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Experimental Model to Treat BOD_5, COD in Wastewater by Eichhornia Crassipes Raft, and Propose a Plan to Restore Water Source of To Lich River, Hanoi, Vietnam

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Abstract: This paper presents the results of studies on evaluating the effectiveness of wastewater treatment by Eichhornia crassipes raft, the influent is the water of To Lich river. This study was conducted 3 times with 3 different velocity (0.037 m/s, 0.0099 m/s and 0.0126m/s) in the tank of eichhornia crassipes. Each time took 04 water samples for analysis at 4 locations: the influent source and 3 points at a distance of 4.0 m, 8.0 m and 12.0 m from the influent. Based on the experimental results, it proposes the size, number and type of raft to control the growth of eichhornia crassipes and treat the sewage of To Lich river to meet the Vietnamese Water Standard QCVN 08 (column A2, B1) and combine ecological landscaping.

Key words: Wastewater treatment, eichhornia crassipes, restore water resources.

1. Introduction

To Lich river basin has a total area of 77.5 km^2 including 8 sub-basins: Westlake, To Lich, Lu river upstream, Lu downstream, Set, Kim Nguu, Hoang Liet and Yen So, with the length of 14.6 km [1]. Currently, there are over 200 large and small outlets to discharge wastewater into the river causing polution, many indicators exceeded the limitation of column A2 of the National Technical Regulation on Surface Water Quality QCVN 08 [2], affectting the health of people living around [3, 4]. Therefore, research and solutions to restore water quality of To Lich river are necessary.

In Vietnam, eichhornia crassipes is most widely used in wastewater treatment ponds [5]. It is living in the water with fast growth speed, unecessary to care, easy to adapt to the environment of waste water [6]. Besides, it can limit or prevent algae growth by shielding light from the surface [7, 8]. Thus, eichhornia crassipes is very useful and easy to treat polluted water [9].

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2. The Approach and Methodology

2.1. Approach Method

The approach method is shown in Fig. 1.

2.2. Research Method

- Method of inheritance: inheriting the results of the previous studies on flow, the status of wastewater discharge into water sources;
- Field survey: some major methods are: topographic, velocity and water quality measurements;
- Method of modeling: used to simulate the flow on the river;
- Statistical method: to evaluate the relationship among water quality, length of treatment tank and flow velocity.

3. Experimental Model of Wastewater Treatment by Eichhornia Crassipes Raft and Effective Treatment

3.1 Survey Results on To Lich River

Here is the diagram of the surveyed river across

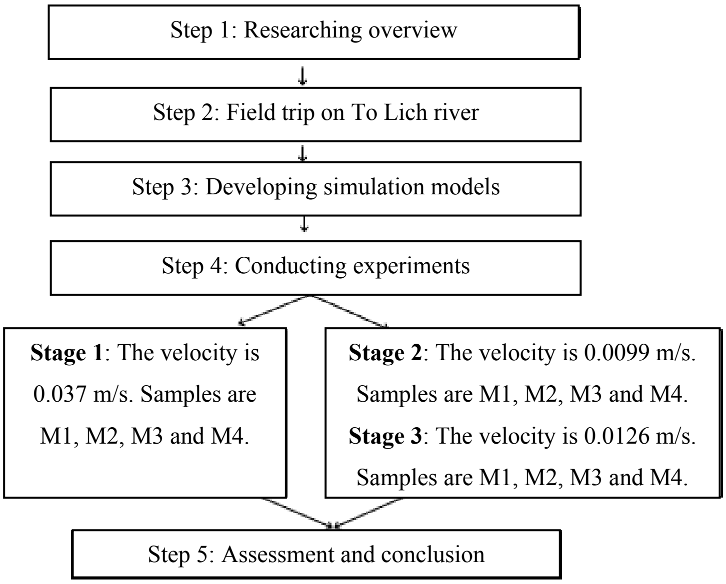


Fig. 1 Diagram of research approach.

