

Use of water primrose (*Jussiaea repens* L.) for treatment of some pollutants in domestic wastewater under laboratory condition

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ABSTRACT

The objective of this study was to examine the abilities of *Jussiaea repens* L. in removing organic compounds, nitrogen and phosphorus from domestic wastewater under laboratory conditions. The experimental model consisted of four plastic tanks, each measuring 52 x 32 x 27.5 cm, labeled as NT1, NT2, and NT3 corresponding to 150, 300, and 450 g of *Jussiaea repens* L., respectively. The control tank contained only domestic wastewater without the plants. The input domestic wastewater parameters (mean $\pm$ standard deviation, $n = 3$) were as follows: pH = 6.66 ± 0.32 , BOD₅ (Biological oxygen demand) = 347.64 ± 39.60 mg/L, NH₄⁺ = 27.53 ± 1.74 mg/L, NO₃⁻ = 2.23 ± 0.26 mg/L, and PO₄³⁻ = 24.69 ± 1.27 mg/L. After twenty days of experimentation, the tank containing 450 g of plants achieved the highest treatment efficiencies for BOD₅, NH₄⁺ and NO₃⁻, with respective efficiencies of 29.1, 24.2, and 43.8%. Regarding phosphate removal, the tank (NT2) using 300 g of plants achieved the highest treatment efficiency (by plants), with a reduction of 9.5% after 20 days.

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1. Introduction

Natural aquatic plants are widely used for wastewater purification. *Jussiaea repens* L., locally known as Water Primrose, has garnered considerable attention in recent years for its promising potential in wastewater treatment. Numerous studies have highlighted the remarkable ability of *Jussiaea repens* L. to remediate various pollutants present in wastewater. *Jussiaea repens* L. has ability to reduce the concentrations of NO_3^- , NH_4^+ , PO_4^{3-} , COD, coliforms in slaughterhouse wastewater (Vo & Tran, 2008; Dang & Hoang, 2018). Moreover, *Jussiaea repens* L. causes decreased levels of Cu and Hg in wastewater (Chandra et al., 2018; Gupta, 2021). Thus, *Jussiaea repens* L. can be effectively utilized for detoxification of heavy metals (Mukhopadhyay et al., 2016).

In this research, *Jussiaea repens* L. was tested to remove organic compounds, nitrogen (in the forms of NH_4^+ and NO_3^-) and phosphorus from contaminated domestic wastewater and satisfactory results were obtained. The objective of this study was to examine the abilities of *Jussiaea repens* L. in removing organic compounds, nitrogen and phosphorus from domestic wastewater under laboratory conditions.

2. Materials and Methods

2.1. Domestic wastewater characteristics

Domestic wastewater was collected from the collecting tank of Soho Residence (Figure 1), located at No. 100 Co Giang Street, district 1, Ho Chi Minh City, Vietnam, between 7:00 and 8:00 AM, from November 2023 to February 2024, in accordance with TCVN 6663-1:2011 and ISO 5667-1:2006 standards. The input domestic wastewater quality parameters (mean $\pm$ standard deviation, $n = 3$) were as follows: pH = 6.66 ± 0.32 , $\text{BOD}_5 = 347.64 \pm 39.60$ mg/L, $\text{NH}_4^+ = 27.53 \pm 1.74$ mg/L, $\text{NO}_3^- = 2.23 \pm 0.26$ mg/L, $\text{PO}_4^{3-} = 24.69 \pm 1.27$ mg/L.

2.2. Conditions of *Jussiaea repens* L.

Jussiaea repens L. was harvested from Tan Tru district, Long An province before each experimental session (Figure 2). The plants were fresh, healthy, free from pests and diseases, and uniform in size. After harvesting, the plants were put in domestic wastewater for 2 days to acclimate before being introduced into the experimental model.



Figure 1. Sampling of domestic wastewater.



Figure 2. Sampling of *Jussiaea repens* L.

