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Using Aquatic Plants for Pig Wastewater Treatment After Primary Removal by Biogas Process

Thi Pha Tran[1], Huu Tap Van[2], Thi Huyen Trang Dao[1], Thi Thu Hang Phan[1]

[1]Faculty of Environment, Thai Nguyen University of Agriculture and Forestry, Thai Nguyen City, Viet Nam
[2]Department of Environmental Technology, Faculty of Environment and Earth Sciences, Thai Nguyen University of Sciences (TNUS), Thai Nguyen City, Viet Nam

Email address

tapvh@tnus.edu.vn (H. T. Van)

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Abstract: Research on the use of aquatic plants to treat pig wastewater shows that the growth, development and treatment of pollutants are different by others plant species. Results of treatment of pig wastewater by three aquatic plants including hyacinth, spinach and lucky bamboo were quite high. Lucky bamboo was the most efficiency in removing pig wastewater. After 4 weeks of treatment, DO decreased from 2.96 mg/l to 2.267 mg/l (reached 60.91%). BOD_5 reduced from 13.653 mg/l to 5.707 mg/l (91.08%). After treatment, COD dropped from 17.067 mg/l to 7.133 mg/l (86.07%). TSS removal reached 16.75% (from 34 mg/l to 33.3 mg/l). Cl^- decreased from 8.833 mg/l to 4.567 mg/l (77.72%) and the removal of NO^{3-} was 65.09% (reduced from 1.54 mg/l to 0.641 mg/l. Pts indicator (PO_4^{3-}) decreased from 0.017 mgl to 0.009 mg/l with the efficiency of 99.3% after 4 weeks.

Keywords: Pig Wastewater, Hyacinth, Spinach, Lucky Bamboo and Aquatic Plants

1. Introduction

Pollution from digested piggery wastewater includes organic compounds, nitrogen, phosphorus the veterinary antibiotics and heavy metals. The consequencies of piggery farm are increasing public concern wastewater because of its high pollutants [1, 7]. Several aquatic plants including bulrush (*Scirpus spp.*), cattail (*Typha angustifolia L.*), and vetiver grass (*Vetiveria zizanioides L.*) were used to treat piggery wastewater [9]. Duckweed and azolla plants [8] and hyacinth, water Lettuce and vetiver Grass [10] were also used to remove wastewater.

In this study, treatment efficiency of pollutants by some aquatic species and an algal has been tested under laboratory conditions. It showed that they haved the potential for wastewater treatment [2]. The body and leaves of semi-submerged plants and floating plant roots slow down the flow rate, resulting in changes in the filtration and settling out of the seed, are the living habitat of many algae and microorganisms. Oxygen is transfered from the body and leaves to the roots and released into the root zone, facilitating the nitrification and nitrate reaction. Therefore, aquatic plants play a key role in reducing NH^{4+}, NO^{3-}, PO_4^{3-} as well as TSS and COD from water and wastewater. In addition, the wetland ecosystem consists of mainly aquatic plants, one of the highest primary ecosystems due to the abundance of light, water and nutrients. In Vietnam, plants used to treat domestic wastewater [3, 4, 5, 6], pig wastewater are a novely engineering wich was studied in recent years due to an understanding of absorption and transformation mechanism, pollutant removal by some plant species. The research on the use of plants for treatment of wastewater has also been carried out and applied in practice by some species such as: hyacinth, reed, aquarium, spinach, cilantro, lucky bamboo... etc.

2. Material and Method

2.1. Studying Contents

Assessing the growth capacity of aquatic plants in pig wastewater after the biogas tank.

Assessing the ability of pig wastewater treatment by aquatic plants.

2.2. Methods

2.2.1. Method of Data Collection

Gather information from relevant documents needed for the topic.

2.2.2. Experimental Design

Sampling, analysis of wastewater samples for testing in some pig households:

Experimental design: 4 treatment with 3 replicates:

Treatment 1: Control: water sampling in livestock households.

Treatment 2: Treatment of livestock wastewater by hyacinth.

Treatment 3: Treatment of animal wastewater by spinach.