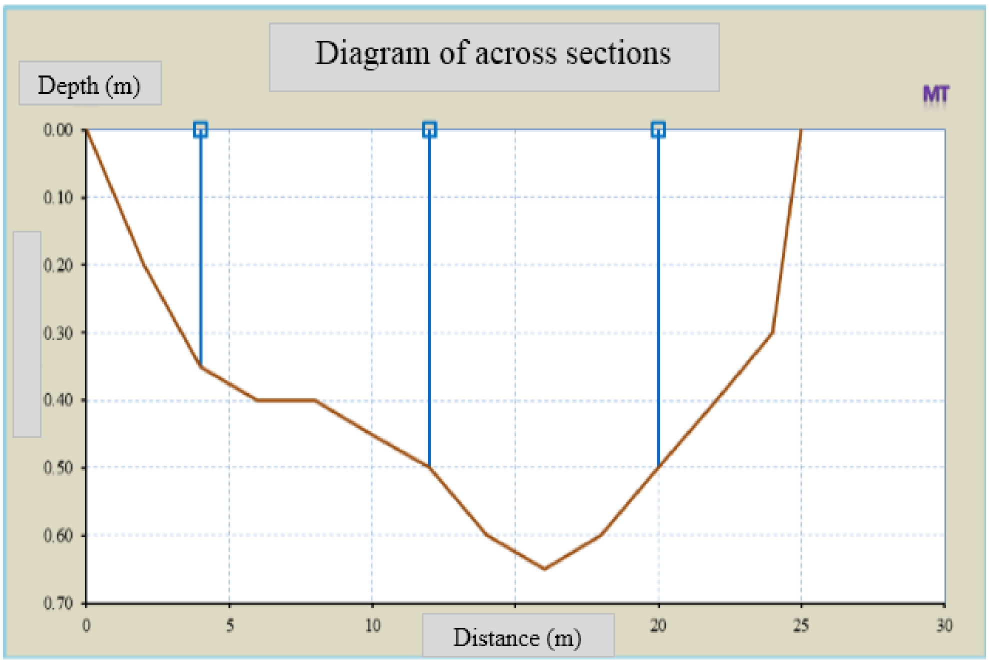


Fig. 2 Accross section at Cau Moi, Nga Tu So.

sections (Fig. 2) and the survey information at Cau Moi, Nga Tu So (Table 1).

3.2 Experimental Model

Eichhornia crassipes feed, tending to adapt to sewage environment until a stable growth will conduct experiments. Eichhornia crassipes density is 60 single clusters/1.72 m^2 of treatment tank area corresponding to 35 single clusters/1 m^2.

Here are the images of eichhornia crassipes hyacinth cultivation in home garden of the authors (Fig. 3).

3.3 Results of Water Quality Analysis

The purpose of water quality analysis is to evaluate the effectiveness of the model corresponding to the flow velocity (Table 2).

Table 1 Survey information at Cau Moi, Nga Tu So.

No	Parameters	Unit	Result
1	Discharge	m^3/s	2.96
2	Across section area	m^2	10.6
3	Average velocity	m/s	0.28
4	Max velocity	m/s	0.32
5	The width of the water	m	25
6	Average depth	m	0.42
7	The biggest depth	m	0.5

