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RESEARCH ARTICLE **AJHSE-OWSD-04**

EFFECTIVENESS OF *EICHHORNIA CRASSIPES* IN THE TREATMENT OF AQUACULTURE EFFLUENT FROM A FISH FARM IN BENIN CITY, NIGERIA

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ABSTRACT

Aquaculture production has seen much increase in Nigeria in recent times due to the rise in fish farming occasioned by the availability of water and materials for setting up, the profit turn-over, increase in demand for fish, and the effort to curb the rising youth unemployment rate. However, this massive surge of interest in aquaculture and fish farming is accompanied by the challenge of pollution as the effluent from aquacultural settings gets discharged into nearby water bodies hence the need for remediation. Aquatic plants have been used to remediate polluted water bodies and possess many advantages over other methods. Therefore, this study aimed to investigate the effectiveness of *Eichhornia crassipes* in the clean-up of aquaculture effluent. Wastewater collected from a commercial fish pond in Benin City, Nigeria, were divided into two treatment groups. One group was diluted with an equal volume of distilled water (50%), and the other group consisted of 100% wastewater. Distilled water was used as a control (0%). The samples were treated with *Eichhornia crassipes* for 14 days, following which samples were collected for physicochemical analysis. The result showed that *E. crassipes* reduced significantly the pH from 7.44 to 5.98 and 7.28 to 6.10 in the 50% and 100% effluent samples, respectively. The removal efficiency of *E. crassipes* in the 100% effluent sample was 69% for phosphate, and 94% for nitrate. The study suggests that *E. crassipes* may be effective in improving the quality of aquaculture wastewater.

Keywords: *Aquaculture, Eichhornia crassipes, wastewater, treatments, efficiency*

INTRODUCTION

Over the past three decades, fish output in Nigeria has grown steadily, making the country the largest aquaculture fish producer in sub-Saharan Africa, accounting for 52 percent of the total farmed fish products in the region. This increase is attributable to several reasons, including a plentiful supply of water, availability of materials for setting-up, favourable meteorological conditions, rising demand for fish, building profitable business ventures, and reducing youth unemployment. Nigeria's aquaculture focuses mainly on freshwater fish, with catfish species accounting for 64 percent of aquaculture production (WorldFish, 2018).

Currently, Nigeria's small-scale fish farmers produce about 0.5 million metric tons of fish annually for the fast-growing population (Sambo *et al*., 2021; Bradley *et al*., 2020; FAO, 2017; FDF, 2008). Despite the numerous benefits, the aquaculture sector still faces challenges of water quality degradation and the impact of discharged effluent on the environment. Aquaculture effluents contain dissolved and suspended solids, ammonia, nitrogen, and phosphorus derived from fish excreta, feed residues (Wang *et al*., 2012; Jung and Lovitt, 2010), and other organic and inorganic compounds. Special attention is directed towards phosphorus and nitrogen as the primary pollutants in aquaculture. These nutrients at high levels can lead to eutrophication and oxygen depletion due to increased microbial activities in the water body (Bonsdorff, 2021). Therefore, it is necessary to manage this environmental load as a potential pollution source to maintain the sustainable growth of aquaculture (Osti *et al*., 2020; Akinbile and Yusoff, 2012 and Amirkolaie, 2011).

Phytoremediation is an environmentally friendly and low-cost method of removing pollutants from water (Pagoray and Ghitarina, 2020; Mudgal *et al.,* 2010; Juhaeti *et al.,* 2005). Different aquatic plant species such as *Eichhornia crassipies*, *Pistia stratiotes, Phragmites australis, Lemna* spp have been used widely to remove nutrients from wastewater (Pagoray and Ghitarina, 2020; Akinbile and Yussof, 2012). *Eichhornia crassipes*, a free-floating aquatic macrophyte, has been known to sustain its growth in polluted water due to its root's enormous surface area, absorption capacity, and settlement action. The higher productivity and growth rate of *E. crassipes* is one of the most significant reasons why it is frequently used for the treatment of wastewater (Osti *et al*., 2020; Khare and Lal, 2017; Rezania, *et al*., 2014; Rubim *et al*., 2014; Jianbo *et al*., 2008). This study was aimed at investigating the effectiveness of *E. crassipes* as a biofilter in the clean-up of aquaculture wastewater

MATERIALS AND METHODS

PLANT COLLECTION

Eichhornia crassipes were collected from a local lake in Edo State. The roots of the sampled plants were carefully washed with running tap water to remove any adhering dirt, weighed, and transferred to plastic bowls having five liters capacity of wastewater in different concentrations.