Treatment 4: Treatment of pig wastewater by lucky bamboo.

* Aquatic plants were stocked in styrofoam containers containing pig wastewater. Styrofoam containers were placed under the roof to prevent rain and sunlight entered in. Samples of pig wastewater were analyzed periodically to determine the ability of pig wastewater treatment by aquatic plants.

* Observating the growth of aquatic plants: counting the number of plants and leaves after 2 and 4 weeks.

* Initial wastewater was taken after 2 and 4 weeks for analysis at Faculty of Environment, Thai Nguyen University of Agriculture and Forestry.

2.2.3. Sampling and Analysis Methods

Monitoring, sampling for analyzing indicators: pH, DO, BOD_5, COD, TSS, Cl^-, NO_3^-, total P.

** Sampling method: pig wastewater sample was taken at the efluent of biogas tank according to TCVN 5995 - 1995.*

** Sample analysis method:*

The concentration of pig wastewater was analyzed in the laboratory, including the following criteria: BOD_5, COD, TSS, NO_3^-, *total P, as follows:*

+ BOD_5: the method of implantation and dilution, titration.

+ COD: oxidation and titration method with $K_2Cr_2O_7$

+ Nitrate: determined by the kjeidahl method, samples were autoclaved with H_2SO_4 acid

+ Phosphate: determined by colorimetric method with blue molybdenum

+ TSS: Determination of content Determined by mass method

+ PH determination: Use a pH meter to measure

2.2.4. Data processing methods

- Use excel and SAS software to process data.

3. Results and Discussion

3.1. Growth Capacity of Aquatic Plants in Pig Wastewater After Biogas Tank

Table 1. *Fluctuations in the number of aquatic plants in the experiment.*

Treatment	Average number of aquatic plants (M ± SD)		
	0 week	After 2 weeks	After 4 weeks
Control	-	-	-
Hyacinth	20	24.33 ± 0.577^b	28.33 ± 0.577^b
Spinach	20	29.33 ± 1.155^a	36 ± 3.464^a
Lucky bamboo	20	22.67 ± 0.577^c	26 ± 1.732^b
LSD_{05}	-	1.6313	4.5168
	Average leaf quantity (M ± SD)		
Control	-	-	-
Hyacinth	116.67 ± 5.774^c	146 ± 3.464^b	170 ± 3.464^b
Spinach	186.67 ± 11.547^a	293.33 ± 11.547^a	360 ± 34.641^a
Lucky bamboo	136.67 ± 5.774^b	158.67 ± 4.041^b	182 ± 12.124^b
LSD_{05}	16.313	14.666	13.169

Note: Numbers with the same index a, b, c (in columns) have negligible differences at significance level $\alpha = 0.05$.

The number of aquatic plants growed rapidly. Results show that the density of aquatic animals increased from week o to week 2 and week 4, especially the spinach, which developed very quickly after 4 weeks.

Hyacinth: The body of the hyacinth was green, fat and larger than original body. This shows that the hyacinth was able to adapt, grow and develop well in this environment. So, the hyacinth can be used to treat pollutants in pig wastewater. Root and leaf of the hyacinth can be collected and processed after growth.

Lucky bamboo: After 4 weeks of growth and development shows that it was high, green, leafy and roots were growing very fast, which indicated that lucky bamboo was able to adapt and treat well pig wastewater.

Spinach: It usually grows on pond banks, drainage ditches, or places containing pig or domestic wastewater. Experiments show that spinach also growed fast in the wastewater. So, spinach was also capable of treating nutrients in wastewater.

The number of leaves of aquatic plants has grown rapidly. The density of aquatic species increased from the beginning of planting to week 2 and week 4, especially after 4 weeks.

Hyacinth: hyacinth growed rapidly, the number of leaves increased from 146 leaves (after 2 weeks) to 170 leaves (after 4 weeks). The body of hyacinth was green and heavier than the original. This shows that hyacinth adapted well in pig wastewater. Roots and the body of whyacinth can be collected and treated after growth.