2.3. Experimental model

The experimental model consisted of four plastic tanks (Figure 3), each measuring 52 x 32 x 27.5 cm, labeled as NT1, NT2, and NT3 corresponding to 150, 300, and 450 g of *Jussiaea repens* L., respectively. The control tank contained only domestic wastewater without the

plants. After collecting and analyzing the input parameters, domestic wastewater was added to each tank at a volume of 20 L. Concentrations of BOD₅, NH₄⁺, NO₃⁻, and PO₄³⁻ of the wastewater were determined on day 5, 10, 15, and 20. The experiments were repeated three times.



Figure 3. Experimental model.

2.4. Analytical methods

Biological oxygen demand (BOD₅) was analyzed according to TCVN 6001-2:2008 (MSAT, 2008a), NH₄⁺ was analyzed according to TCVN 5988:1995 (MSAT, 1995), NO₃⁻ was analyzed according to SMEWW 4500-NO₃⁻.B:2023 and PO₄³⁻ was analyzed according to TCVN 6202:2008 (MSAT, 2008b). All parameters were analyzed by Research Institute for Biotechnology and Environment, Nong lam University, Ho Chi Minh City, Vietnam.

2.5. Statistical analysis

All data were presented as mean ± standard deviation (SD). Level of parameters in domestic wastewater were compared to the QCVN 14:2008/BTNMT standards (MONRE, 2008). Statistical analysis was conducted using IBM SPSS Statistics for Windows, version 27.0. The significance level was set at $P < 0.05$. A Tukey test, in conjunction with one-way analysis of variance (ANOVA) with replication, were used to evaluate differences in parameter levels in treated domestic wastewater over time.

The Total removal efficiency was calculated using the following equation:

$$\text{Total Removal efficiency (\%)} = \frac{C_0 - C_{20}}{C_0} \times 100\%$$

Where, C_0 (mg/L) represents the concentrations of parameters on day 0 (input concentrations), and C_{20} (mg/L) represents the concentrations of parameters on day 20.

The removal efficiency (by *Jussiaea repens* L.) was calculated using the following equation:

$$\text{Removal efficiency (by } Jussiaea repens \text{ L.) (\%)} = \text{Removal efficiency (Total - Control)}$$

3. Results and Discussion

3.1 pH

The pH of the wastewater tended to slightly increase, from an initial pH of 6.66 ± 0.32 to a range of 7.06 ± 0.08 to 7.29 ± 0.63 after 20 days of experimentation. The reason was that *Jussiaea repens* L. absorbed CO_2 to carry out the photosynthesis process, leading to an increase in pH of the wastewater. Conversely, H^+ and bicarbonate (HCO_3^-) can be produced due to the reaction of CO_2 and water according to the mechanism: $\text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{CO}_3 \leftrightarrow \text{H}^+ + \text{HCO}_3^-$ (Kanabkaew & Puetpaiboon, 2004), thereby causing a decrease in pH. However, CO_2

absorbed by aquatic plants for photosynthesis is faster than the amount of CO_2 generated from the respiratory process of the aquatic plants. Consequently, plants must take CO_2 from the metabolism of HCO_3^- ($2\text{HCO}_3^- \rightarrow \text{CO}_2 + \text{CO}_3^{2-} + \text{H}_2\text{O}$) (Kanabkaew & Puetpaiboon, 2004). As a result, pH of the water increases.

3.2 Biological oxygen demand (BOD₅) removal

Organic matters can be assimilated by plants (Vymazal & Kropfelova, 2009). The microbes around the roots can also contribute to the purification. Thus, the organic matter can be removed effectively (Nguyen et al., 2018).

