High Efficiency of Waste Stabilization Ponds using Para Grass (*Brachiaria Mutica*) Vegetation for Treatment of Industrial Waste in Ho Chi Minh City, Vietnam

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Abstract. In recent years, wastewater treatment by using biological method has been concerned because it low cost, easy to operate and environmentally friendly. In this study, stabilization pond – one of the biological wastewater treatment methods has been researched for treating industrial wastewater in Industrial park, District 2, Ho Chi Minh city, Viet Nam. In stabilization pond, Para grass planted on the surface of the pond with roots in the water. Important elements of the treatment process were surveyed to provide optimal operation conditions, include: flow rate of influent, grass cutting cycle, initial COD concentration, fraction of N and P, the height of Para grass after cutting, pH in influent. The results show that Para grass grows well in wastewater and treatment efficiency of stabilization is high when flow rate of influent at 0.12 m³/h and 0.18 m³/h (corresponding to retention time is 7.8 days and 5.3 days, respectively). Besides, Para grass need to be cut periodically for about 20-22 days and the height of grass after cutting from 0.2 - 0.4 m to ensure the best treatment efficiency. Effect of pollution parameters of influent has been also surveyed. The results showed that stabilization pond treats wastewater efficiently when the initial COD concentration is from 200 to 350 mg/l, the fraction of N/P is from 4 to 6 and pH= 7. Wastewater after treatment with stabilization pond meets standards QCVN 40:2011/BTNMT (National Technical Regulation on Industrial Wastewater) with parameters in effluent such as COD, TN, TP, BOD₅, Coliform. Moreover, biomass of Para grass after treatment can be used as feed source for livestock and ensure safety according to QCVN 01-183:2016/BNNPTNT. These results show the applicability of stabilization pond using Para grass vegetation in concentrated industrial wastewater treatment with low cost, simple but efficiency, environmentally friendly and towards sustainable development.

1. Introduction

Stabilization ponds (SPs) are engineered systems that have been design and operate to utilize the natural processes of free-floating vegetation and the associated microbial assemblages to assist in treating wastewater. They are designed to take advantage of many of the same processes that happen in natural environment, but these processes are still controlled by operating parameters. Wastewater stabilization pond treatment is an effective and low-cost method of pathogen removal.

Para Grass is native to Brazil and Africa and is found in many tropical countries. This grass was introduced into South Vietnam in 1875 and entered Central Vietnam in 1930 and then to Northern Vietnam. Now this grass is grown everywhere. Para grass likes hot and humid temperatures, grows well in the summer [1,2,3].
In Vietnam, Para grass is currently mostly used as a feed source for livestock because of soft leaves and trunk. There are a number of studies around the Para grass in the world, but only on the ability to absorb nutrients of Para grass.

Valencia-Gica's research has studied the ability of Para grass to produce biomass and nutrient removal in milk processing wastewater. Results showed that Para grass has a dry biomass yield (4357 tons/ha/year) and its ability to absorb nutrients in wastewater is quite high (Nitrogen (N): 1083–1405 kg/ha/year; Phosphorus (P): 154 –164 kg/ha/year, Potassium (K): 1992–2141 kg/ha/year) [4].

In 1981, in Hawaii-US, it was used Para grass to remove nitrogen in domestic wastewater. The amount of irrigation water is 98 mm/day, 5 days/week, the average water loss is 4.6 mm/day, the total amount of nitrogen is removed from 130-2600 kg/ha.year. In which, 79% is absorbed by grass, 3% is retained during filtration, 29% is lost due to nitrate reduction. After processing the remaining nitrogen in the water is 10mg/l [5]. The results of this study open the way to use Para grass as a plant to treat wastewater.

Based on the potential of absorbing nutrients in the wastewater of Para grass, the aim of this study is to compare efficiency when changing operating parameters in SPs covered by Para grass: flow rate (Q), COD, N/P rate, pH, height of grass after cutting. This comparison could help to propose the operating parameters most adapted when applying processing model for treating industrial wastewater in Industrial park, District 12, Ho Chi Minh city, Viet Nam.

