

Performance of Constructed Wetland on the Removal of Nutrient in Domestic Wastewater Using *Chrysopogon Zizanioides*

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ABSTRACT

In this study, a native wild plant, *Chrysopogon zizanioides* (C-zi), was used in a wetland system to treat household wastewater. The root system of the C-zi is comprised of primary roots, secondary roots, and filamentous roots that all extend vertically deep into the soil rather than spreading horizontally. Depending on the concentration of the influent water, the water entering the vetiver-containing tank was stored for 3 to 5 days. These results demonstrated C-superior zi's ability to degrade organic waste as well as nutrients. COD, BOD, phosphorus, and ammonia are all removed with a high degree of effectiveness (82%, 82%, 80%, and 76%, respectively) in both stages of domestic wastewater treatment. The plant's roots had grown from 5 to 30 centimeters in length over the course of three months. In aspects of wastewater treatment and high biomass growth in wetland system, it was proposed that the use of C-zi is favorable.

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1. Introduction

Cities in developing countries are increasingly concerned with water pollution and the availability of clean water. Untreated sewage from homes contributes a significant portion of the sum in urban areas. This wastewater is only partially treated by simple systems like septic tanks before it is flushed down the drain or dumped into a canal. Septic tank effluent almost never strictly adheres to discharge standards. Because of this issue, both surface water and groundwater are contaminated. Urban centers' public health and aesthetics are also negatively impacted.[1] - [3] In addition, many nations must deal with rising emission rates due to growing traffic congestion and the rapid expansion of industrial zones, both of which contribute to the release of greenhouse gases (CO₂) and, in turn, to the warming of the planet and the resulting climate change. However, due to rising populations, more rapid urbanization, and increased industrialization, the amount of land covered in greenery—which helps to absorb CO₂ from the air—has been steadily declining. To address these issues, researchers need treatment technologies that are user-friendly, efficient, compact, and power-conscious so that we can protect our planet for future generations. A constructed wetland for domestic wastewater treatment has been regarded as an efficient, low-cost, and easy approach[1, 4-6]. Plants play a significant role in stabilizing the surface of the material, accelerating the removal of contaminants, and creating open areas[1], [4] - [10]. Numerous plants have been proposed and effectively used for subsurface constructed wetland [6], [9], [11]. As a result, earlier research has suggested various plant species with possible applications, including *Melampodium paludosum*, *Kyllinga brevifolia* Rottb, and *Cyperus javanicus* Houtt. This study is interested in using *Chrysopogon zizanioides* (C-zi), common name as vetiver grass to supplement the plants for intermittent wetland system since these species also meet the above-mentioned plant selection criteria. Stem structure that is robust, dense, and woody. Numerous shoots sprout from the roots in all directions. Herbs grow to an average height of 1.5-2 meters. The top body is unbranched, whilst the lower body is heavily branched. The leaf blade is approximately 45-100 cm long, 6-12 mm wide, and has strong serrations along its edge. The roots are the most important and functional portion of a plant. Most weeds have fibrous roots that stretch horizontally from the top of the grass stalk and adhere to the soil, whereas vertical roots do not develop deeply. The C-zi's root system consists of primary roots,

secondary roots, and filamentous roots, all of which extend vertically deep into the earth rather than spreading horizontally. Vetiver is tolerant to extreme climate variations including protracted droughts, flooding, and inundation. Resistant to waterlogging for up to 45 days at a depth of 0.6-0.8m and temperature extremes ranging from -10°C to 48°C. Furthermore, *C-zi* is a wildy abundant indigenous grass in the Mekong Delta, making it very easy to locate and adapt to the Vietnamese environment.

The goal of this research is to examine into the organic matter and nutrient removal efficiency of a wetland system using *Chrysopogon zizanioides* (*C-zi*) as the major plant. Additionally, the growth of plant biomass is evaluated in order to determine adaptability and wastewater treatment performance.

