Study on organic pollution treatment from Van Thanh canal water by vetiver grass model on gravel and sand in water circulation conditions

L V Giang\(^1\), D A Le\(^{2,3}\), L Q Tuong\(^{2,3}\), L V Tan\(^4\), T Tran\(^{1,2,3*}\)

\(^1\)Faculty of Environment and Natural Resources, Ho Chi Minh City University of Technology (HCMUT), VNU-HCM, Ho Chi Minh City, 700000, Vietnam
\(^2\)NTT Hi-Tech Institute, Nguyen Tat Thanh University, Ho Chi Minh City, 70000, Vietnam
\(^3\)Faculty of Food and Environmental Engineering, Nguyen Tat Thanh University, Ho Chi Minh City, 70000, Vietnam.
\(^4\)Department of Science and Technology of Ben Tre Province, 86000, Vietnam

*Corresponding author: tthanh@ntt.edu.vn

Abstract. Most canals in Ho Chi Minh City receive urban wastewater which was led by underground sewers in the untreated cities and causes serious environmental pollution. The main objective of this paper was to investigate the effects of application models of vetiver grass in purifying wastewater in Van Thanh canal water. This model combined many vetiver grass and materials like sand, gravel, and stone to remove pollutants based on sedimentation, filtration, accumulation, and decomposition mechanisms of microorganisms that allow water to flow through the substrate, the system provides good transport of oxygen into the substrate, facilitating nitrification. The research was conducted under hydroponic conditions in three treatments (Treatment1: Gravel treatment, Treatment 2: Sand treatment, and Treatment 3: Combination material (Gravel& Sand). Each treatment was designed \((n=2)\), with dimensions of 0.66 m x 0.46 m x 0.21 m (length, width, height), a layer of material with a thickness of 80 mm. Results showed that the average processing efficiency in the modes was PO\(_4^{-3}\) 91.34%, NH\(_4^+\) 96.67%, COD above 80% reaching QCVN 08: 2015/ BTNMT, Vetiver had a very high capacity to purify wastewater. Result also illustrated that vetiver grass had a very high capacity to purify wastewater in Treatment 3 called the combination material of Gravel& Sand. Applying the CW CSFS system using Vetiver grass was proved for the needs of surface water treatment in Van Thanh canal water with restoring the ability of natural cleaning and restoring greenery in the whereas.

1. Introduction
Ho Chi Minh City (Ho Chi Minh City), one of the regions of the Southern key economic region, has been developing significantly over the past 10 years. Along with economic development, the problem of water pollution was of great concern for user activities. Most of the domestic wastewater in urban and suburban residential whereas has not been properly treated and directed directly into watersheds of rivers, canals. Many up to 156 interlaced canals with a length over 700 km, flowing through 24 districts, have contributed to the regulation of water, irrigation, air condition for the city, and cleaning the environment. Recognizing these urgent issues, the city has set up many projects and spent tens of thousands of billion dongs to free residents along the canals, overcome water pollution in the above...
basins - improve the Nhieu canal system. Loc - Thi Nghe was nearly 4,000 billion VND, the project of cleaning and flood prevention Ben Nghe - Tau Hu can cost about 8,000 billion VND. However, the number of canals was too large, the solutions handle virtually [1]. The route of Van Thanh - Dien Bien Phu bridge passing the Van Thanh canal was a key route and on the strong development of Binh Thanh district. Van Thanh canal was located in the Nhieu Loc - Thi Nghe canal system, it was one of the heavily polluted canals and gradually losing its ability to clean itself due to encroachment on drainage systems in Ho Chi Minh City. [2]. Currently always in a state of pollution, dark water, stink [3]. All were ineffective and there were still many untreated canals. Ordinary pollutants, such as NH4+, not directly humans, but their products become nitrite and nitrate (nitrite and nitrification), being toxic. Nitrite and nitrate also affect the aquifer, when entering the human body, nitrite affects red blood cells causing anemia, which can cause cancer. However, most of the properties of wastewater show that it is not too high, only approximate to the domestic wastewater. The current situation of infrastructure in Vietnam, particularly in Ho Chi Minh City is developing as well as in many other countries, the establishment of a centralized collection and treatment system will cause significant pressure to the city's economy, which should be used widely for important other development activities. Besides, the plan to develop water treatment plants is currently planned in the long-term, but in the short-term, it cannot be resolved. Therefore, phytoremediation is one of the best choices of biological wastewater treatment methods [4, 5] because a low-tech system like phytoremediation has gained substantial interest in its use for wastewater treatment and resource recovery at low cost and minimal maintenance.