Lucky bamboo: monitoring the growth and development of lucky bamboo after 4 weeks showed that the leaves and roots growed very fast, high, green, fast; the number of leaves were 158.67 (after 2 weeks) and 182 (after 4 weeks). That proves that lucky bamboo were adaptable in this environment.

After 4 weeks of monitoring the growth and development of spinach show that the leaves growed very fast, high, green; The number of leaves was 293.33 (after 2 weeks) and 360 (after 4 weeks).

This shows that aquatic plants have strong growth and development in pig wastewater.

According to the results of this study, the growth of aquatic plants in treatments was different, the best growth was found in Treatment 3 (spinach), followed by treatment 4 (lucky bamboo), and the lowest growth was in treatment 2 (hyacinth).

3.2. Assessment of the Ability of Pig Waste Water Treatment by Aquatic Plants After Biogas

Table 2. *Ability to treat pig wastewater by aquatic plants after 2 and 4 weeks through assessment of some parameters.*

Parameters		Results (M ± SD)							
		Control	Efficiency (%)	Hyacinth	Efficiency (%)	Spinach	Efficiency (%)	Lucky bamboo	Efficiency (%)
pH	2 weeks	8.267±0.058^{a}	-	7.767±0.115^{b}	-	7.833±0.404^{b}	-	7.6±0.173^{b}	-
	4 weeks	7.507±0.021^{a}	-	7.203±0.196^{ab}	-	7.503±0.023^{a}	-	6.96±0.362^{b}	-
DO (mg/l)	2 weeks	4.447±1.172^{ab}	23.33	3.413±1.137^{b}	41.16	5.667±0.115^{a}	2.29	2.96±0.312^{b}	48.97
	4 weeks	3.727±0.298^{ab}	35.74	3.08±0.849^{bc}	46.9	4.063±0.006^{a}	29.95	2.267±0.289^{c}	60.91
COD (mg/l)	2 weeks	45.2±5.196^{a}	11.72	42.133±4.619^{a}	17.71	46.2±4.33^{a}	9.77	17.067±4.691^{b}	66.67
	4 weeks	23.333±0.577^{a}	54.43	10.133±10.623^{bc}	80.21	21.333±2.309^{ab}	58.33	7.133±6.293^{c}	86.07
BOD_5 (mg/l)	2 weeks	36.160±4.157^{a}	43.5	33.707±3.695^{a}	47.33	36.960±3.464^{a}	42.25	13.653±3.695^{b}	78.67
	4 weeks	18.667±0.462^{a}	70.83	8.107±8.499^{bc}	87.33	17.067±1.848^{ab}	73.33	5.707±5.034^{c}	91.08
TSS (mg/l)	2 weeks	37.33±2.309^{ab}	7.15	36.33±2.309^{ab}	9.2	39.7±0.58^{a}	0.75	34±1.732^{b}	15
	4 weeks	36.3±2.309^{ab}	37	33.7±0.58^{b}	15.75	37.7±1.2^{a}	5.75	33.3±0.023^{b}	16.75
Cl^- (mg/l)	2 weeks	16.167±2.887^{a}	21.14	10.5±3.464^{b}	48.78	16.167±2.887^{a}	21.14	8.833±1.443^{b}	56.91
	4 weeks	10.1±2.771^{a}	50.73	8.167±0.289^{ab}	60.16	10.1±2.771^{a}	50.73	4.567±0.058^{b}	77.72
NO_3^- (mg/l)	2 weeks	1.782±0.0358^{a}	2.94	1.705±0.0485^{a}	7.14	1.798±0.0219^{a}	2.07	1.54±0.1022^{b}	16.12
	4 weeks	1.713±0.062^{a}	6.7	1.316±0.312^{ab}	28.32	1.686±0.086^{a}	8.17	0.641±0.676^{b}	65.09
Total P (mg/l)	2 weeks	1.185±0.0583^{a}	8.21	0.3867±0.633^{b}	70.05	1.152±0.058^{a}	10.77	0.017±0.0017^{b}	98.68
	4 weeks	1.084±0.058^{a}	16.03	0.35±0.578^{b}	72.89	1.051±0.058^{a}	18.59	0.009±0.007^{b}	99.3

