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Using benthos a bioindicator to assess the efficiency constructed wetland community wastewater treatment system

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ABSTRACT

BACKGROUND AND OBJECTIVES: The increasing population and urban growth have led to a higher demand for water in various sectors, resulting in a significant amount of wastewater. Constructed wetlands mimic natural wetlands, using the interaction between plants, soil, and microorganisms to treat wastewater efficiently. This study assesses the diversity, species composition, and distribution of benthic organisms in a community wastewater-filter grass system and explores the relationship between water quality and benthos.
METHODS: Water samples were collected from plant plots between December 2021 and March 2022. On-site measurements included temperature, dissolved oxygen, salinity, and pH, whereas laboratory analysis encompassed the biochemical oxygen demand, ammonia, nitrate, total phosphorus, orthophosphate, and suspended solids. Soil samples were taken before and during planting at 2-week intervals, evaluating organic matter, pH, electrical conductivity, salinity, phosphorus, potassium, calcium, magnesium, and plant growth indicators. Benthos sampling involved polyvinyl chloride pipe cores at a depth of 5 cm from the soil surface. Statistical tests were performed to analyze the water quality data.
FINDINGS: The study observed a decrease in *Chironomid* abundance in both constructed wetland systems, indicating their effectiveness in treating wastewater. A comparison of system types revealed that the 5-day detention–2-day dry release system exhibited higher *Chironomid* abundance than the continuous flow system, and the biological oxygen demand maximum decreasing rate was 95%. The ammonia and nitrate maximum decreasing rates were 97% and 94%, respectively, indicating greater wastewater-treatment efficiency. The study also identified diverse benthic organisms, particularly chironomids, as bioindicators for assessing wastewater conditions.
CONCLUSION: The continuous flow system and the 5-day detention–2-day dry release system of constructed wetlands can reduce the organic compounds and increase the oxygen levels in the plant plots. The interaction among plants, soil, and microorganisms is critical in wastewater treatment. In addition, the study highlighted the diversity and abundance of benthic organisms, particularly chironomids, which were more prominent in the continuous flow system. Consequently, the 5-day detention–2-day dry release system was more efficient in treating wastewater than the continuous flow system.

NUMBER OF REFERENCES
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NUMBER OF TABLES
6

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INTRODUCTION

The increasing population and urban growth cause a demand for water for domestic consumption, industries, and agriculture (Hoekstra and Chapagain, 2007; Bisselink *et al.,* 2018; Moghadam and Samimi, 2022; Nimesha et *al.,* 2022), causing a lot of wastewater. Human activities, such as washing, cooking, toilets, laundry, and others, cause municipal wastewater (Widyarani *et al*., 2022; Preisner, 2020; Fahad *et al*., 2019). Wastewater contaminates organic matter (OM) and inorganic matter (Hidayah *et al.,* 2022). Municipal wastewater has high nitrogen and phosphorus contents, causing eutrophication (Wang *et al*., 2012; Loomer *et al*., 2014; Ruiz *et al*., 2011; Piri and Sepehr *et al.,* 2022), which causes a lack of oxygen in the water. It increases aquatic plants (algal or plankton blooms), reduces the light intensity, and produces toxins that kill fish or other organisms that deoxygenate in the water (Muigai *et al*., 2010; Rabalais, 2002; Cahyonugroho *et al.,* 2022), affecting the water quality and environment. Wastewater treatment before releasing it into natural sources solves wastewater problems (Parvin *et al*., 2020). The treatment includes activated sludge, rotating biological contactor, and anaerobic filters (Gernaey *et al*., 2004; Waqas *et al*., 2021; Cortez *et al*., 2008; Samimi and Shahriari Moghadam, 2018; Dhayalan and Karuppasamy, 2021; Manjarrez Paba *et al.,* 2021), which are complicated, costly procedures and not ecofriendly (Kour *et al*., 2021). However, natural wastewater-treatment technology is easy and convenient. Constructed wetlands are similar to natural wetlands to mimic the wastewater-treatment mechanisms of existing wetlands (Haberl *et al*., 2003; Hunt *et al*., 1997). It takes advantage of the interaction between plants, soil, and microorganisms in wastewater treatment (Li *et al*., 2021; Hussain *et al*., 2018). The constructed wetland is a popular biological wastewater-treatment system due to its low cost and energy. It is efficient for treating suspended solids (SS), the chemical oxygen demand, the biological oxygen demand (BOD), nutrient nitrogen (N), and phosphorus (P) (Mantovi *et al*., 2003; Rousseau *et al*., 2004 ; Samimi and Shahriari Moghadam, 2020) by microorganisms in the root. Bacteria are crucial in decomposing OM by nitrification and denitrification, and the transformation of nitrogen and phosphorus comes from the microbial activity in the root area (Cui *et al*., 2013; Hu *et al*., 2023). The tolerance of hypertrophic waterlogged plants and their ability to remove pollutants should be considered (Scholz and Lee, 2005). Wetland ecosystems can increase biodiversity and be nutrient traps, contributing to high bird biodiversity benthos and macrophytes (Hansson *et al*., 2005). Benthos is a biomarker to assess ecosystem health (Kelly *et al*., 2017). This research studies the diversity, species, proportion, and distribution of benthos and finds the relationship between the water quality and benthos in the community wastewater-filter grass system. This study was conducted in the constructed wetland community wastewater-treatment system at the King's Royally Initiated Laem Phak Bia Environmental Research and Development Project (LERD), in Phetchaburi, Thailand, from 2021 to 2022.

