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Nutrient concentration variations during *Oenanthe javanica* growth and decay in the ecological floating bed system

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Abstract

The ecological floating bed system is a natural alternative to technical methods of wastewater treatment and involves complex processes induced by plants or microorganisms in the wastewater. This study aimed to identify nutrient concentration variations during *Oenanthe javanica* (Blume) DC growth and decay in the ecological floating bed system. Results showed that the third-order polynomial equation was suitable to describe pollutant concentration changes, showing that the effect of *O. javanica* ecological floating bed system on polluted water could be divided into the purification phase and decay phase. During the purification phase, nutrient concentrations rapidly decreased because *O. javanica* influenced water microbial communities and water physical parameters (i.e., dissolved oxygen, pH, and temperature), and had a direct uptake of nutrients. However, during the decay phase, nitrogen and phosphorus concentrations in the plant tissues decreased, and these lost nutrients ultimately transferred to water and led to water quality deterioration. Results also showed that the uptake and storage of *O. javanica* in nutrients were temporary and the plant served only as media of the nutrients removed from the water. Under these circumstances, harvesting was an appropriate intervention to improve the treatment efficiency of *O. javanica* ecological floating bed system.

Key words: *Oenanthe javanica* ecological floating bed; purification; decay; polluted water

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Introduction

Ecological engineering programs are natural alternatives that offer simple, cheap, and energy-efficient methods for wastewater treatment, and are thus widely used over the world. These programs include constructed wetlands (Haberl et al., 1995; Hammer, 1992), floating aquatic macrophytes (Sooknah and Welkie, 2004), mosaic community of macrophytes (Wang et al., 1997), and physico-ecological engineering (Pu et al., 1997). Some of these methods have already been implemented in treating polluted water, such as domestic wastewater (Huang et al., 2000; Neralla et al., 2000), agricultural runoff (Bezbaruah and Zhang, 2003; Hammer, 1992; Huett et al., 2005; Yang et al., 2008), tannery wastewater (Calheiros et al., 2007), farm wastewater (Van der Valk and Jolly, 1992), irrigation drainage water (Li and Freindrich, 2002), dairy wastewater (Mantovi et al., 2003; Sooknah and Welkie, 2004), fish farm wastewater (Comeau et al., 2001; Naylor et al., 2003; Zachritz and Jacquez, 1993), landfill wastewater (Alessandro and Stefano, 2009; McBean and Rovers, 1999), and urban runoff (Field et al., 1997; Chang et al., 2006; Lee and Bang, 2000). Previous studies have indicated that ecological restoration has a positive effect on pollutant removal (Kivaisi, 2001; Susan and John, 1996; Vathalie et al., 2003), and may offer a cost-efficient and sustainable method of pollution wastewater treatment, which is especially suitable for developing countries (Haberl et al., 1995; Hammer, 1992; Kadlec, 1995). A disadvantage of such systems is the requirement of a large area, which has limited the construction of wetlands, ecotones, mosaic community of macrophytes, and physico-ecological engineering all over the world.

Recently, there has been growing interest in the use of ecological floating bed systems to control water pollution from small towns and villages for the protection of vulnerable rivers. Ecological floating bed systems require only an experimental field and no new equipment; it can accomplish remediation and pollutant removal, and is affordable, easy to maintain, and environment friendly (Huett et al., 2005; Yang et al., 2008). Among the various ecological floating bed systems, the purification effect has been studied extensively in laboratories and pilot levels for large-scale nutrient removal from wastewaters (Guo et al., 2007; Song et al., 1998; Sooknah and Welkie, 2004; Sun et al., 2009). However, most of previous studies have focused only on the purification phase and effectiveness of the system in treating polluter water. There are no reports

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on the influence of plant senesce and decay as seasons change on water composition.

This study aims to monitor the nutrient concentration variations in an ecological floating bed system during the *Oenanthe javanica* (Blume) DC growth and decay process, to analyze the mechanism of wastewater pollutant purification of *O. javanica*, and to evaluate the decomposition of *O. javanica* when excavated by harvesting.