2. Materials and Methods

2.1 Vegetation

In this study, the *C-zi* was chosen based on essential characteristics such as local availability, low cost, aesthetics, wastewater treatment capacity, and resilience to varying weather conditions. The leaves of initial plants were approximately 15 cm length. *C-zi* was purchased in Binh Duong province, Vietnam. The earliest *C-zi* was 3 months old and had a root length of 5 cm.

2.2 Lab-scale wetland system

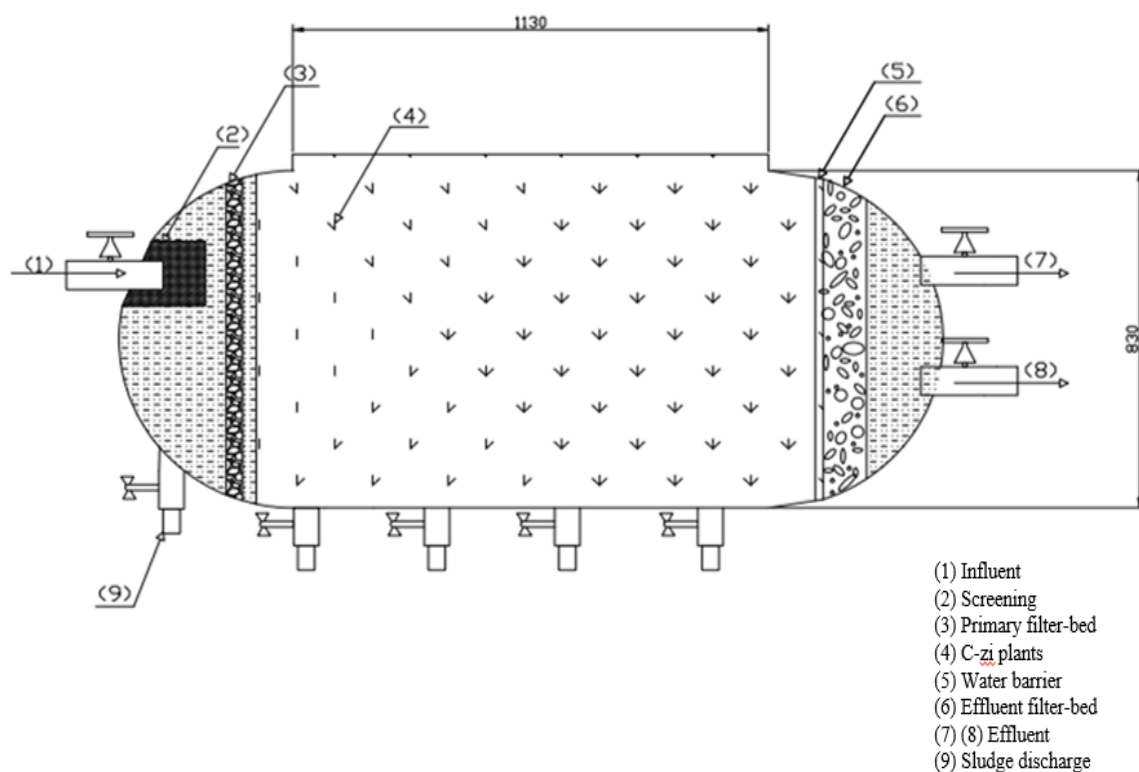


Figure 1. Schematic diagram of the lab-scale wetland system

The schematic diagram of lab-scale wetland system is shown in Fig.1. The wetland system has a volume of 500 liters of water. Plants were planted horizontally with their roots and soil submerged in water. The distance growth between the plant was 1 cm. Influent of domestic wastewater via pipe (1), garbage filter retains solids larger than 1cm (2). In chamber (3), the water was filtered once again by coconut fiber. The water entering the vetiver-containing tank (4) was stored for 3 to 5 days, depending on the concentration of the influent water. The water that passes through the filtration system tank is utilized for agriculture.

2.3 Feed wastewater

Influent of wastewater was taken directly from the collection tank of the sewage wastewater treatment system. The characteristics of the sample water were as shown Table 1.