Table 1. Concentrations of BOD₅ (mean $\pm$ SD, n = 3) over time

Time (day)	BOD ₅ (mg/L)			
	Control	NT1	NT2	NT3
0	347.64 ± 39.60			
5	247.67 ± 67.58	260.45 ± 80.38	291.55 ± 18.29	314.34 ± 49.54
10	291.62 ± 72.99	253.39 ± 85.90	347.64 ± 39.60	230.00 ± 7.60
15	156.07 ± 27.53^b	147.31 ± 29.15^b	212.92 ± 15.02^a	71.76 ± 6.14^c
20	139.71 ± 39.99^a	54.62 ± 7.78^b	85.83 ± 11.95^{ab}	38.68 ± 5.00^b
Total removal efficiency (%)	59.80	84.30	75.30	88.90
By <i>Jussiaea repens</i> L. (%)		24.50	15.50	29.10

Mean values in the same rows with different superscript letters differ significantly ($P < 0.05$). BOD₅: Biological oxygen demand; NT1: 150 g of *Jussiaea repens* L.; NT2: 300 g of *Jussiaea repens* L.; NT3: 450 g of *Jussiaea repens* L.

The concentrations of organic compounds tended to decline over time (Table 1). The initial BOD₅ of 347.64 ± 39.60 mg/L was reduced to 54.62 ± 7.78 (NT1), 85.83 ± 11.95 (NT2) and 38.6708 ± 5.0015 mg/L (NT3) after 20 days, corresponding to the total removal efficiencies of 84.3, 75.3, and 88.9% respectively. Meanwhile, the control sample (without *Jussiaea repens* L.) showed a less significant reduction in organic concentration compared to those with *Jussiaea repens* L. From 347.64 ± 39.60 mg/L at the beginning, it was decreased to 139.71

± 39.99 mg/L at day 20, corresponding to the total treatment efficiency of 59.8%. Therefore, the BOD₅ removal efficiencies by plants were 24.5, 15.5, and 29.1% for NT1, NT2, and NT3, respectively (Table 1). BOD₅ level at day 20 of the control, NT1 and NT2 exceeded the permitted standards of the QCVN 14:2008/BTNMT (column B, BOD₅ ≤ 50 mg/L) (MONRE, 2008) by 2.8-, 1.1- and 1.7-fold, respectively. Meanwhile, the BOD₅ concentration of NT3 after 20 days was within the permissible limits of QCVN 14:2008/BTNMT. Differences in

concentrations of BOD₅ between NT1 and the control, as well as between NT3 and the control on day 20, were both statistically significant ($P < 0.05$). However, there were no statistically significant differences in concentrations of BOD₅ among tanks containing plants (NT1, NT2 and NT3) at the end of the experiments ($P > 0.05$) (Table 1).

3.3. Ammonium NH₄⁺ removal

Concentrations of ammonium NH₄⁺ on days 0, 5, 10, 15 and 20 for NT1, NT2, NT3 and the control were presented in Table 2.

Table 2. Concentrations of ammonium NH₄⁺ (mean $\pm$ SD, n = 3) over time

Time (day)	NH ₄ ⁺ (mg/L)			
	Control	NT1	NT2	NT3
0	27.53 $\pm$ 1.74			
5	18.73 $\pm$ 3.68 ^a	15.88 $\pm$ 1.86 ^a	17.00 $\pm$ 2.02 ^{ac}	24.53 $\pm$ 1.74 ^b
10	18.06 $\pm$ 2.54	15.66 $\pm$ 2.61	14.77 $\pm$ 4.52	21.72 $\pm$ 3.19
15	17.03 $\pm$ 3.28	14.87 $\pm$ 1.31	14.63 $\pm$ 3.58	16.57 $\pm$ 2.09
20	15.83 $\pm$ 2.70 ^a	12.43 $\pm$ 2.75 ^{ab}	14.27 $\pm$ 2.70 ^{ab}	9.17 $\pm$ 0.61 ^b
Total removal efficiency (%)	42.50	54.90	48.20	66.70
By <i>Jussiaea repens</i> L. (%)	-	12.40	5.70	24.20

Mean values in the same rows with different superscript letters differ significantly ($P < 0.05$). NT1: 150 g of *Jussiaea repens* L.; NT2: 300 g of *Jussiaea repens* L.; NT3: 450 g of *Jussiaea repens* L.