WASTEWATER COLLECTION

The wastewater was randomly collected from a commercial fish farm in Benin City that breeds Catfish. Twenty-seven (27) liters of aquaculture wastewater were collected at the point of discharge from the pond and transported to the laboratory for a preliminary physicochemical analysis. Two treatment samples were prepared from the wastewater. For one of the treatments, the wastewater was diluted with an equal volume of distilled water (50%), while the other samples consisted of undiluted wastewater (100%). Distilled water was used as treatment control (0%). *E. crassipes* with a fresh weight of 250 ± 15 grams were then placed in the treatment bowls containing three (3) liters of the prepared wastewater samples in triplicates. After fourteen (14) days, samples of the treated water were taken for physicochemical analysis. The experiment was carried out at the Screen House of the Department of Plant Biology and Biotechnology, University of Benin.

PHYSICOCHEMICAL ANALYSIS

The pH, TDS, EC were measured using a handheld multimeter. The standard analytical methods in accordance with APHA (1998) were used in determining the composition of phosphate (PO_4) and nitrate (NO_3^-) in all the samples before and after treatment.

DATA ANALYSIS

The Data were analysed using IBM SPSS version 20 for paired-sample T-Test**.** The removal efficiency was calculated using the replicates averages of 0%, 50%, and 100% for nitrate and phosphate using the formula below (Shafi *et al.*,2015):

$$\text{Removal efficiency} = \left(\frac{WC - C}{WC}\right) * 100$$

Where WC = initial value of water quality parameter

C= value of water quality parameter on termination of the experiment.

RESULTS AND DISCUSSION

pH value decreased significantly ($p < 0.05$) in all treatments from 7.44 to 5.98 and 7.28 to 6.10 at 50% and 100% treatment concentration, respectively, after treatment with *E. crassipes* (figure 1).

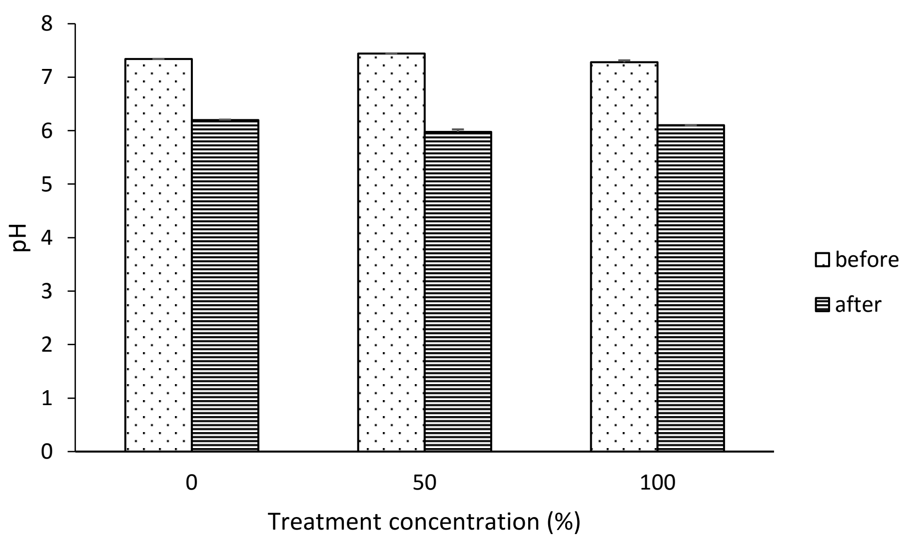

Figure 1: pH concentration in aquaculture wastewater before and after treatment with *E. crassipes*