1 Materials and methods

1.1 Plant material

O. javanica are fast-growing macrophytes capable of growing well in polluted water and tolerate freezing temperatures during winter. Its flourishing roots play an important role in polluted water remediation, and have made it the preferred organism for ecological floating beds. In this study, *O. javanica* of uniform size were collected from the garden center of Xianlin University City (Nanjing, China). They were pre-cultured to allow for adaptation before experimentation. After one week, they were thoroughly washed with deionized water and planted into ecological floating beds.

1.2 Experiment water

Polluted water was collected from the Sanyong River (Nanjing, China). The properties of experiment water as follows: total nitrogen (TN) (12.00 ± 0.58) mg/L; NH_4^+-N (9.00 ± 0.33) mg/L; total phosphorus (TP) (0.68 ± 0.02) mg/L and chemical oxygen demand (COD) (30.00 ± 5.68) mg/L.

1.3 Experimental design

The experiments were operated during April 2007 to June 2007 (63 days) at the Water Environment Ecological Remediation Platform of the Key Laboratory of Jiangsu Province, China (latitude 32°02′N and longitude 118°50′E). Experiments were performed in this platform with a glass roof, thus facilitating natural photoperiods while excluding the effects of rainfall.

A plastic tank (internal dimension of 66 cm length × 50 cm width × 38 cm height) contained floating beds made from 4-cm thick perforated polystyrene foam sheets. *O. javanica* seedlings were evenly planted into the beds at a plant density of 50 m^{-2}. The tank was filled with 40 L experiment water, and the same volume was placed in another tank with the same size to serve as a control. The control system contained floating beds without plants. Losses in water volume due to evapotranspiration were countered by the addition of deionized water up to the original level every week, by which time the level had decreased by an average of 2 cm. Water sampling was performed on the second day following volume adjustment, so that the deionized water added would impact measurements minimally. The experiment was done in triplicates.

1.4 Sampling and analysis

Water samples were collected once a week at 10:00 am. TN, NH_4^+-N, NO_3^--N, and TP were analyzed using flow injection analysis on a Skalar San^{++} Automated Ion Analyzer (Skalar Co., The Netherlands). COD was measured according to standard methods (State Environmental Protection Administration of China, 2002). Temperature, pH, and dissolved oxygen (DO) at sampling sites were monitored on-site every day at 10:00 am.

To obtain initial biomass dry weight, two sets of plants having similar fresh weight were taken for each subtreatment at the beginning of the experiment. One set was used in the experiment, while the other was dried for 72 hr at 70°C and its measured weight used to estimate the initial biomass. At the end of the experiment, all living plant material, both above and below ground, were harvested, while dead plant material that fell into the water were taken and separated into roots, stems, and leaves, and then dried to constant mass at 70°C. Dried and weighed plant material were ground to less than 1 mm for analysis of TN and TP.

1.5 Statistical analysis

A one-way analysis of variance (ANOVA) was conducted to examine the differences between the *O. javanica* ecological floating bed system and the control system, which were considered significant when $p < 0.05$ (SPSS16.0).

2 Results

2.1 Model description of nutrient concentration dynamic changes in the *O. javanica* ecological floating bed system

A total of six equations, including first-order, second-order, and third-order polynomial equations, logarithmic equation, exponential equation, and the power equation, are used to describe the experimental data of TN, NH_4^+-N, TP, and COD_{Mn} concentration dynamic changes in the *O. javanica* ecological floating bed system. Based on the R^2 values of these equations (Table 1), the third-order polynomial equation is the most suitable model to describe the pollutant concentration changes (Table 2). Based on these models, the effect of the *O. javanica* ecological floating bed system on polluted water could be divided into two phases: the purification phase and the decay phase.

2.2 Nutrient changes in the purification phase

Figure 1 and Table 3 present variations in nutrient concentrations during the purification phase in the *O. javanica* ecological floating bed system in the purification phase. Results show that *O. javanica* systems can rapidly remove large amounts of nutrients and effectively control pollution in water. Despite corresponding decreases in the control system over the same time period, nutrient removal efficiency of *O. javanica* systems were significantly higher than that of the control system ($p < 0.05$).

