The conclusions of this research are:

1. Water hyacinth was able to reduce the concentration levels of the selected greywater parameter
2. The maximum reduction of concentration was at day 3 of the research.
3. The concentration levels of the selected greywater parameter began to increase after day 3, the research recommends removing the water hyacinth after three days and reintroducing fresh water hyacinth every three days until the desired outcome is achieved.

According to study, phytoremediation is a less expensive option that should to be used to treat greywater.

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