TDS decreased from 71 mg/l to 59 mg/l at 0%, and 99 mg/l to 48 mg/l at 100% concentration respectively. No significant difference was observed ($p > 0.05$). Reduction of TDS in wastewater by *E. crassipies* has been attributed to particle sedimentation and metabolic activities of bacterial films on plant roots (Ugya *et al*., 2019; Chakrabarty *et al*., 2017). Mudavanhu *et al*. (2014) reported TDS removal values of 77.3% for diluted and 69.3% for undiluted effluent of plastic recycling industry wastewater after treatment with *E. crassipes* and *Typha capensis.*

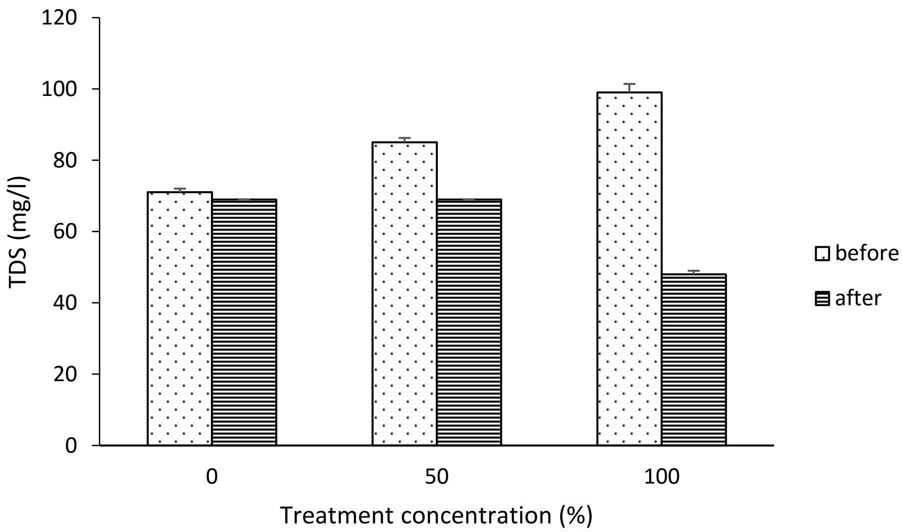

Figure 2: TDS concentration in aquaculture wastewater before and after treatment with *E. crassipes*

Figure 3 shows that there was a significant ($p < 0.05$) reduction in conductivity before and after exposure to *E. crassipies*. At 50% treatment concentration, conductivity values decreased from 101 µS/cm to 85 µS/cm. The changes observed in conductivity suggest that the *E. crassipies* utilized the ions present in the wastewater. Rezania *et al*., 2016 also reported a reduction in conductivity of domestic wastewater treated with *E. crassipies*. Chakrabarty *et al*. (2017) also reported a 46.56% reduction in conductivity of tannery effluent treated with *E. crassipes.*

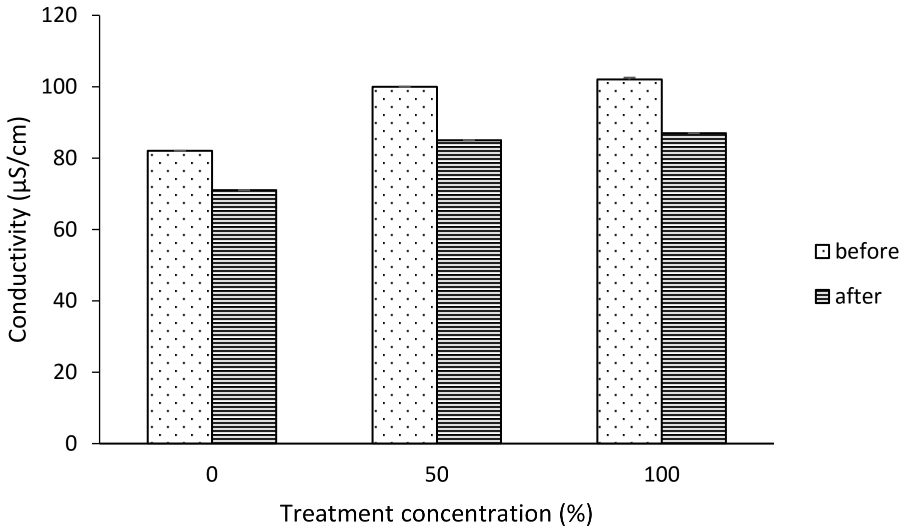

Figure 3: Conductivity concentration in aquaculture wastewater before and after treatment with *E. crassipes*