Table 1. The characteristics of domestic wastewater

Parameter	Unit	Value	Vietnamese Standard 14:2015/Department of Environment resource	
			Column A	Column B
COD	mg/L	408	75	150
pH		7,4-7,8	6 – 9	5,5 – 9
NH ₄ ⁺	mg/L	12	5	10
TP	mg/L	3	4	6
BOD ₅	mg/L	270	30	50

2.4 Operating conditions

Wastewater was diluted and fed into the system with an initial BOD, COD concentration of 158 mg/L and 265 mg/L, respectively. The DO concentration in the wetland system was kept between 2 and 4 mg/L by an aeration system. The pH, DO, BOD, COD, ammonia, and nitrate concentrations in the system's influent and effluent were measured every 3 days to assess the removal efficiencies. The operative phase began after the adaptive phase efficiency was equilibrium. The feed wastewater was the original domestic wastewater, with BOD concentrations ranging from 270 to 300 mg/L.

3. Results and Discussion

3.1 Performance of organic matter removal

Organic matter served as the primary carbon source for microbial activity. Plant roots provided oxygen for aerobic decomposition via transfer, atmospheric diffusion, and fluid flow.[11] The change in COD concentration in the output is shown in Fig 2. The initial COD input was 265 mg/L during the adaptation phase. After three days of operation, the COD gradually decreased to 168 mg/L, resulting in a 36% treatment efficiency. COD had dropped dramatically to 48 mg/L by days of 15 and 18, achieving 82% treatment efficiency. Following the acclimatization period, the actual wastewater with an initial COD concentration of 408 mg/L was used as the influent wastewater. Since the COD concentration was 2 times higher compared with one in adaptation period, the COD removal efficiency was low during the first 6 days. Adaptation to the high concentration of pollutants was necessary for the plant and bacteria at this stage. On the 30th day, the COD level had dropped to 72 mg/L, meeting the domestic wastewater output standard of column A. *C-zi* grass had gradually adapted to and absorbed organic compounds found in wastewater in order to grow. Furthermore, the microflora found in the roots of *C-zi* grass aids in the breakdown of organic compounds into CO₂ and water [3] - [12]. BOD parameters were also monitored every 5 days and showed a significant decrease. On the 39th day of system operation, the concentration of COD dropped from 270 mg/l to 30 mg/l. Meanwhile the COD value in the A column of QCVN 14-MT:2015/BTNMT (National technical regulation on domestic wastewater) is 75 mg/L, which is twice as high as the effluent COD.