The concentration of NO_3^--N shows a trend unlike those of the other nutrients during the purification phase: it rapidly increased and accumulated to a maximum value of 0.23 (91.67%) within 34 days in the *O. javanica* systems, while it decreased by 25.00% over the same time period in the

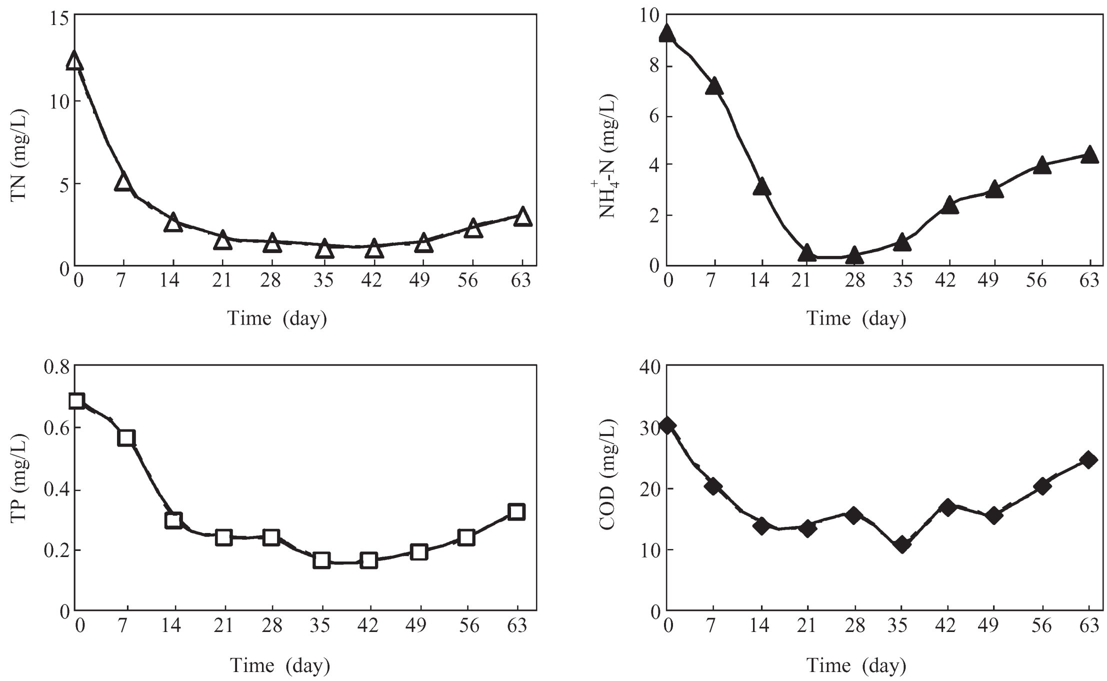

Fig. 1 Nutrient concentration variations in the *O. javanica* ecological floating bed system.

Table 1 R^2 values of the models for nutrient concentration dynamic changes in *O. javanica* ecological floating bed systems

Parameter	First-order polynomial equation	Second-order polynomial equation	Third-order polynomial equation	Logarithmic equation	Exponential equation	Power equation
TN	0.3597	0.8695*	0.964**	0.6644	0.3037	0.5864
NH_4^+-N	0.1538	0.9023*	0.945**	0.3863	0.0105	0.1075
TP	0.1029	0.8419*	0.960**	0.3174	0.0522	0.2104
COD_{Mn}	0.0003	0.8860*	0.917**	0.0941	0.0003	0.0684

** R^2 is highly significant ($p < 0.01$); * R^2 is significant ($p < 0.05$); $n = 10$.

Table 2 Models to describe pollutant concentration changes in the *O. javanica* ecological floating bed system

Parameter	Model
TN	$y = -0.0002x^3 + 0.0237x^2 - 0.9219x + 11.821$
NH_4^+-N	$y = -0.0001x^3 + 0.0173x^2 - 0.7277x + 10.108$
TP	$y = -10^{-6}x^3 + 0.0005x^2 - 0.0303x + 0.6904$
COD_{Mn}	$y = -0.0001x^3 + 0.0283x^2 - 1.3167x + 29.013$

Independent (x): experimental day (day); dependent (y): pollutant concentration (mg/L), $n = 10$.
** R^2 is highly significant ($p < 0.01$);
* R^2 is significant ($p < 0.05$).

control system. The differences in NO_3^--N concentration between the *O. javanica* and control systems is significant ($p < 0.05$).