Table 2. *Continued.*

Parameters		LSD	QCVN 01-39:2011	QCVN 62:2016
pH	2 weeks	0.4314	6-8.5	5.5-9
	4 weeks	0.3885		
DO (mg/l)	2 weeks	1.5691	-	-
	4 weeks	0.8893		
COD (mg/l)	2 weeks	8.8522	10	300
	4 weeks	11.838		
BOD_5 (mg/l)	2 weeks	7.0818	6	100
	4 weeks	9.4705		
TSS (mg/l)	2 weeks	3.52	3.000	150
	4 weeks	3.31		
Cl^- (mg/l)	2 weeks	5.2204	300	-
	4 weeks	3.7		
NO_3^- (mg/l)	2 weeks	0.7082	50	
	4 weeks	0.7082		
Total P (mg/l)	2 weeks	0.6013	-	-
	4 weeks	0.5494		

Note: Numbers with the same index a, b, c (in columns) have negligible differences at significance level $\alpha = 0.05$.

After 4 weeks of monitoring the growth and development of aquatic plants in pig wastewater, these aquatic plant species growed very well, were highly adaptable to the new environment, especially in pig wastewater containing high levels of nutrients.

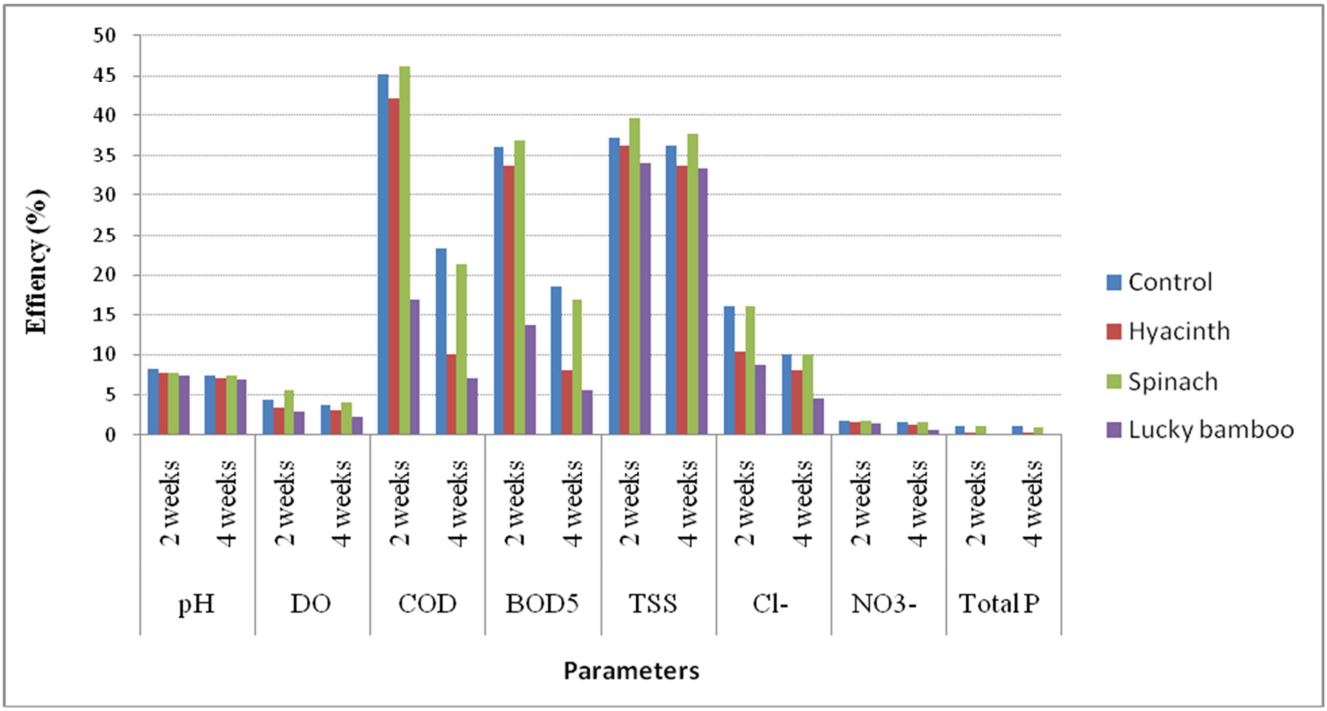

Figure 1. *The efficiency of figgery wastewater treatment by aquatic plants.*

Data after being processed by SAS software for each parameters of (Pr> F) <0.05, which showed the efficiency of treatment of pollutants from pig wastewater, assessed through pH, DO, COD, BOD5, TSS, Cl^-, NO_3^-, total P, by aquatic plants (hyacinth, spinach and lucky bamboo) after 2 and 4 weeks were different at the 0.05 significance level (in other words the efficiency of treating pollutants with reliable aquatic plants at 95% confidence), as follows:

* DO:

In control: DO decreased from 4.447 mg/l (after 2 weeks) to 3.727 mg/l (after 4 weeks). Performance reached 23.33% (after 2 weeks), increased to 35.74% (after 4 weeks).

In treatment by hyacinth: it was 3,413 mg/l (after 2 weeks) reduced to 3.08 mg/l (after 4 weeks). Performance reached 41.16% (after 2 weeks) up to 46.9% (after 4 weeks).

In treatment by spinach: it was 5.667 mg/l (after 2 weeks) decreased to 4.063 mg/l (after 4 weeks). Performance increased from 2.29% (after 2 weeks) to 29.95% (after 4 weeks).

In treatment by lucky bamboo: it decreased from 2.96 mg/l (after 2 weeks) to 2.267 mg/l (after 4 weeks), the efficiency increased from 48.97% to 60.91%, respectively.