Phosphate (PO_4) and nitrate (NO_3) are limiting nutrients and major pollutants in wastewater responsible for eutrophication. Therefore, they must be removed from wastewater through the phytoremediation process before discharge into the aquatic environment. The 100% treatment concentration had the highest removal efficiency of 69% and 94% for both phosphate and nitrate respectively (figure 4 and 5). Several authors have observed that *E. crassipes* in aquaculture wastewater treatment not only reduce the nitrate and phosphate concentrations but also store these excess nutrients in its root and shoot system (Osti *et al*., 2020; Ayanda *et al*., 2020; Nizam *et al*., 2020; Kutty *et al*., 2009). *E. crassipes* root area provides a large absorption surface, favoring the process of sedimentation and development of root-associated biofilm (Grajales *et al*., 2020 and Sipaúba- Tavares *et al*., 2002).

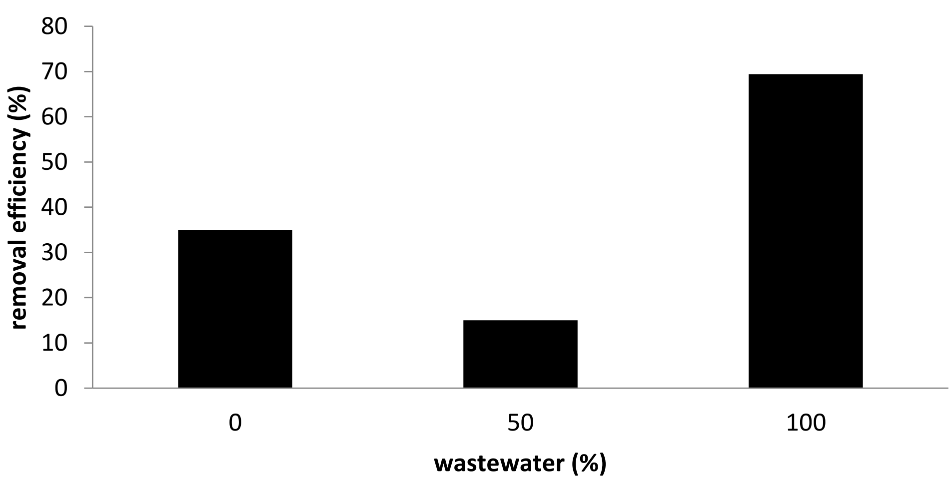

Figure 4: Removal efficiency of phosphate by *E. crassipes* from aquaculture wastewater

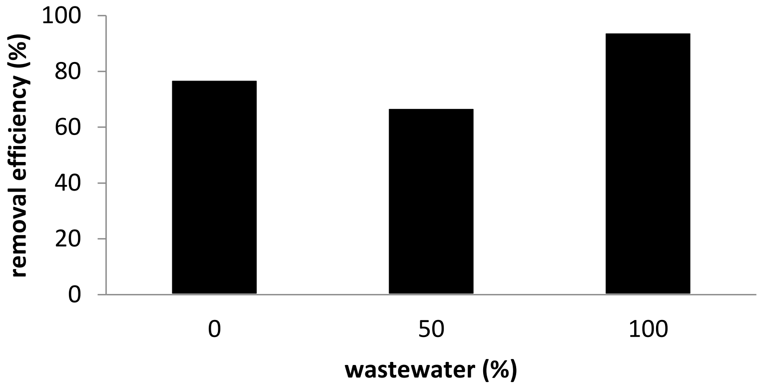

Figure 5: Removal efficiency of nitrate by *E. crassipes* from aquaculture wastewater

CONCLUSION

Aquaculture wastewater treatment with *E. crassipes* was effective in reducing the pH, TDS, EC, phosphate, and nitrate in the water. It was observed that *E. crassipes* in treatments with 100% aquaculture wastewater was most effective in improving the quality of the wastewater. We, therefore, recommend the adoption of this technique by small and medium-sized farmers in a controlled and well-managed environment as this species is highly invasive and represents a major threat in wetlands all over the world.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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