2.3 Nutrient changes in the decay phase

Figure 1 and Table 4 present the changes in nutrient concentrations during the decay phase in the *O. javanica* ecological floating bed system. In contrast to the purification phase, nutrient concentrations rapidly increase in the decay phase in *O. javanica* systems. However, in the control systems, nutrient concentrations continue to decrease. Differences in nutrient concentrations between the *O. javanica* and control systems in the decay phase are significant ($p < 0.05$).

Similar to the trend in the purification phase, NO_3^--N concentration changes in the decay phase differ from the trend of other nutrients. NO_3^--N concentration decreases by 30.43% in *O. javanica* systems. In the control system, NO_3^--N changes follow the same trend as other nutrients and increases by 22.23%.

Table 3 Nutrient changes in the purification phase

Parameter	Treatment	TN		NH_4^+-N		NO_3^--N		TP		COD_{Mn}	
		Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Concentration variation (mg/L)	*O. javanica*	12.58	1.16	9.33	0.31	0.12	0.23	0.68	0.16	29.96	10.93
	Control	12.58	4.35	9.33	2.79	0.12	0.09	0.68	0.45	29.96	15.26
Removal efficiency (%)	*O. javanica*	90.78		96.68		–91.67*		76.47		96.32	
	Control	65.42		70.00		25.00		33.82		49.07	

* An increase in pollutant concentration in the late experiment period.

Table 4 Nutrient changes in the decay phase

Parameter	Treatment	TN		NH_4^+-N		NO_3^--N		TP		COD_{Mn}	
		Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Concentration variation (mg/L)	*O. javanica*	1.16	3.02	0.31	4.52	0.23	0.16	0.16	0.32	10.93	24.65
	Control	4.35	2.98	2.79	1.32	0.09	0.07	0.45	0.36	15.26	12.73
Removal rate (%)	*O. javanica*	–160.34*		–1358.06*		30.43		–100.00*		–125.52*	
	Control	31.49		52.69		22.23		20.00		16.57	

* An increase in pollutant concentration at the end of the experiment.

Table 5 Biomass and nutrient bioaccumulation of living and dead *O. javanica* material in the ecological floating bed system

	Biomass (dry weight) (g/m^2)			TN bioaccumulation (mg/g)			TP bioaccumulation (mg/g)		
	Stem	Leave	Root	Stem	Leave	Root	Stem	Leave	Root
Living material	578.8	394.2	648.6	27.2	29.1	22.5	3.19	4.18	3.25
Dead material	21.5	13.5	28.9	5.63	4.62	3.16	0.84	1.23	1.42
Loss (%)	–	–	–	79.3	84.1	85.9	73.6	70.5	56.3

–: no data available.

2.4 *O. javanica* growth, biomass yield, and bioaccumulation

The stems, leaves, and roots of *O. javanica* started vigorous growth by the third day of the experiment. Length and height of roots grew from 12 to 52 cm (0.857 cm/day) and from 12 to 31 cm (0.543 cm/day), respectively, by the end of 35 days. Water temperatures ranged from 26.8 to 35.4°C, with an annual average of 32.5°C, which is normally detrimental to *O. javanica* growth. As expected, they stopped growing and senesced, with some material dying off and falling into the surrounding water from day 36 to day 63.

Table 5 provides information on the living and dead *O. javanica* material collected at the end of the experiment. Decomposition of plant stems, leaves, and root materials lasted 28 days (from 35 to 63 days) of decomposition, and N content decreased by 79.3%, 84.1%, and 85.9% in the *O. javanica* stems, leaves, and roots, respectively. P loss in the same parts was 73.6%, 70.5%, and 56.3%, respectively. N and P lost from plant tissues ultimately transferred to the water and led to a significant water quality deterioration from day 35 to day 63.

3 Discussion

3.1 Nutrient removal mechanisms of the ecological floating bed system

The ecological floating bed system is a natural alternative to technical methods of wastewater treatment and involves complex processes induced by plants or microorganisms in the wastewater. One way to study these processes is by analyzing nitrogen biological degradation pathways and removal mechanisms, which include ammonia volatilization, nitrification-denitrification, and plant uptake of contaminants in the ecological floating bed system.