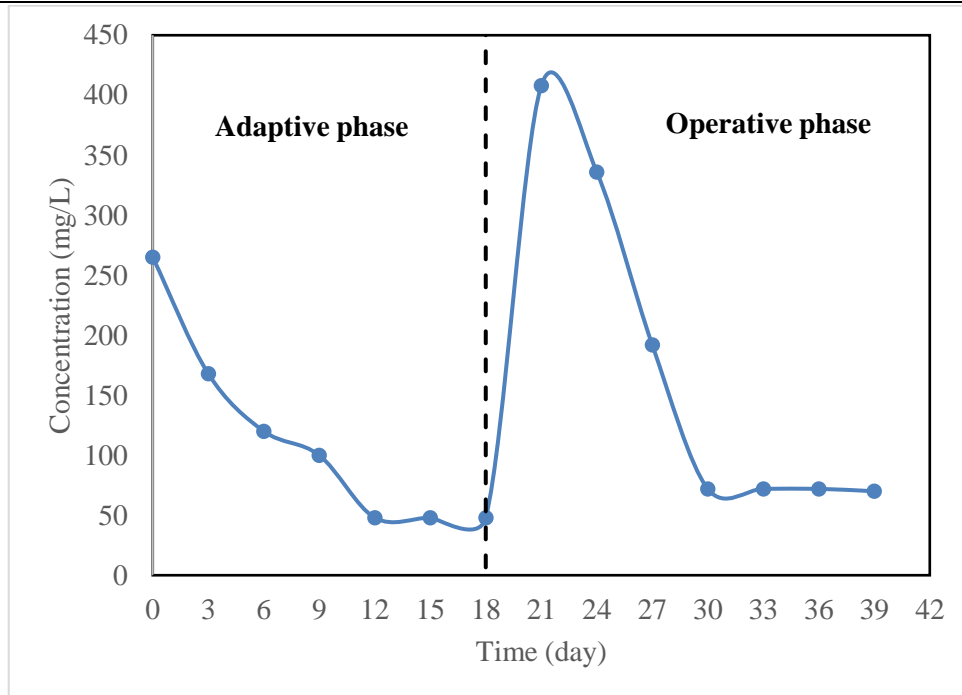


Figure 2. The effluent COD concentrations

3.2 Nitrogen balance

Most of the nitrogen in the wastewater was removed. This nitrogen loss was caused primarily by denitrification. The plant transports oxygen to the root system. Consequently, aerobic zones were formed connected to the roots and rhizomes, where nitrifying microorganisms convert ammonia to nitrite and then to nitrate [13] - [15]. There were constantly anoxic zones in the bed medium where denitrification occurs. Thus, nitrate was converted to nitrogen gas and released into the air. Meanwhile, plant nitrogen uptake ranged from 0.0 to 11.3%. Through their roots and leaves, plants primarily absorbed nitrate and ammonium nitrogen. Nitrogen amplified photosynthetic processes, leaf growth, and biomass assimilation rate in plants. [11] Also, the *C-zi* grass's root system expanded from 5 cm to 20 cm after 39 days of cultivation (Fig.5) . This indicated that the grass's biomass was grown using the organic matter and nutrients found in the wastewater.

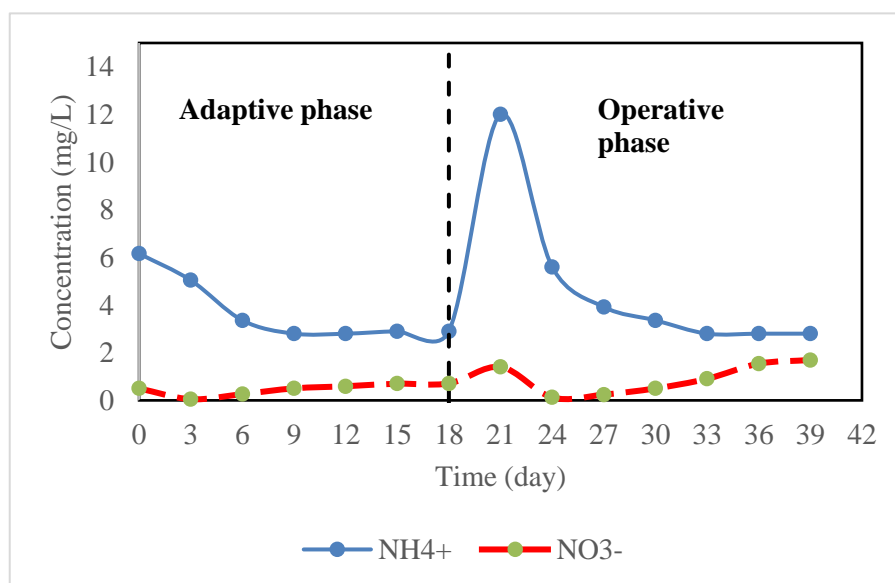


Figure 3. Nitrogen fluctuation in the system

Ammonia and nitrate concentrations in the system were shown to have fluctuated during two time periods, as depicted in Fig.3. In the adaptive phase, the ammonia concentration at the input was 6 mg/L. The level of ammonia steadily declined over time. Ammonia was converted to nitrate by microorganisms in *C-zi* grass's root system, which led to a slight increase in nitrate concentration.[13], [16], [17] The plant also preserved some of the ammonia it generated. Ammonia removal efficiency was up to 76%.