The concentrations of ammonium NH₄⁺ (mg/L) in domestic wastewater tended to decrease over time, from 27.53 $\pm$ 1.74 mg/L at day 0 to 15.83 $\pm$ 2.70 mg/L at day 20, corresponding to the Total removal efficiency of 42.5%, even without using *Jussiaea repens* L. However, the concentrations of ammonium decreased more in tanks containing plants. After 20 days of experimentation, the ammonium concentrations were only 12.43 $\pm$ 2.75 (NT1), 14.27 $\pm$ 2.70 (NT2), and 9.17 $\pm$ 0.61 mg/L (NT3). The highest ammonium removal efficiency by *Jussiaea repens* L. after 20 days was 24.2% (NT3), followed by NT1 (12.4%), with NT2 having the lowest efficiency at 5.7% (Table 2). After 20 days of experimentation, the

Ammonium concentration of NT3 was within the permissible limits of QCVN 14:2008/BTNMT. Meanwhile, the concentration of Ammonium at day 20 of the control, NT1 and NT2 exceeded the permitted standards of the QCVN 14:2008/BTNMT (column B, NH₄⁺ $\leq$ 10 mg/L) (MONRE, 2008) by 1.6-, 1.2- and 1.4-fold, respectively. Differences in concentrations of ammonium between NT3 and the control at the end of the experiments were statistically significant ($P < 0.05$). However, there were no statistically significant differences in concentrations of ammonium among tanks containing plants (NT1, NT2, and NT3) at the end of the experiment ($P > 0.05$).

3.4. Nitrate NO_3^- removal

Concentrations of nitrate NO_3^- on days 0, 5, 10, 15 and 20 for NT1, NT2, NT3 and the control were presented in Table 3.

Table 3. Concentrations of nitrate NO_3^- (mean $\pm$ SD, $n = 3$) over time

Time (day)	NO_3^- (mg/L)			
	Control	NT1	NT2	NT3
0	2.23 ± 0.26			
5	1.87 ± 0.91	1.13 ± 0.19	1.64 ± 0.75	1.32 ± 0.90
10	1.68 ± 0.11^a	1.05 ± 0.06^b	0.66 ± 0.31^{bc}	0.22 ± 0.13^c
15	1.30 ± 0.46^a	0.41 ± 0.30^b	0.56 ± 0.27^{ab}	0.20 ± 0.11^b
20	1.04 ± 0.213^a	0.38 ± 0.13^b	0.55 ± 0.28^{ab}	0.15 ± 0.10^b
Total removal efficiency (%)	48.80	81.10	72.80	92.60
By <i>Jussiaea repens</i> L. (%)	-	32.30	40.50	43.80

Mean values in the same rows with different superscript letters differ significantly ($P < 0.05$). NT1: 150 g of *Jussiaea repens* L.; NT2: 300 g of *Jussiaea repens* L.; NT3: 450 g of *Jussiaea repens* L.

If *Jussiaea repens* L. was not used, nitrate was also partly removed due to the self-clean ability of wastewater. The nitrate concentrations decreased from 2.23 ± 0.26 mg/L at day 0 to 1.040 ± 0.213 mg/L at day 20. However, the use of *Jussiaea repens* L. enhanced the ability to remove nitrate from wastewater. After 20 days, the nitrate concentrations remaining in the wastewater was 0.38 ± 0.13 (NT1), 0.55 ± 0.28 (NT2), and 0.15 ± 0.10 mg/L (NT3), with the treatment efficiencies by *Jussiaea repens* L. of 32.3, 40.5, and 43.8%, respectively (Table 3). After 20 days of experimentation, the nitrate concentrations of all tanks were within the permissible limits of QCVN 14:2008/BTNMT (column B, $\text{NO}_3^- \leq 50$ mg/L) (MONRE, 2008). Differences in concentrations of nitrate between NT3 and the control at the end of the experiments were statistically significant ($P < 0.05$). However, there were no statistically significant differences in concentrations of nitrate among tanks containing plants (NT1,

NT2, and NT3) at the end of the experiment ($P > 0.05$).