3.1.1 Ammonia volatilization

Ammonia volatilization refers to NH_4^+-N removal from wastewater. This process is greatly dependent on pH. It is enhanced when pH > 8.0 and is restricted when pH < 7.5 (Lu et al., 2006). Since *O. javanica* systems had a pH range of 6.9–7.9 (day 0–35) (Table 6), the measured removal efficiency is not the maximum and can still be improved. Volatilization is the most likely mechanism of NH_4^+-N reduction, which would be enhanced by the increasing pH levels from 6.9 to 9.2 (day 0–35) in control systems, as shown in Table 6. This would explain the relatively high NH_4^+-N removal efficiency (70.00%) in the control system.

Table 6 Physical parameters in the purification and decay phases of the *O. javanica* ecological floating bed system

Phase	System	Temperature (°C)	pH	DO (mg/L)
Purification	*O. javanica*	14.3–27.3	6.9–7.9	2.48–4.25
	Control	14.2–27.6	6.9–9.2	2.32–2.61
Decay	*O. javanica*	26.8–35.4	8.2–9.2	1.19–0.67
	Control	25.7–35.8	7.8–9.1	2.02–2.67

3.1.2 Nitrification-denitrification

Nitrification is the oxidation of NH_4^+ or NH_3 to NO_3^- via NO_2^-, $NH_4^+ \longrightarrow NO_2^- \longrightarrow NO_3^-$ (Tanner et al., 2002; Wu et al., 2009). This process requires the participation of two organisms: the ammonia-oxidizing bacteria responsible for nitrite formation, and the nitrite-oxidizing bacteria for the conversion of nitrite to nitrate. Its counterpart process is denitrification, the microbial-mediated conversion of NO_3^- into N_2 via intermediates NO_2^-, NO and N_2O; $NO_3^- \longrightarrow NO_2^- \longrightarrow NO \longrightarrow N_2O \longrightarrow N_2$ (Tallec et al., 2008; Wu et al., 2009). DO concentration plays an important role in nitrification-denitrification because nitrification is strictly aerobic (DO > 2.0 mg/L) while denitrification is strictly anoxic (DO < 1.0 mg/L) (Tallec et al., 2008). The main oxygen supply in the ecological floating bed system is the O_2 transported from *O. javanica* leaves and stems to roots through internal spaces (parenchyma), which lead to DO levels of 2.48–4.25 mg/L. This means that all microsites in the *O. javanica* system are aerobic, and NH_4^+-N concentration can be expected to decrease (from 9.33 to 0.31 mg/L) in the purification process. The decrease in NH_4^+-N concentration is significantly correlated (p <

0.05) with the increase in NO_3^--N concentration in the purification process. This indicates that there is high nitrification in the *O. javanica* system, and that the most likely main mechanism of NH_4^+-N removal from wastewater is nitrification by bacteria. This indicates that there is high nitrification in the *O. javanica* system, and that the most likely main mechanism of NH_4^+-N removal from wastewater is nitrification by nitrifying bacteria owing to the *O. javanica* well-developed root system providing good surface area for those nitrifying bacteria growth. In the control system, nitrification probably did not occur due to the lack of support for the growth of the nitrifying biofilm, such that NH_4^+-N removal by nitrification was seldom, and no significant amount of NO_3^--N was produced in the control system.

3.1.3 Plant uptake

N and P plant uptake can be described by a positive linear relationship between biomass and nitrogen bioaccumulation in plant tissue (Jiang et al., 2004). In this research, *O. javanica* N and P uptake were estimated by relating the measured plant biomass and nutrient content data in plant tissue to values taken from water. Stem, leaf, and root samples indicate that N taken up from the system is 15.74, 11.47, and 14.59 g/m^2, respectively, and P taken up from the system is 1.846, 1.647, 2.107 g/m^2, respectively.

There are many mechanisms that can determine P concentration in ecological floating bed systems: (1) sedimentation, the gravitational settling of solids; (2) precipitation, the formation of or co-precipitation with insoluble compounds; (3) adsorption to plant surfaces; and (4) plant uptake, the significant quantity taken by plants under proper conditions (Lu et al., 2009). In this study, the temperature (14.3–27.3°C in the purification phase) was suitable for *O. javanica* growth and microbe activity, and was thus beneficial for phosphorus absorption by the macrophytes. Mechanisms 3 and 4 are the primary factors, while mechanism 1 is incidental for P removal from the ecological floating bed system. In the control system, mechanisms 1 and 2 are factors, which can explain the significant difference in P removal efficiency in the purification phase between *O. javanica* systems (76.47%) and the control system (33.82%).