3.3 The fluctuation of pH in the system

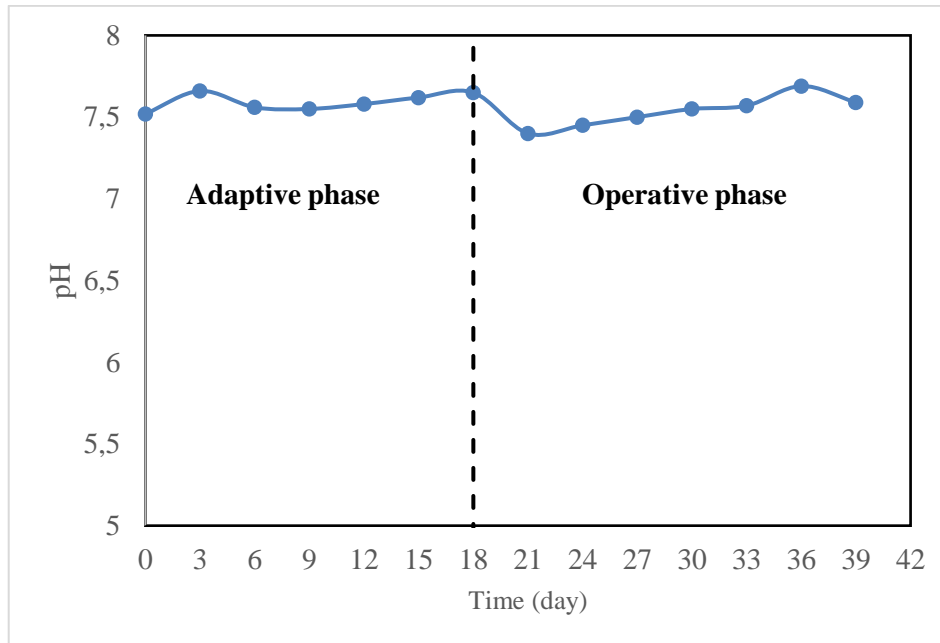
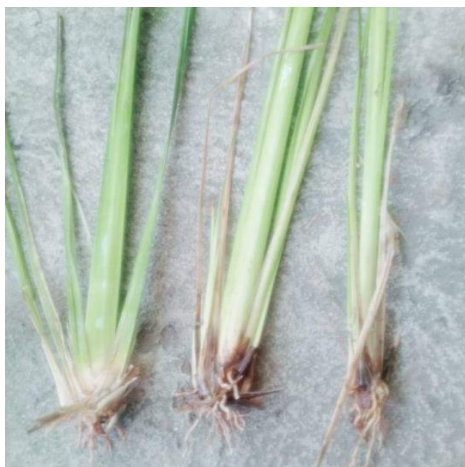


Figure 4. The fluctuation of pH parameter in the system

The pH change during system operation is depicted in Fig.4. In both the adaptive and operative phases, the pH level remained nearly constant. Furthermore, the pH dropped slightly at the start of the operative phase due to an increase in the initial COD concentration. At this point, the plant and root's bacteria had not yet adapted with the high COD concentration. This resulted in an unstable pH. The pH was then stable in the 7.6 range, which corresponds to the output standard and is a good condition for the growth of *C-zi* plants.



(a) Original plant



(b) After treatment plant

Figure 5. Comparison of *C-zi* biomass in the wetland system (before and after)

4. Conclusions

Chrysopogon zizanioides (C-zi), a native wild plant, was used in a wetland system to treat both the actual and simulated wastewater from housing developments in this research. These results show that C-zi is superior to other microbes in its ability to degrade organic waste and nutrients. Both operation stages of wastewater have very effective removal of COD, BOD, phosphorus, and ammonia (82%, 82%, 80%, and 76%, respectively). The plant's roots expanded from 5 centimeters to 30 centimeters in length over the course of three months. It was suggested that C-zi could be useful in improving wastewater treatment and cultivating substantial biomass growth in a wetland system.

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