2. Materials and methods

2.1. Pilot model

The experiment was carried out in the industrial waste water is taken from the wastewater collection tank of the central wastewater treatment plant of Tan Thoi Hiep Industrial Park, District 12, HCMC. Facultative waste stabilization pond was built in pilot scale with size LxWxH = 4.0x2.0x4.0 (m). (Figure 2) Para grass was grown in this model of which wastewater is provided continuously on one side. Influent wastewater is controlled by flow valvess.
2.2. Experiment
In this study, facultative waste stabilization pond covered Para grass was researched in many different operating conditions. The characteristic of each experiment is described in Table 1. The chemical used to adjust the COD concentration is Glucozo (C₆H₁₂O₆), adjust the N/P ratio is Mono potassium phosphate (KH₂PO₄) and adjust the pH is NaOH and H₂SO₄.

Table 1. Characteristic of experiments

| Flow rate (Q) m³/h | COD mg/L | N/P | pH  | Height of grass after cutting m |
|-------------------|----------|-----|-----|-------------------------------|
| 0.12              | 200      | 2   | 5.5 | 0.6                           |
| 0.18              | 350      | 4   | 7   | 0.4                           |
| 0.24              | 500      | 6   | 8.5 | 0.2                           |

2.3. Sampling
During the course of the experiment (2 years) from 1/2017-12/2018, water samples collected every three days per week. The sample of wastewater is collected at outlet of the Para grass model based on TCVN 5999: 1995 (ISO 5667-10: 1992). Measurements parameters is pH, COD, TN and TP. Influent sample is collected at S1 point and effluent sample is collected at S2 point (Figure 3).

![Figure 3](image-url)

Figure 3. Facultative waste stabilization pond covered with Para grass on the pilot scale.

2.4. Chemical and parasitical analysis

Water analysis was done according to methods described in Table 2.

Table 2. Parameter analysed and methods used

| Variables           | Unit     | Analytical methods                        |
|---------------------|----------|-------------------------------------------|
| Chemical Oxygen demand COD | (mg/O₃/l) | 5220 C. Closed Reflux, Titrimetric Method. |
| pH                  |          | 4500 – H+ B. Electrometric Method          |
| TN                  | mgN/L    | 4500 – Norg B. Macro Kjeldahl Method       |
| TP                  | mgP/L    | Standard Method 4500 – PD                 |
3. Results and discussions

3.1. Results of survey of Para grass’s growth.

![Figure 4. Growth process of Para grass height over time](image)

The growth process of Para grass is shown in Figure 4. During the 35-days survey of Para growth in waste water, the growth process of the grass was divided into two stages. Stage 1 is the period of growth and development, grass grows quite quickly and evenly in the first 20-21 days. Stage 2, starting on the day 22nd, the grass began to grow slowly. Therefore, it is necessary to periodically cut grass during the period from 23 to 25 to stimulate grass growth and maintain the efficiency of wastewater treatment.

![Figure 5. Growth process of Para grass height over time](image)
3.2. Surveying the wastewater treatment efficiency of stabilization pond using Para grass vegetation in different operating parameters

Figure 6. Average of % removal of organic load and nutrients in different inflow’s flow rate

Figure 7. Average of % removal of organic load and nutrients in different influent COD concentration

Figure 8. Average of % removal of organic load and nutrients in difference of ratio between nitrogen and phosphorus
We have studied waste water treatment ability of Stabilization pond using Para grass vegetation at different operation conditions such as inflow’s flow rate, influent COD concentration, ratio between nitrogen and phosphorus, Para grass height after cutting and pH of wastewater. The results at figure 6, 7 and 8 show that stabilization pond can treat efficiently parameters of wastewater such as COD, TN, TP. When changing inflow’s flow rate, the model reaches the highest processing efficiency at \( Q = 0.18 \text{ m}^3/\text{h} \) (corresponding retention time is 7.4 days). COD, TN and TP removal efficiency is 53.8 \pm 0.9\%, 43.2 \pm 1.7\% and 32 \pm 1.68\%, respectively.

COD is one of the important parameters which is concerned in industrial wastewater treatment, especially using biological treatment method. The study has concerned about effluence of influent COD concentration to effective of model. Results show that at concentration is from 200 to 350 mg/l, stabilization pond using Para grass can treat efficiently domestic wastewater. COD and TN removal efficiency at COD 200 mg/l is 60.7 \pm 1.1\% and 56.1 \pm 1.1\%, respectively. These results show application ability of stabilization pond using Para grass vegetation at high-level processing stage or arrange this model after clarification tank to advance treatment efficiency.