3.2 Influence of *O. javanica* decay on water quality in the ecological floating bed system

Plant decomposition plays a central role in ecosystem nutrient cycling (Richardson, 1994; Xie et al., 2004). Álvarez and Bécaresb (2006) reported that vegetation will decay by the end of summer or winter, and will degrade during the rest of the year, contributing a surplus of organic matter (autochthonous input) to the treatment system. Kadlec (1999) reported that the majority of plant storage of N and P is temporary, as plant tissues die and decompose, nutrients re-release into the water treatment system. Plant matter decay begins before plant parts fall into the water (Kuehn et al., 1999; Kuehn and Suberkropp, 1998; Ágoston-Szabó, 2006). Aber and Melillo (1980) found that the dynamics of leaf decomposition could be described by an inverse linear relationship between the percentage of original mass remaining and the N concentration in the residual material.

In this study, *O. javanica* stem, leaf, and root tissues lost 79.3%, 84.1%, and 85.9% of nitrogen and 73.6%, 70.5%, and 56.3% of phosphorus, respectively. The pattern of plant body nutrition loss is similar to that reported by Wrubleski et al. (1997) and Asaeda and Nam (2002). As a result of nutrient release from decomposing plant to water, water quality deteriorated significantly from day 35 to day 63 in the *O. javanica* system. This was accompanied by a rapid decrease in DO concentration (from 1.19 to 0.67 mg/L) and an increase in pH (from 8.2 to 9.2), indicating that plant decomposition could affect the physical parameters of water and the removal of contaminants by the treatment system. Thus, *O. javanica* N and P uptake and storage is temporary and the plant acts only as a media for nutrients in the ecological floating bed system.

3.3 Role of plant and plant harvesting in nutrient removal in the ecological floating bed system

Plants are the most obvious components of the ecological floating bed ecosystem, and they play a crucial role in nutrient removal from wastewater. Several authors have reported that plants contribute directly and indirectly to pollutant treatment (Ciria et al., 2005; Gottschall et al., 2007; Manning et al., 2008; Read et al., 2008; Stottmeister et al., 2003). Indirect effects include influences on water microbial communities, both within the rhizosphere and external to it, and modification of water retention, possibly by affecting water physical parameters, such as DO, temperature, and pH. Oxygen released by plant roots and atmospheric diffusion constitute the main oxygen supply in the ecological floating bed system. The plants were often claimed capable of providing adequate oxygen via their root zones to degrade the organics and nitrogen compounds present in the wastewater. Reddy et al. (1989) pointed out that there is an aerobic zone and an anaerobic zone located separately around the roots of aquatic macrophytes, and Tanner (2001) stated that plants transport oxygen from their leaves and stems to their roots through their internal spaces (parenchyma). Guntenspergen and Stearns (1989) reported that oxygen from the macrophyte root zone can enhance organic removal by microorganisms on the surface of stems and roots of the macrophytes. Atmospheric diffusion is due to the DO gradient between ambient air and water in the ecological floating bed system. In this study, atmospheric diffusion was virtually eliminated by plant coverage of the water surface (about 80%–90%), such that root oxygen release is the main oxygen supply in the system. In contrast, atmospheric diffusion is the main oxygen supply in the control system because of the lack of plants in it. The plants influence water pH via root exudates of acidic material during the start of vigorous plant growth, so that water inside the treatment system is less alkaline than the surroundings. This was also observed in the present study: the *O. javanica* system had a less alkaline pH (6.9–7.9 at day 0–35) compared to the control system (pH 6.9–9.2) during the purification phase, which can be attributed to vigorous *O. javanica* growth. Temperature in the ecological floating bed system depends on plant cover that shades the wastewater. Due to the differences in DO, pH, and temperature, there were significant differences in pollutant removal efficiency during the purification phase between the *O. javanica* system and control system ($p < 0.05$). Water physical parameters, including DO, pH and temperature, exhibited in the *O. javanica* ecological floating beds system may have provided more favorable conditions for microbial, including nitrobacteria and denitrifying bacteria, composition and activity, thereby ultimately influence pollutant removal.