Through domestic and international studies, Vetiver has extremely special abilities such as special morphological [6], physiological, and endurance characteristics to adapt well to many adverse and harsh environmental conditions, for instance to the ability to absorb, accumulate pollutants, heavy metals with high concentrations [7], vetiver has been successfully applied in the field of environmental conservation [8, 9]. The model also provides effective treatment of pollutants with high efficiency (from 50-99.9%). The artificial wetland method was applied in both developed and developing countries thanks to the advantages such as one of the effective solutions to protect the natural environment with operating and investment costs low [10], does not require complex technology attached as well as environmentally friendly, restores canal and canal ecosystems, further improves the city's green area, regulates the climate. Furthermore, we can harvest and beneficial use of the plant biomass produced from the remediations system [9] such as agriculture-related activities (mulch, compost, nursery block/planting medium, animal feedstuff, mushroom cultivation, botanical pesticides, and allelopathy), handicraft, and artworks, medicinal applications, fragrance, the input of construction-related activities (roof thatch, hut, mud brick, vetiver-clay composite storage bin, veneer/fiberboard, artificial pozzolans, ash for concrete work, and straw bale), containers (pottery, melamine utensils, water containers), bouquet, energy sources (ethanol, green fuel), industrial products (pulp and paper, panel), and miscellaneous other utilization [11, 12].

Hence, basing on the simple structure and design, high treatment efficiency, low construction, and operating costs, minimizing the odor of wastewater and no more odor generation, restoring ecosystems, regulating climate, a Vertiver's canal wastewater treatment experimental system has been designed and tested for treatment in this study. The aim of this research works was to evaluate the potential of the model using the vetiver grass for biological treatment from Van Thanh canal's polluted water. Thereby, the research results will be the basis for proposing quick solutions in a short time to the pollution situation of the canals, which is a very common problem.

2. Materials and research methods

2.1. Experimental material

Vetiver grass was selected the same or similar cloves of size, shape, length. Each pot will be planted with a quantity of 75 cloves of grass, distributed into 15 clusters, each cluster has 5 cloves of grass. Each cluster was 10 cm apart.
There were two main phases for preparing this study, as the adaptation phase and the test run phase in order to catch the correction in Figure 1, to be detail as following:

An acclimatization trial (phase 1) was conducted within 2-3 weeks with the aim of stabilizing the Vetiver grass individual after a long process of previously living in the soil environment and changing to a wetland environment [13]. This development was assessed through a table of biomass development indicators.

Test run phase (phase 2): Each treatment in the model will be sampled at the appropriate time of the day for each load. Analysis results from the samples taken daily should be analyzed in time to support the ongoing monitoring process. The corresponding retention time showed 7 days. The result was estimated that for This phase for 14 days, Vetiver grass stabilized in the model from start time to 7 days, and then test activities ran the phase of the model operation from 7days to 14 days.

![Research process flowchart](image)

**Figure 1.** Research process flowchart

2.2. Experimental design

Model of hydrostatic drainage - vertical underground flow using containers, with the size (long: width: height) being 0.66: 0.46: 0.21 meter. The bearing frame was designed from square iron (3cm x 3cm, material thickness 1mm) into 4 floors, each floor's height has 20 cm. The floor plan of each floor was designed with an additional iron bar to increase the calculation bearing from the pot. (Total weight of each pot with materials, plants, and water was around 41kg). The model consisted of three pots (n=3), as designed in Figure 2, pots 1 & 2 were designed with internal materials, and pot 3 had the water basin at the end of the source. The below layers of the material were placed a thin filter that was responsible for limiting the washout of the material inside the basin, causing losses as well as clogging of the water pipe.

The model divided into 3 treatments as follows: Treatment 1 used a layer of material in each pot with gravel with a diameter of 20-30 mm, the height of the material layer was 80 mm. Treatment 2 uses a layer of material in each pot was construction sand with a diameter of 0.1 - 0.5 mm, the height of the material layer was 80 mm. Treatment 3 had a combination of 2 materials of sand and gravel with a ratio of 1:1.
2.3. Experimental design

Water samples were collected 7-8 am in the morning and 6-7 pm is late in the afternoon. And then stored with 2.0 liters in a plastic bottle in a refrigerator at 4°C with proper storage in the laboratory of Nguyen Tat Thanh University where proper equipment was in operation. The sampling process was conducted according to the current standards/standards: WASO 5667-2: 2006, Water quality - Sampling - Part 1: Technical guidelines for sampling, TCVN 6663 -3: 2003 (WASO 5667-3: 1985) Water quality - Sampling - Part 3: Guidance on storage and handling of samples; and TCVN 6663-6: 2008 (WASO 5667-6: 2005) Water quality - Sampling - Part 6: Guidance on sampling in rivers and streams. Methods of analyzing parameters such as pH measured by a machine, NH4+ (TCVN 6179-1: 1996), Phosphate (PO43−) (TCVN 6202: 2008), and COD (TCVN 6491: 1999).