For wastewater treatment model using aquatic plant in treatment process, nutrients ratio in wastewater is also an important parameter. In this study, three ratios between N and P have been surveyed is 2, 4 and 6. At N/P = 6, treatment efficiency of wastewater is the most stable, with COD, TN and TP removal efficiency is 57.0 \pm 1.2\%, 48.0 \pm 0.8\% and 20.9 \pm 0.36\%, respectively.

Stabilization pond using Para grass vegetation treats Total phosphorus in domestic wastewater is ineffective, so it is necessary treat P separately when the TP concentration is higher than the permitted level.

![Figure 9. Average of % removal of organic load and nutrients in different Para grass height after cutting.](image)

In this study, Para grass will be periodically cut for 22 days with different grass heights to survey the effect of cutting grass on treatment efficiency of SP covered by Para grass. The average treatment efficiency of the parameters of organic matter and nutrients at the grass height after cutting (\( H = 0.6; 0.4; 0.2 \text{ m} \)) is shown in Table.

The results have shown that at different heights after cutting, treatment efficiency was different. The efficiency of wastewater treatment tends to increase as the height of grass after cutting was reduced. The highest treatment efficiency was found at the remaining grass height \( H = 0.2 \text{ m} \) after cutting, the average percent elimination of COD, TN, TP were, respectively, 54.7\%; 37.2; 28.6\% (Figure 9). This can be explained that cutting grass helps stimulate grass growth leading to photosynthesis processes, absorbing nutrients of Para grass in wastewater occur more strongly. However, the remaining height of the grass is too short, which will lead to a longer recovery of the grass than the regular cutting time. Because of the characteristics of grass, the grass will grow budding at the grass node about 10-30 cm from the roots. Therefore, height \( H = 0.4 \text{ m} \) is the appropriate and optimal height for Para grass to recover and ensure wastewater treatment efficiency. At \( H = 0.4 \text{ m}, \)
average percent elimination of COD, TN, TP were not much difference from H = 0.2 m, respectively, 53.6%; 36.0%; 26.5%.

The effect of pH on the ability to treat wastewater of SPs covered by Paragrass was studied, the experiment was conducted at 3 different pHs corresponding to 5.5; 7; 8.5 From there, evaluate the effectiveness of COD, TN, TP treatment of the experimental model.

The result showed that COD, TN and TP treatment efficiency was highest at pH = 7. The values of pH = 5.5 and pH = 8.5 showed lower treatment results for all parameters. Because pH is one of the important factors to control in wastewater treatment process in particular and in life in general. This result is consistent with previous practices and studies have shown that pH values suitable for aquatic life are 6 -8[6]

When the pH of the environment is too high or too low, it is not conducive to the development of aquatic organisms, because it will inhibit plants' ability to breathe and develop, thereby reducing the natural processing efficiency of the lake. [7]

3.3. Evaluating treatment efficiency and proposing operation conditions of stabilization ponds using Paragrass vegetation for industrial wastewater treatment

The survey results show that it is only through 01 stage of direct treatment but stabilization pond covered Paragrass is capable of effectively treating industrial wastewater. The efficiency of wastewater treatment at different operation conditions is summarized in Table 3.

With the size of stabilization pond is L x W x H = 4 x 2 x 4 (m), wastewater treatment efficiency is the most effective with operating parameters: inflow’s flow rate Q = 0.18 m³/h, influent COD concentration COD ≈ 200 mg/l, the ratio between nitrogen and phosphorus N/P ≈ 6, height of grass after cutting H = 0.6 m and pH = 7. Besides main environmental parameter in industrial wastewater such as COD, TN, Heavy metals (As, Pb) and Coliform were also analyzed to assess the ability of the stabilization pond planning Paragrass at flow 0.18 m³/h. Table 3.2 show that all the parameter after one stage treatment are achieved column A QCVN40:2011/BTNMT, especially As, Pb and Coliforms have high efficiency (efficiency Coliform treatment reached over 90%).
Table 3. Wastewater treatment efficiency of stabilization pond covered Para grass at different operation conditions