Direct contributions include the uptake of macronutrients when plant cycles make direct use of N and P. Comin et al. (1997) studied the uptake of dissolved inorganic N in naturally restored wetlands dominated by *Typha latifolia* in Spain treating agricultural runoff, and found that plant uptake accounted for over 66% of N removal. Greenway and Woolley (2000) reported that 27%–47% of TN and 47%–65% of P removal was due to plant uptake. In contrast, some researchers, such as Brix (1997), reported that the impact of direct nutrient uptake by plants may only be significant when wastewater nutrient levels are low. Depending on plant species used, type of wastewater treated, and nutrient loading rates, plant nutrient uptake have been shown to account for 3%–47% of N removal and 3%–60% of P removal (Cooke, 1992; Greenway and Woolley, 2000; Kuusemets et al., 2002; Tanner et al., 1995). N uptake into plant biomass is of minor importance from a technical viewpoint because harvesting the aboveground biomass remove only 5%–10% N (Thable, 1984). Tanner (1996) estimated the N concentrations in aboveground biomass of helophytes to be between 15 and 32 mg N/g dry mass. Owing to these relatively low levels of nutrients, plant biomass is usually not harvested in Europe. Most previous plant uptake studies may underestimated nutrient storage by sampling only aboveground biomass, as considerable amount of storage can be found in roots and rhizomes.

In this study, *O. javanica* matter quickly decays after plant parts fall into the water as temperature rises with season overturns, resulting in the release of large amounts of nutrients into the treatment systems and significant deterioration of water quality from day 35 to day 63. These indicate that *O. javanica* uptake and storage of N and P is temporary and it serves only as media of nutrients removed from wastewater. Under these circumstances, harvesting is an appropriate intervention to improve the treatment system efficiency of *O. javanica*.

Harvesting during the plant decay phase is advantageous for three reasons. First, harvesting not only effectively inhibits and avoids N and P release into the water during decomposition, but also increases the removal of N and P in large amounts from the treatment system. Second, plants harvested from wastewater can be used as fuel and feed. Third, the harvest provides temporary jobs throughout the year. Thus, harvesting promotes pollutant removal and provides considerable economic and social benefits (Lu et al., 2009). Similar results were reported by Jing et al. (2001), who found that the best way to ensure long-term and continuous P removal from water systems is to plant macrophytes that can tolerate highly polluted water conditions and to harvest the vegetation regularly to remove excess P from the treatment system.

4 Conclusions

The ecological floating bed system was found to have a significant influence on nutrient concentration variations in wastewater. Based on third-order polynomial equation models, the effect of the *O. javanica* ecological floating bed system on polluted water can be divided into two phases: purification phase (day 0–35) and decay phase (day 35–63). During the purification phase, the ability of the ecological floating beds system to treat polluted water is greatly affected by the growth of *O. javanica*, which affects changes in water quality. The organics N and P were removed from the wastewater efficiently, with TN, NH_4^+-N, TP, COD_{Mn} removal efficiencies at 90.78%, 96.68%, 76.47%, and 96.32%, respectively, which were significantly higher than in control systems ($p < 0.05$). The decline of nutrient concentrations in the purification phase depends on the indirect and direct effects of *O. Javanica*. Indirect influence refers to the changes in water physical parameters, such as DO, pH, and temperature, that provide more favorable conditions for microbial, including nitrobacteria and denitrifying bacteria, composition and activity, ultimately influencing pollutant removal. The direct influence of *O. javanica* is its direct uptake of N and P.

However, as the seasons overturn, *O. javanica* naturally senesced and began dying. Large amounts of nutrients were released into the system by the decomposition of dead *O. javanica* tissues. As a result, TN, NH_4^+-N, TP, COD_{Mn} concentrations increased and water quality deteriorated. These indicate that *O. javanica* uptake and storage of N and P are temporary and the plant serves only as media for the nutrients removed from wastewater. Under these circumstances, harvesting is an appropriate intervention to improve *O. javanica* treatment system efficiency.

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