Total nitrogen in wastewater refers to the sum of all nitrogen compounds present in the water, including organic nitrogen, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen. The primary pathways for removing ammonium from wastewater involve uptake and oxidation processes by plants or microbes, known as nitrification. The mechanism of nitrification involves the conversion of NH_4^+ to NO_3^- , proceeding through the steps: $2\text{NH}_4^+ + 3\text{O}_2 \rightarrow 4\text{H}^+ + 2\text{NO}_2^- + 2\text{H}_2\text{O}$, followed by $2\text{NO}_2^- + \text{O}_2 \rightarrow 2\text{NO}_3^-$. Subsequently, the reduction of nitrate to nitrogen gas occurs through a bacterially catalyzed process known as denitrification. The denitrification mechanism is represented as: $4\text{NO}_3^- + 5\{\text{CH}_2\text{O}\} + 4\text{H}^+ \rightarrow 2\text{N}_2 + 5\text{CO}_2 + 7\text{H}_2\text{O}$ (Manahan, 2000). Once NO_3^- has been denitrified, it was released in the atmosphere as dinitrogen gas (N_2) (Fu & He, 2015).

3.5. Phosphate PO₄³⁻ removal

Concentrations of phosphate on days 0, 5, 10, 15 and 20 for NT1, NT2, NT3 and the control were presented in Table 4.

Table 4. Concentrations of PO₄³⁻ (mean ± SD, n = 3) over time

Time (day)	PO ₄ ³⁻ (mg/L)			
	Control	NT1	NT2	NT3
0	24.69 ± 1.27			
5	20.15 ± 1.42 ^a	22.49 ± 0.78 ^{ab}	16.88 ± 0.56 ^{ac}	23.95 ± 2.18 ^{ab}
10	16.39 ± 0.73 ^a	20.43 ± 1.50 ^b	16.55 ± 0.49 ^a	18.87 ± 0.56 ^{ab}
15	14.79 ± 1.24 ^b	16.94 ± 0.99 ^{ab}	12.48 ± 0.49 ^{bc}	17.82 ± 0.70 ^a
20	13.99 ± 1.11 ^a	11.92 ± 0.16 ^b	11.64 ± 0.33 ^b	12.57 ± 0.52 ^{ab}
Total removal efficiency (%)	43.40	51.70	52.90	49.10
By <i>Jussiaea repens</i> L. (%)	-	8.30	9.50	5.70

Mean values in the same rows with different superscript letters differ significantly ($P < 0.05$). NT1: 150 g of *Jussiaea repens* L.; NT2: 300 g of *Jussiaea repens* L.; NT3: 450 g of *Jussiaea repens* L.

The phosphate concentrations in domestic wastewater tanks with *Jussiaea repens* L. and the control decreased over time. Among them, the control had the lowest total phosphate treatment efficiency, 43.4% after 20 days (corresponding to the initial phosphate concentration of 24.69 ± 1.27 mg/L decreasing to 14.79 ± 1.24 mg/L). Among the tanks containing *Jussiaea repens* L., NT2 had the highest total treatment efficiency, 52.9%, corresponding to the phosphate concentration decreased from 24.69 ± 1.27 to 11.64 ± 0.33 mg/L after 20 days. NT1 and NT3 had total phosphate treatment efficiencies of 51.7 and 49.1%, respectively, with phosphate concentrations decreasing to 11.92 ± 0.16 and 12.57 ± 0.52 mg/L at the end of the experiments. Therefore, the phosphate removal efficiencies (by *Jussiaea repens* L.) after twenty days were 8.3, 9.5, and 5.7% for NT1, NT2, and NT3 respectively (Table 4).