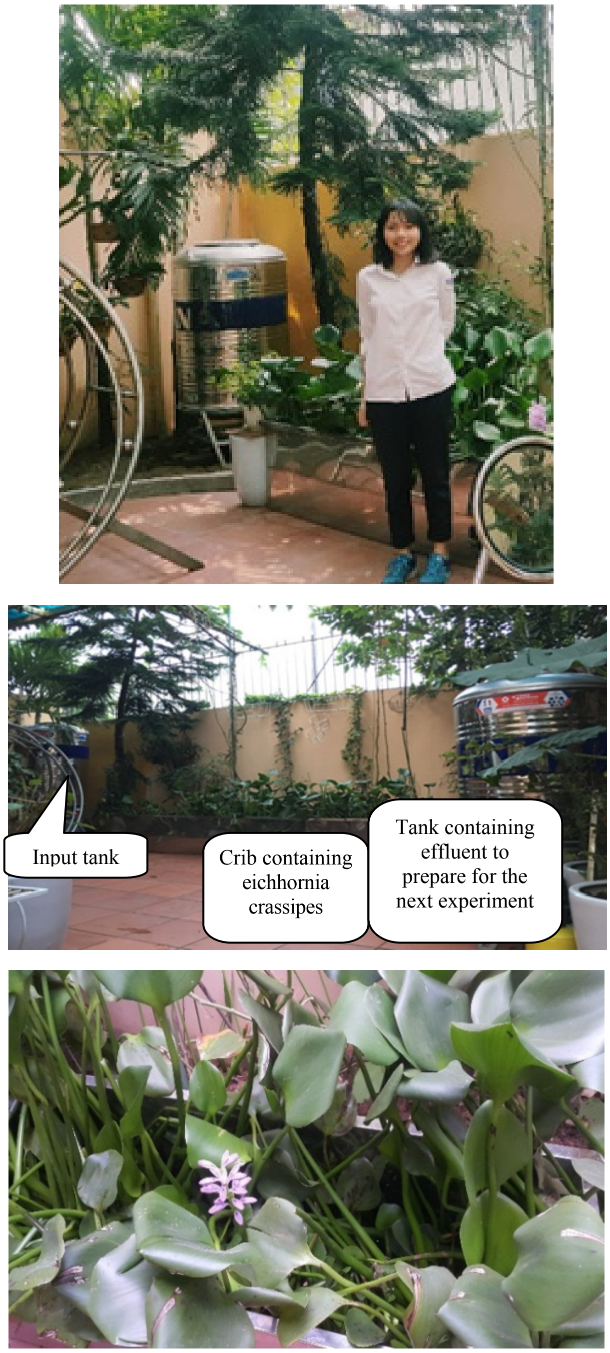


Fig. 3 Eichhornia crassipes has developed normally.

3.4 Treatment Efficiency

The results of water quality analysis showed that:

- The farther locations from the influent source is, the lower the concentration of the indicators are;
- The wastewater velocity in the experimental tanks range from 0.0099 m/s to 0.037 m/s, through 12 m length of treating tank, processing performance indicators from 14.3% to 96.7% and is shown in Table 3;
- Treatment efficiency of BOD_5 achieved 17.3% to 44.9%;
- Treatment efficiency of COD achieved 24.5% to 51.1%.

3.5 Evaluating the Length of Treatment Tank Corresponding to Flow Velocity for Water Quality Meet the Standard QCVN08

3.5.1 For Experiment Velocity

Based on the results of water quality analysis, it showed that the relationship between treatment efficiency and the distance from the influent source to the sampling location is linear and close, the correlation coefficient (R^2) is over 0.75 and is shown in Fig. 4.

Therefore, it can be estimated as: assuming that the sewage concentration target is C_0, through the tank length is L_d (L_d has been identified on the model), the water quality is C_d in the tank length L_d (C_0 and C_d were analyzed by experiments), then the calculation of L_x (length of tank is x) to qualify standard C_q can be interpreted according to the diagram in Fig. 5.

Then, from Fig. 5, it can calculate as:

$$L_x = L_d * \frac{C_0 - C_q}{C_0 - C_d} \quad (1)$$

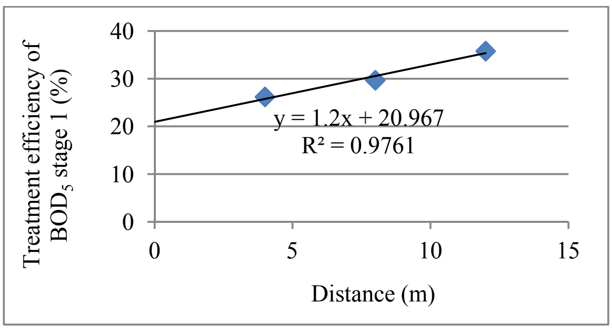
According to Eq. (1), the length of experimental tank (L_x) is 25.7 m for C_q to achieve regulation of column A2 corresponding to the effluent velocity on the experimental tanks is highest (v1); L_x = 12.5 m for C_q to achieve regulation of column B1 corresponding to the effluent velocity on the experimental tanks is highest (v1). The results are shown in Table 4.

Table 2 Results of water quality analysis.