MATERIALS AND METHODS

Study site

Constructed wetland is located at the King's Royally Initiated Laem Phak Bia Environmental Research and Development Project (The LERD

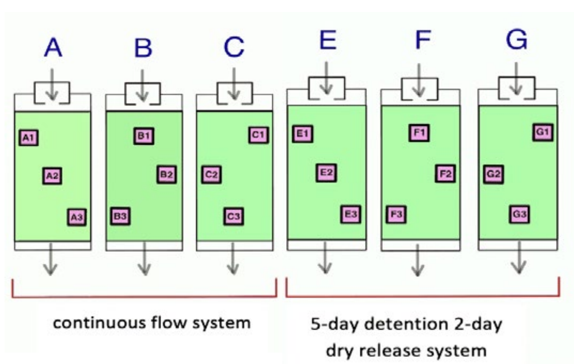

Fig. 1: Sample plant plots

(a) (b)

Fig. 2: Constructed wetland system (a) continuous flow system and (b) 5-day detention–2-day dry release system

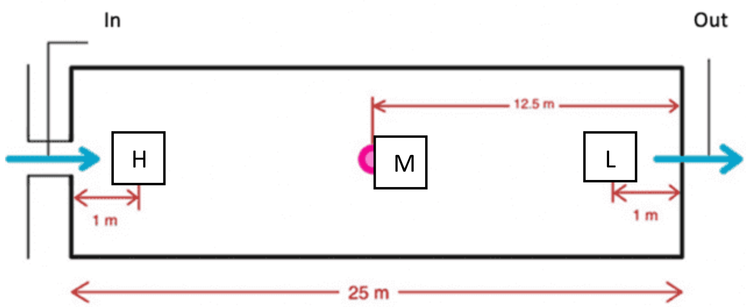

Fig. 3: Soil and benthos sampling point

project), Phetchaburi, Thailand. The treatment system consists of six constructed wetland plots (Fig. 1). using *Phragmites australis*. Community wastewater was discharged from the municipality of Phetchaburi into the plots in the continuous flow system (Fig. 2a). and 5-day detention 2-day dry release system (Fig. 2b). The treatment system consists of six constructed wetland plots, each measuring 5x25x1.5 meters (width x length x depth) and filled with a layer of gravel (30 centimeter: cm), sand (20 cm), soil (30 cm), and a 30 cm high water level. The plots were planted with small reed (*Phragmites australis Cav*.) with a planting distance of 40x40 cm and nine plants per square meter. Community wastewater was discharged from the municipality of Phetchaburi into the plots in a detention-dry release system (5-day detention and 2-day dry release system), and the flow was continuous for six study plots. Plots A to C were operated in the continuous flow system, while plots E to G were operated in 5-day detention 2-day dry release system. Water, soil, and benthos samples were collected at three monitoring stations located at 0 m, 12.5 m, and 25 m distances from the inflow point.