After 20 days of experimentation, the phosphate concentrations of the control, NT1, NT2 and NT3 were all exceeded the permitted standards of the QCVN 14:2008/BTNMT (column B, PO₄³⁻ ≤ 10 mg/L) (MONRE, 2008) by 1.4-, 1.2-, 1.2- and 1.3-fold, respectively. Differences in concentrations of phosphate between NT1 and the control, as well as between NT2 and the control on day 20, were both statistically significant ($P < 0.05$). However, there were no statistically significant differences in concentrations of phosphate among tanks containing plants (NT1, NT2 and NT3) at the end of the experiments ($P > 0.05$) (Table 4).

Similar to nitrogen, phosphorus is the essential nutrient for plant growth. It can be assimilated by plants and be converted into various kinds of organic matter of plants (Xiaoping et al., 2005). The initial fresh weight of *Jussiaea repens* L. were 150 (NT1), 300 (NT2) and 450 g (NT3). After 20 days of experimentation, the fresh weight

of *Jussiaea repens* L. in NT1, NT2, and NT3 increased to 170.67 ± 3.06 , 388.33 ± 10.02 , and 602.67 ± 7.09 g, respectively. The equivalent percentages compared to the initial fresh weight of plants were 113.8, 129.4, and 133.9% for NT1, NT2 and NT3, respectively. Floating plants have developed roots, which can effectively absorb nutrients in the water body (Su et al., 2019). *Jussiaea repens* L., therefore, could assimilated PO_4^{3-} in wastewater and make a reduction in phosphate concentrations.

4. Conclusions

The influent domestic wastewater contained the average of 347.64 mg/L of BOD_5 , 27.53 mg/L of NH_4^+ , 2.23 mg/L of NO_3^- , and 24.69 mg/L of PO_4^{3-} , with pH of 6.66. When using *Jussiaea repens* L., pH slightly increased to a range of 7.06 to 7.29, while the concentrations of BOD_5 , nitrogen (in the forms of NH_4^+ and NO_3^-), and phosphorus (PO_4^{3-}) decreased over time. The tank (NT3) using 450 g of *Jussiaea repens* L. achieved the highest treatment efficiencies for BOD_5 , NH_4^+ and NO_3^- by *Jussiaea repens* L. after 20 days, with respective efficiencies of 29.1, 24.2, and 43.8%. Regarding phosphate removal, the tank (NT2) using 300 g of *Jussiaea repens* L. achieved the highest treatment efficiency (by plants), which was 9.5%, after 20 days.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

References

- Chandra, R., Dubey, N. K., & Kumar, V. (2018). *Phytoremediation of environmental pollutants* (1st ed.). Florida, USA: CRC Press.
- Dang, H. T. T., & Hoang, T. H. (2018). Study into the treatment of water in Nhu Y river, Hue city by water primrose (*Jussiaea repens* L.) in the laboratory scale. *HUAF Journal of Agricultural Science and Technology* 2(2), 683-692. <https://doi.org/10.46826/huaf-jasat.v2n2y2018.154>.
- Fu, X., & He, X. (2015). Nitrogen and phosphorus removal from contaminated water by five aquatic plants. In Chan, A.P.C., Hong, W., Mellal, M.A., Narayanan, R., Nguyen, Q.N., Ong, H.C., Sachsenmeier, P., Sun, Z., Ullah, S., Wu, J. and Zhang, W. (Eds.). *Proceedings of The International Conference on Mechatronics, Electronic, Industrial and Control Engineering (MEIC 2015)* (1394–1397). Paris, France: Atlantis Press. Retrieved July 1, 2017, from <https://doi.org/10.2991/meic-15.2015.290>.
- Gupta, A. (2021). *Heavy metal and metalloid contamination of surface and underground water: Environmental, policy, and ethical issues* (1st ed.). Oxon, UK: CRC Press.
- Kanabkaew, T., & Puetpaiboon, U. (2004). Aquatic plants for domestic wastewater treatment: Lotus (*Nelumbo nucifera*) and Hydrilla (*Hydrillaverticillata*) systems. *Songklanakarin Journal Science Technology* 26(5), 749-756.
- Manahan, S. E. (2000). *Environmental chemistry* (7th ed.). Washington DC, USA: Lewis Publisher.