Phase	Number of sample	Sampling locations on experimental tank (m)	BOD_5 (mg/L)	COD (mg/L)
I	Phase 1, v1 = 0.037 m/s			
	M1 influent	0	22.9	65.6
	M2	4	16.9	48.3
	M3	8	16.1	46
	M4	12	14.7	42
II	Phase 2, v2 = 0.0099m/s			
	M1 influent	0	32.3	79.4
	M2	4	26.7	46.2
	M3	8	20.1	42.8
	M4	12	17.8	38.8
II	Phase 3, v3 = 0.0126m/s			
	M1 influent	0	32.6	94
	M2	4	24.4	71
	M3	8	19.3	52
	M4	12	18.9	52
IV	QCVN08 [6]			
	Standard A2		6	15
	Standard B1		15	30
	Standard B2		25	50

Table 3 Wastewater treatment efficiency at different positions (behind influent source) on experimental tanks.

No	Indicator analysis	Processor performance of indicators (%)		
		Sampling locations (m)	BOD_5	COD
I	Phase 1, wastewater velocity, v1 = 0.037 m/s			
1	Behind the influent source 4 m	4	26.2	26.4
2	Behind the influent source 8 m	8	29.7	29.9
3	Behind the influent source 12 m	12	35.8	36
II	Phase 2, wastewater velocity, v2 = 0.0099 m/s			
1	Behind the influent source 4 m	4	17.3	41.8
2	Behind the influent source 8 m	8	37.8	46.1
3	Behind the influent source 12 m	12	44.9	51.1
III	Phase 3, wastewater velocity, v3 = 0.0126 m/s			
1	Behind the influent source 4 m	4	25.2	24.5
2	Behind the influent source 8 m	8	40.8	44.7
3	Behind the influent source 12 m	12	42	44.7
	MIN		17.3	24.5
	MAX		44.9	51.1
	TB		33.3	38.4



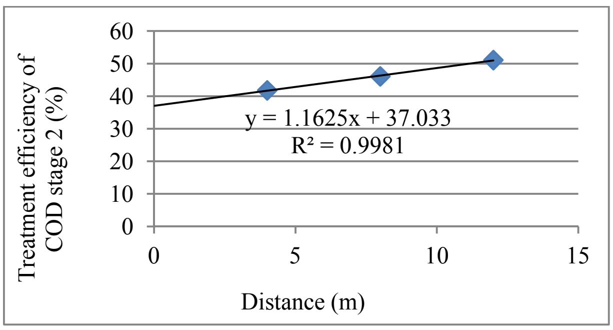


Fig. 4 The relationship between treatment efficiency of BOD_5, COD and the distance from the influent source to the sampling location.

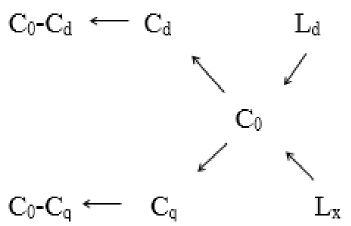


Fig. 5 Diagram method of calculating the length of experiment tank.

3.5.2 For Real Speed on the River

Base on the results in Table 4, it presents drawing chart and relation between experimental flow velocity and length of experiment tank. It is shown in Fig. 6 that correlation coefficient (R^2) is over 0.75. So, correlation equation can be used to calculate length of experiment tank for real flow velocity of river.

From Fig. 6, the correlation equation between flow velocity and length of tank is:

$$y = 87.356 * x + 21.534 \quad (2)$$

$$y = 199.64 * x + 18.474 \quad (3)$$

Where, y is length of experiment tank (m), x is experimental flow velocity (m/s).

In fact, river flow is about 0.32 m/s when having no rain and maximum 6.0 m/s when having heavy rain. Thus, from Eqs. (2) and (3), it calculate the maximum value of tank length is 1,216 m to treat river water quality C_q towards A2 column for domestic purposes but requiring appropriate treatment technology.

3.6 Calculating the Amount and Arrangement of Eichhornia Crassipes Raft to Treat To Lich River Water to Achieve Quality as A2 Column in Regulation QCVN08

(1) Design raft style: each raft is designed to float, having beveled shape (front and rear) and grid to locate and control growth of eichhornia crassipes, ensure the density of eichhornia crassipes in each raft is 35 single clusters/1 m^2. Dimension is proposed as in Fig. 7 (5.0 m length, 2.0 m width and 8.0 m^2 area).

Table 4 The results of calculating the length of experiment tank corresponding to velocity of experiment flow.