Water sample analyses

The water samples in the plant plots were collected and analyzed from December 2021 to March 2022 (10 weeks). Four water quality parameters were measured on-site: temperature (temp), dissolved oxygen (DO), salinity, and potential hydrogen (pH). Six parameters were measured in the laboratory: BOD, total nitrogen (TN), total kjeldahl nitrogen (TKN), ammonia (NH_3), nitrate (NO_3^-), total phosphorus (TP), orthophosphate (OP), phosphate (PO_4^{3-}), and SS were evaluated according to the standard methods for examining water and wastewater (APHA, 2005).

Soil and plant analyses

Take a soil sample before and during planting every 2 weeks. Soil quality parameters were measured as OM, pH, electrical conductivity (EC), salinity, phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) at the head (H), middle (M), and last (L) of the plot (Fig. 3) and plant growth, such as plant height and circumference, was studied.

Benthos sampling

Benthos was sampled using a polyvinyl chloride (PVC) pipe (core), eight inches in diameter, sampled down to 5 cm height from the soil surface at the head (H), middle (M), and last (L) of the plot (Fig. 3). Fixed with 7% formalin and fined benthos species. Cell counting was conducted in a laboratory. The diversity indices were calculated using the Shanon–Weiner Index method.

Statistical analysis

Statistical analysis was performed using the statistical package for social sciences to analyze the water quality data. Descriptive statistics were calculated for all parameters, and inferential statistics, such as *t*-tests or analysis of variance, were conducted to assess differences between system types and time points. Regression analysis was used to explore the relationship between water quality variables and benthic organism diversity. The statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Water quality

The continuous flow and 5-day detention–2-day dry release systems at H, M, and L of the plot have different treatment efficiencies and water qualities. The average temperature, pH, BOD, TP, and DO in the continuous flow and 5-day detention–2-day dry release systems were equal to the standard values. The average DO, SS, and NO_3^- increased, whereas the average BOD, NH_3, TKN, TN, TP, and PO_4^{3-} decreased (Tables 1 to 3). The BOD decreased because the increased oxygen in the two constructed wetlands was enough for microorganisms to oxidize the organic compounds in wastewater (Prihatini *et al*., 2019). The average NO_3^- concentration increased while the average NH_3 concentration decreased. The removal of NH_3 was primarily due to the increasing nitrification process and the growth of nitrification bacteria that converted nitrogen from NH_3 to NO_3^-. Consequently, the nitrate concentration increased and NH_3 decreased in the constructed wetland

Table 1: Water quality of continuous flow and 5-day detention–2-day dry release systems

Parameters	Continuous flow system			Average	5-day detention–2-day dry release system			Avg.
	H	M	L		H	M	L	
Temp. (°C) (23-32[2])*	26.97	26.79	26.63	26.80	26.29	26.35	26.23	26.28
pH (5.5-9.0[1])*	7.58	7.61	7.64	7.61	7.75	7.75	7.79	7.76
DO (mg/L) (>3[2])*	1.20	2.09	2.94	2.08	5.88	5.66	6.54	6.02
BOD (mg/L) (<20[1])*	11.57	11.05	6.78	9.80	8.51	5.87	7.97	7.45
SS (mg/L)	18.70	16.87	21.60	19.06	26.07	26.20	30.63	27.62
NO_3^- (mg/L)	0.06	0.06	0.11	0.08	0.17	0.12	0.24	0.18
NH_3 (mg/L)	1.44	1.27	1.15	1.29	0.93	0.77	0.56	0.76
TKN (mg/L)	4.87	4.67	3.51	4.35	3.36	2.94	2.75	3.02
TN (mg/L)	4.87	4.67	3.51	4.35	3.36	2.94	2.75	3.02
TP (mg/L) (<2[1])*	1.00	1.07	0.95	1.01	1.00	0.66	0.78	0.81
OP (mg/L)	1.77	1.67	1.63	1.69	1.09	1.03	0.87	0.99

[1] The water quality standard of control drains effluent water from the community wastewater-treatment system from the Ministry of Natural Resources and Environment, Thailand.

[2] The water quality standard of water quality for aquatic animal life from the Department of Fisheries, Thailand.