3. Results and discussion

3.1. Quality of input water sample - water quality of Van Thanh canal

Water inlet was taken at the monitoring point of Van Thanh canal water level at the tide about 1.8 - 2.5 in the day. Sample analysis was taken place during the dry season because then the amount of natural water was carefully considered. Water properties were measured and expressed as average values in the following table:

| Parameter                  | Unit  | Result     | National Standards |
|----------------------------|-------|------------|---------------------|
| COD                        | mg/l  | 161 – 186  | 30*                 |
| BOD5                       | mg/l  | 148 - 154  | 15*                 |
| pH                         | -     | 6,99 – 7,4 | 5,5-9*              |
| Amoni (N-NH4+)             | mg/l  | 6,73 – 7,28| 0,9*                |
| Phosphate (P-PO43−)        | mg/l  | 1,96 – 2,17| 0,3*                |
| Total dissolved solids TDS | mg/l  | 317        | -                   |
| Total suspended solids TSS | mg/l  | 142        | 50*                 |

*(QCVN 08-MT, 2015): National Technical Regulation on Surface Water Quality, Vietnam - (Column B1).

Results showed that N-NH4+ and P-PO43- parameters exceeded QCVN 08-MT: 2015/BTNMT (Column B1) with 8.1 times and 7.2 times respectively, the highest number exceeded the standard parameters. In general, it can be seen that although the pollution level of the canal water exceeds Vietnam's standards, the actual pollution content is not higher than the properties of domestic wastewater [14]. Therefore, the study content focused on analyzing and evaluating the two indicators as the measured BOD5 and COD concentrations of the sample water, being inferred: BOD5/COD = 148/161 = 0.9 - 0.92, this water resource was suitable for biological treatment.
3.2. Assessing the adaptability of Vetiver grass to Van Thanh canal water source
In the first 4 - 7 days, Vetiver grass was underdeveloped and yellowing due to flooding. After the first week of observation, leaf biomass began the growth up. This period recorded the survival rate of the grass compared to the number of original crops from 95 to 98%. From the 7th to the 10th day, when new water was supplied - 5 times diluted water from the model. At this time, the grass showed the changed signs in color to a greener, the leaves of yellow leaves gradually turned greener. On the 10th day, water exchange was taken directly from the basin to the model in order to assess the adaptability of the plants to the actual environment. Observed on the 15th day, the grass had a clear chance, the stems were sturdier, the leaves grew longer and faster, the grass color was greener, there were more young shoots. Take note in the growth of grass biomass at 35th day, the height of the grass was 0.65 m. The adaptation process also presented that the grass in the gravel-shaped model developed leaf being less than the other two models. The model with the combined material pointed out the highest height of vetiver grass. The survival rate of grass after 35 days was observed in gravel, sand model, combining sand and gravel at the level of 93%, 96%, 93% respectively. The rate tree rates not dying but not developing more leaves of gravel and sand models, combined was 9%, 13%, and 6%. From the 15th day, the data showed that Vetiver was well adapted to the new environment.