No		Flow velocity on the tank (m/s)	C_0 (mg/L)	C_3 (mg/L)	C_0-C_3 (after 12 m (mg/L)	C_0-C_q (A2) (mg/L)	C_0-C_q (B1) (mg/L)	L_x of tank to reduce C_q to A2 (m)	L_x of tank to reduce C_q to B1 (m)
I	For BOD_5								
1	v1	0.037	22.9	14.7	8.2	16.9	7.9	24.7	12.5
2	v2	0.0099	32.3	17.8	14.5	26.3	17.3	21.8	10.1
3	v3	0.0126	32.6	18.9	13.7	26.6	17.6	23.3	9.3
II	For COD								
1	v1	0.037	65.6	42	23.6	50.6	35.6	25.7	8
2	v2	0.0099	79.4	38.8	40.6	64.4	49.4	19	9.9
3	v3	0.0126	94	52	42	79	64	22.6	7.9
	MAX							25.7	12.5

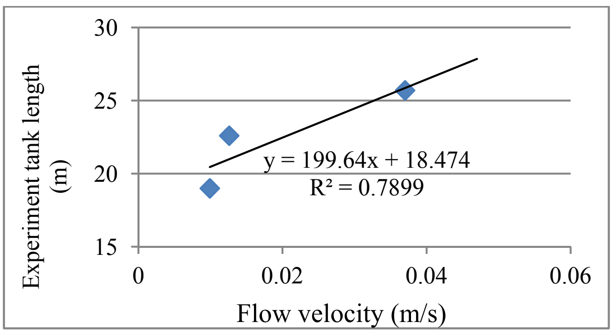


Fig. 6 Relation between experimental flow velocity and length of tank.

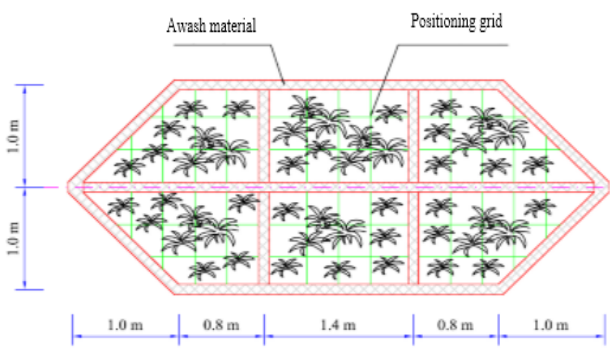


Fig. 7 Raft structure.

(2) Calculating the amount and arrangement of rafts to treat To Lich river water achieving QCVN08: in fact, width of river is about 25 m, and raft arrangement needs to ensure flow circulation. Thus, author proposes raft arrangement as in Fig. 8. With this arrangement, length of river part for rafts is 7,296 m.

4. Conclusion

(1) Studied natural conditions of To Lich river flow, average flow velocity when having no rain is 0.28 m/s, and velocity is 6.0 m/s when having heavy rain;

(2) Based on natural conditions of To Lich river flow, author built experimental model to treat water of To Lich river by eichhornia crassipes with eichhornia crassipes density of 35 single clusters/1 m^2.

When water flows through 12 m length of tank with velocity 0.0099 m/s, concentrations of pollution indicators decreased significantly, BOD_5 ecreased 44.9% and COD decreased 51.1%. When the flow velocity increases, the performance decreases, with the velocity 0.0137 m/s, BOD_5 decreased 35.8% and COD decreased 36%;

(3) Based on the experimental result of the model, the length of treatment tank is 1,296 m to treat river water achieving A2 column of surface water regulation for domestic use but requiring appropriate treatment technology. And based on it, proposed raft design to float, having grid, ensure the density of eichhornia crassipes in each raft is 35 single clusters/1 m^2 (5.0 m length, 2.0 m width and 8.0 m^2 area). With this raft style and arranged into clusters, there are 3 rafts according to river cross section and 5 rafts according to river length. Clusters are arranged staggered, even rows 2 clusters with distance 6 m, odd rows 1 cluster at the center. Space between odd and even clusters is 10 m, then minimum raft amount is 13,683 rafts and arranged river part of 4,864 m length.

If achieving B1 column, it needs 7,212 rafts and arranged in river part of 2,564 m length.

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