After treatment with aquatic plants about 2 and 4 weeks, the concentration of pollutants in pig wastewater decreased significantly. After 2 weeks, the exception of COD exceeding QCVN 01-39: 2011, the remaining paraeters were less than the standard (QCVN 01-39: 2011 and QCVN 62: 2016), specifically:

* COD:

For the control sample: After 2 weeks of treatment, COD remained 45.2 mg/l, exceeding the allowed standard of 4.52 times, it decreased to 23.333 mg/l but still exceeded the allowable standard of 2.333 times for 4 weeks. The processing efficiency was 11.72% (after 2 weeks) and increased to 54.43% after 4 weeks.

For the treatment of hyacinth: COD was at 42.133 mg/l, it exceeded the standard of 4.213 (after 2 weeks) and decreased to 10.133 mg/l, exceeding the allowable standard 1.0133 times after 4 weeks. Performance increased from 17.71% to 80.21% after 4 weeks.

For the treatment of spinach: This indicator reached 46.2 mg /l, exceeding the standard of 4.62 times (after 2 weeks) but reduced to 21.333 mg/l, exceeding 2.133 times after 4 weeks. The efficiency increased from 9.77% (after 2 weeks) to 58.33% (after 4 weeks).

For the treatment of lucky bamboo: it reached 17.067 mg/l, exceeded the standard of 1.7067 times (after 2 weeks) and reduced to 7.133 mg/l, exceeding the permissible standard of 0.7133 times in 4 weeks. Performance increased from 66.67% to 86.07% after 4 weeks.

* BOD_5:

For the control sample: it reached 36.160 mg/l, exceeded the standard of QCVN 01-39: 2011 was 6.027 times, belowed the standard of QCVN 62: 2016 was 0.3616 times (after 2 weeks) decreased to 18.667 mg/l, exceeding the standard of QCVN 01-39: 2011 is 3.11 times, below the standard of QCVN 62: 2016 was 0.18667 times (after 4 weeks). The efficiency increased from 43.5% to 70.83% after 4 weeks.

For the treamtne of hyanch: it reached 36.960 mg/l, exceeded the standard of QCVN 01-39: 2011 was 6.16 times, belowed the threshold of QCVN 62: 2016 was 0.3696 times (after 2 weeks) decreased to 8.107 mg/l, exceeding the standard of QCVN 01-39: 2011 was 1.351 times, belowed the standard of QCVN 62: 2016 was 0.8107 times (after 4 weeks). The performance reached from 47.33% to 87.33%

after 4 weeks.