Figure 3. Vetiver observed on day 1st and day 15th

3.3. Evaluating phosphorus treatment efficiency (PO$_4^{3-}$)

The first section in The average P-PO$_4^{3-}$ input was 2.67 mg/l, after 1 week of treatment, it showed that all three models of SWR were capable of treating the input water from Van Thanh canal’s basin to QCVN 08-MT: 2015/BTNMT column B1. The analyzed concentrations after 7 days of the models in the following order: gravel model 0.1846 ± 0.024 mg/l, sand model 0.1638 ± 0.003 mg/l, combined model 0.1266 ± 0.008 mg/l. In which sand materials were recorded and combined with standard treatment (after 144 hours) with an efficiency of 89.34 ± 0.15%, faster than gravel and sand materials (after 156 hours) with effective rates being respectively 90.03 ± 0.13% and 90.97 ± 0.21%. This result is better than the study of Kanokporn Boonsong et al (only 17.8-35.9%) and Ralph Ash and Paul Truong with 73-76% [15], although the concentration in the wastewater of both studies is not significant <10 mg / L [5].The graph also showed, in the first 12 hours, all three models have a sharp decrease in concentration and the different performance was not too large. In the first stage, the substrate layer had made a strong removal of the amount of PO$_4^{3-}$ presenting in wastewater. Vetiver grass had relatively little impact because the first time was for microorganisms to adapt to the environment. If plants and microorganisms have gone through the first phase (phase), there was a beginning to a performance gap, being considered at the same time. At this point, the decrease of concentration of PO$_4^{3-}$ comes from the impact of the substrate layer and the metabolism of nutrients in plants. During the experiment, the CW
VSFS composite material model always showed better handling ability. In terms of treatment efficiency, the model had a material combining sand and more effective treatment than the other two models.

![Graph showing PO₄³⁻ handling efficiency of all treatments in the model](image)

**Figure 4.** The PO₄³⁻ handling efficiency of all treatments in the model

### 3.4 Assessing the efficiency of handling ammonia nitrogen \((NH₄⁺)\)

Three models of rural waterway showed the ability to treat the input water taken from Van Thanh canal basin to QCVN 08-MT: 2015/BTNMT B1 column \((NH₄⁺\) concentration was 0.9 mg/L) after analysis around 7 days. The analyzed concentrations after 7 days of the models in ascending order were as follows: combined model \(0.2025 ± 0.0713\) mg/l, sand model \(0.2569 ± 0.0191\) mg/l, gravel model \(0.229 ± 0.0088\) mg/l.

All stage performance was recorded, the combined material model always showed the superiority, when compared to the gravel material model with the lowest performance - at the time of recording the approx difference of up to 7.89%. Thus, the model with materials combining sand and soil has the most effective \(NH₄⁺\) treatment than the models. The reduction efficiency of \(NH₄\) was approximately 77%, which was slightly better than the study of Kanokporn Boonsong et al with 61.0-62.5% at the same retention time (HRT) of 7 days [5]. A comparison of the study of Ralph Ash and Paul Truong (total nitrogen) of 48 - 63% with an input concentration of up to 20 mg/l shows that it is likely that the Vertiver grass model will not be inferior [15].
3.5. Assess the COD reduction ability of the model
In COD treatment, it was in the early days, all three treatments were stable, but the gravel model was weaker than other models, only 5.91% while the Sand model was 15.93%, and the combined model was 20.08%. Over the following three days, the models increased by 30.84%, 36.26%, and 26.66% respectively. In the last days, the combined material model reached 74.02%, the two gravel and sand models were 71.90% and 71.99% respectively. With equal input concentrations and 177.9 mg/l, at the end of the treatment cycle, we can see that the Combined model has the highest COD treatment efficiency, equal to 74.02%. Next was the Sand and Gravel model with 71.99% and 71.90%, respectively. The organic reduction capacity of the model is recorded as not reaching 91% as of the study of Kanokporn Boonsong et al [5] but more effective than the research of Ralph Ash and Paul Truong only reached 60% effective in removing organic matter [15], so the model should consider the density and flow rate, the exposure level of water and water. to increase processing efficiency. At the end of the period, COD concentrations in all three models achieved QCVN 08: 2015/BTNMT of 50 mg/l. Thus, it can be seen that the model with materials combining sand and gravel was more effective at handling the remaining models with mode 1.

Figure 5. The $\text{NH}_4^+$ removal efficiency of models

Figure 6. Ability to treat COD of Vetiver grass
4. Conclusion
The vetiver grass treatment model combined with filter materials such as gravel and sand has shown to be highly adaptable to environmental changes from dry to wet environments. With the concentration of pollutants in Van Thanh canal water, Vetiver grass still maintained the nutrient uptake for growth performance. The output water met the treatment of QCVN 08-MT: 2015 / BTNMT column B1. With a vertical underground flow design, combined with the water circulation conditions to create a good environment for processing the input water. The model had high treatment efficiency of phosphorus and nitrogen, in which NH4+ on average has efficiency was over 96%, PO43- was over 94% and COD was over 80%. The final results were an initial evaluation stage for the process of applying the CW CSFS system using Vetiver grass for the needs of surface water treatment, restoring the ability of natural cleaning and restoring greenery in the Whereas. Small and medium canals and canals with relatively low investment and operating costs.

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