| Parameter | Average treatment efficiency at different operation conditions |
|-----------|---------------------------------------------------------------|
|           | $Q = 0.12 \text{ m}^3/\text{h}$ | $Q = 0.18 \text{ m}^3/\text{h}$ | $Q = 0.24 \text{ m}^3/\text{h}$ |
| COD       | 47.1 ± 3.6          | 53.8 ± 0.9          | 47.9 ± 1.4          |
| TN        | 39.8 ± 2.8          | 43.2 ± 1.7          | 36.9 ± 1.6          |
| COD       | 60.7 ± 1.1          | 55.7 ± 0.9          | 47.9 ± 0.6          |
| TN        | 56.1 ± 1.1          | 53.4 ± 0.7          | 49.3 ± 1.5          |
| COD       | 60.4 ± 1.1          | 57.0 ± 1.0          | 57.0 ± 1.2          |
| TN        | 36.1 ± 0.6          | 41.1 ± 1.5          | 48.0 ± 0.8          |
| COD       | 50.9 ± 1.3          | 52.8 ± 1.9          | 55.5 ± 0.2          |
| TN        | 31.7 ± 1.5          | 36.0 ± 2.0          | 37.2 ± 1.5          |
| COD       | 46.2 ± 2.9          | 55.8 ± 0.6          | 48.0 ± 1.2          |
| TN        | 36.7 ± 1.4          | 39.6 ± 0.9          | 33.4 ± 1.7          |

Table 4. Treatment efficiency of heavy metal (As, Pb) and Coliform of stabilization pond covered Para grass at flow rate of 0.18 m$^3$/h

| Parameter          | Inf | Eff          |
|--------------------|-----|--------------|
| As (mg/l)          | 0.026 | Not detected |
| Pb (mg/l)          | 0.04 | Not detected |
| Coliforms (MPN/100ml) | 2.4x10$^4$ | 2.4x10$^3$ |

To explain the treatment efficiency, grass samples (stem and roots) were analyzed before and after treatment. The results are shown in Table 5.

Table 5. Analysis of heavy metals content in the stem and roots of Para grass after treatment.

| No. | Parameter | Unit | Para grass stem | Para grass root | QCVN 01-183:2016/BNNPTNT |
|-----|-----------|------|-----------------|-----------------|--------------------------|
| 1   | Pb        | mg/kg| 0.22            | 0.38            | 5                        |
| 2   | As        | mg/kg| 0.01            | 0.05            | 2                        |

After the experimental period, the results in Table 5 show that Para grass is capable of absorbing heavy metals As and Pb. This can be explained for the heavy metal treatment efficiency of stabilization pond planning Para grass. As and Pb content in Para grass is much lower than that of QCVN 01-183:2016/BNNPTNT - National technical regulation Animal feed - Maximum level of
mycotoxins, heavy metals and microorganisms in compound feeds for livestock. Therefore, biomass after treatment industrial wastewater in this study can be provided as feed source.

Based on the survey results, industrial wastewater treatment model by stabilization pond covered Para grass in pilot scale can be operated in different parameters but still reach good treatment efficiency: influent COD concentration from 200 to 350 mg/l, the ratio between nitrogen and phosphorus from 4 to 6, height of grass after cutting from 0.2 to 0.4 m, pH = 6 - 8 with a retention time of about 7.4 days. [8-9]

4. Conclusions
It can be concluded that stabilization pond covered Para grass can treat industrial wastewater effectively. Wastewater after treatment reaches standards QCVN 40:2011/BTNMT (National Technical Regulation on Industrial Wastewater) (COD, TN, As, Pb, Coliform) and can be discharged safely. Besides, the biomass of Para grass after treatment can be used as feed source for livestock and ensure safety according to QCVN 01-183:2016/BNNPTNT. The study has found operation conditions and performance of model for treatment of industrial waste. These results show the applicability of stabilization pond using Para grass vegetation in concentrated industrial wastewater treatment with low cost, simple but efficiency, environmentally friendly and towards sustainable development. In the future, it is possible to expand research on wastewater treatment capacity of stabilization ponds planning Para grass with different kinds of wastewater such as domestic wastewater, livestock wastewater, medical wastewater, etc.

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