- MSAT (Ministry of Science and Technology). (2008a). Vietnam standard No. TCVN 6001-2:2008. Water quality – determination of biochemical oxygen demand after n days (BOD_n) - Part 2: Method for undiluted samples. Retrieved May 24, 2024, from <https://luatvietnam.vn/tai-nguyen/tcvn-6001-2-2008-xac-dinh-nhu-cau-oxy-sinh-hoa-cua-nuoc-khi-khong-pha-loang-168378-d3.html>.
- MSAT (Ministry of Science and Technology). (2008b). Vietnam standard No. TCVN 6202:2008. Water quality – determination of phosphorus – ammonium molybdate spectrometric method. Retrieved May 24, 2024, from <https://luatvietnam.vn/tai-nguyen/tcvn-6202-2008-xac-dinh-phospho-tronh-nuoc-bang-do-pho-dung-amoni-molipdat-169842-d3.html>.
- MSAT (Ministry of Science and Technology). (1995). Vietnam standard No. TCVN 5988:1995. Water quality - Determination of aminonium - Distillation and titration method. Retrieved April 19, 2024 from <https://luatvietnam.vn/tai-nguyen/tieu-chuan-viet-nam-tcvn-5988-1995-223208-d3.html>.
- MONRE (Ministry of Natural Resources and Environment). (2008). National technical regulation No. QCVN 14:2008/ BTNMT on domestic wastewater dated December 31, 2008. Retrieved March 15, 2024, from <https://thuvienphapluat.vn/TCVN/Tai-nguyen-Moi-truong/QCVN-14-2008-BTNMT-nuoc-thai-sinh-hoat-901760.aspx>.
- Mukhopadhyay, B., Banerjee, A., & Ghosh, S. (2016). Studies on hyper accumulation of Mercury by *Jussiaea repens* under laboratory condition. *International Journal of Advances in Scientific Research* 2(12), 188-190. <https://doi.org/10.7439/ijasrv2i12.3783>.
- Nguyen, T. V. D., Huynh, H. N. T., Nguyen, M. N. H., & Ngo, T. V. (2018). The use of water spinach (*Ipomoea aquatica*) in domestic wastewater treatment. *The Journal of Agriculture and Development* 17(3), 49-54. <https://doi.org/10.52997/jad.7.03.2018>.
- Su, F., Li, Z., Li, Y., Xu, L., Li, Y., Li, S., Chen, H., Zhuang, P., & Wang, F. (2019). Removal of total nitrogen and phosphorus using single or combinations of aquatic plants. *International Journal of Environmental Research and Public Health* 16(23), 4663. <https://doi.org/10.3390/ijerph16234663>.
- Vo, H. T. M., & Tran, T. T. (2008). Study on biophysical and biochemical composition and the ability of treatment to the slaughterhouse wastewater of *Jussiaea repens* L. *Hue University Journal of Science* 48, 1-2.
- Vymazal, J., & Kropfelova, L. (2009). Removal of organics in constructed wetlands with horizontal subsurface flow: A review of the field experience. *Science Total Environment* 407(13), 3911. <https://doi.org/10.1016/j.scitotenv.2008.08.032>.
- Xiaoping, Z., Jianguo, W., Lihong, X., Xiaofeng, X., & Linzhang, Y. (2005). N and P removal characters of eutrophic water body under planted float. *Chinese Journal of Applied Ecology* 16(11), 2199-2203.