For the treatment of spinach: It was 33.707 mg/l and exceeded QCVN 01-39: 2011 by 5.617 times, which is lower than QCVN 62: 2016 at 0.33707 times (after 2 weeks) and decreaseed to 17.067 mg/l (after 4 weeks). Performance reached 42.25% and increased to 73.33% after 4 weeks.

For the treatment of lucky bamboo: It reduced to 13.653 mg/l, exceeding the QCVN 01-39: 2011 by 2,276 times, 0.13653 (after 2 weeks) and lower than that of QCVN 62: 2016, decreasing to 5.707 mg/l. (After 4 weeks). Efficiency increased from 78.67% to 91.08%

* Through the table and chart, results of analysis show that: After 2 weeks of treatment of pollutants in pig wastewater, the concentration of pollutants decreased significantly, the efficiency increased significantly.

4. Conclusion

The use of aquatic plants for pig wastewater treatment was quite high. After 4 weeks of treatment, the concentration of pollutants in pig wastewater decreased significantly. BOD_5: decreased from 13.653 mg/l to 5.707 mg/l; Performance reached 91.08% (after 4 weeks). COD decreased from 17.067 mg/l to 7.133 mg/l; Performance reached 86.07% (after 4 weeks). TSS: reduced from 34 mg/l to 33.3 mg/l and reached 16.75%. Cl^- decreased from 8.833 mg/l to 4.567 mg/l; Performance reached 77.72% after 4 weeks. NO^{3-} decreased from 1.54 mg/l to 0.641 mg/l; Performance reached 65.09%. total P (PO^{4-}) decreased from 0.017 mg/l to 0.009 mg/l; Performance reached 99.3% after 4 weeks.

Experimental results show that the treatment of pig wastewater by lucky bmboo decreased significantly such as BOD_5, COD, TSS, Cl^-, NO^{3-}, total P were better than that of hyacinth and spinach. Concentrations of pollutants in pig wastewater in treatments were the difference of 95% confidence. Treamtment 4 (lucky bamboo) was considered to be the best treatment.

References

[1] Carney K. N, Rodgers, Lawlor, Zhan (2011), "A sustaninable technology for the treatment of piggery wastewaters", Proceedings of the Global conference on Global warming, lisbon, Portugal, 1-7.

[2] Dang Dinh Kim, Le Duc, Tran Van Tua, Bui Thi Kim Anh, Dang Thi An (2011), "Phytoremediation", Agricultural Publishing House.

[3] Hoang Hue (1996), Wastewater Treatment, Hanoi Construction Publishing House.

[4] Le Van Binh (2007), "Research on the use of aquatic plants in agriculture and environmental impacts in Thua Thien Hue", Journal of Agriculture and Rural Development (7), p. 3-4.

[5] Le Quoc Tuan (2006), "Bringing aquatic plants into the aquaculture system to clean the aquatic environment", Journal of Science, Hanoi Agricultural University (5), p. 10-15.

[6] Luong Duc Pham (2003), Biological wastewater treatment technology, Educational Publishing House, Hanoi.

[7] Natsima Tokhun (2010), "Piggery farm wastewater: Alternative solution for agriculture and soil fertility", International Journal of Environmental and Rural Development (1-2), p. 58-61.

[8] Nazim Muradov Mohamed Taha, Ana F Miranda, Krishna Kadali, Amit Gujar, Simone Rochfort, Trevor Stevenson, Andrew S Ball, and Aidyn Mouradov (2014), "Dual application of duckweed and azolla plants for wastewater treatment and renewable fuels and petrochemicals production", Biotechnol Biofuels, p. 7-30.

[9] Piyush Gupta, Surendra Roy, Amit B. Mahindrakar (2012), "Treatment of Water Using Water Hyacinth, Water Lettuce and Vetiver Grass - A Review", Resources and Environment (2), p. 202-215

[10] Supaporn Pongthornpruek (2017), "Treatment of Piggery Wastewater by Three Grass Species Growing in a Constructed Wetland", Applied Environmental Research (39), p. 75-83.