Table 2: Treatment efficiency of the continuous flow system (%)

Week	BOD	SS	FOG	TN	NO_3^-	NH_3	TP	PO_4^{3-}
1	31.36	33.33	95.29	24.53	54.62	53.73	14.81	9.78
2	46.08	−91.30	95.51	49.15	7.14	60.24	13.07	26.22
3	88.78	−42.31	98.48	45.39	88.07	86.16	42.08	16.67
4	38.46	13.33	83.24	36.60	35.74	50.80	15.68	9.39
5	49.93	68.42	52.65	45.10	72.09	17.02	13.31	2.93
6	75.96	−5.88	46.58	55.12	94.83	89.67	22.47	14.60
7	66.35	75.00	67.00	50.64	7.69	49.69	44.27	34.43
8	83.33	−166.67	99.99	13.74	95.79	82.52	11.96	11.71
9	56.16	42.11	97.03	12.86	99.35	56.44	18.59	39.00
10	54.10	33.33	36.00	38.42	1.06	79.33	4.21	4.76

Table 3: Treatment efficiency of the 5-day detention–2-day dry release system (%)

Week	BOD	SS	FOG	TN	NO_3^-	NH_3	TP	PO_4^{3-}
1	60.10	62.50	92.75	24	79.57	83.79	60.96	75.20
2	31.42	−667.86	95.69	7.49	85.00	78.72	54.61	64.17
3	95.06	−290.00	90.97	9.97	39.33	65.63	63.33	54.05
4	16.58	17.39	24.21	6.57	67.91	79.88	61.56	70.32
5	58.16	32.26	15.12	5.08	85.58	88.61	66.38	67.29
6	79.38	20.00	17.72	7.57	74.82	97.13	66.84	67.23
7	6.77	−81.16	69.44	4.23	40.00	38.80	47.31	37.95
8	55.37	−141.67	99.96	1.03	94.35	92.50	55.59	19.39
9	50.18	−18.18	96.99	2.39	56.08	84.61	49.92	48.98
10	63.46	55.56	74.70	35.78	19.32	11.87	32.38	3.23

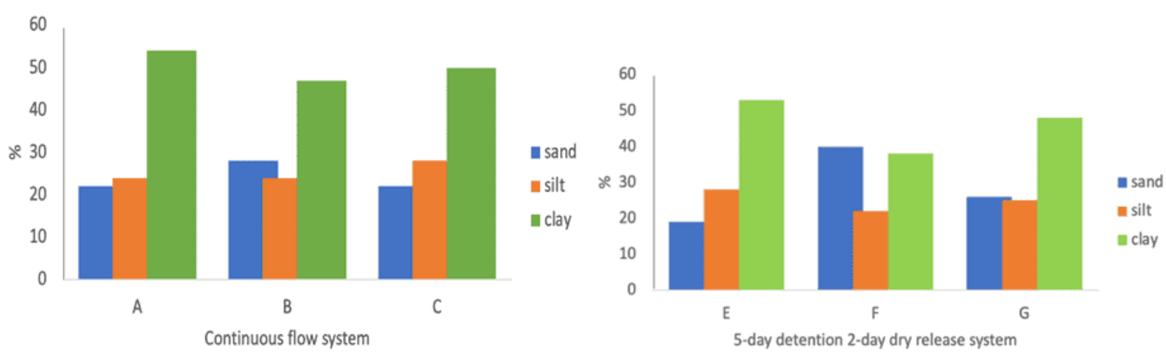

Fig. 4: Soil content in the constructed wetlands

(Jamieson *et al*., 2003). The phosphorus nutrient concentration (TP and OP) decreased and conversed by uptake, precipitation, and assimilation into microbial and plant biomass in the plots (Kouki *et al*., 2009).

Soil and plant

The soil content was classified by the percentage of sand (%sand), percentage of silt (%silt), and percentage of clay (%clay). Three constructed wetlands were compared (A/E, B/F, and C/G). The soil content was clay (>38%), sand (>24%), and silt (>25%) (Fig. 4). Soil texture in the continuous flow system A comprised clay, followed by clay loam, whereas E of the 5-day detention–2-day dry release system comprised clay followed by silty clay. B in the continuous flow system contained clay, followed by clay loam, whereas F of the 5-day detention–2-day dry release system mostly was clay, followed by clay loam, sandy loam clay, and silt loam. C of the continuous flow system was clay, followed by silty clay, whereas G of the 5-day detention–2-day dry release system contained clay, followed by clay silty, silty clay loam, and clay loam.

Fig. 5: Plot of *Phragmites australis*

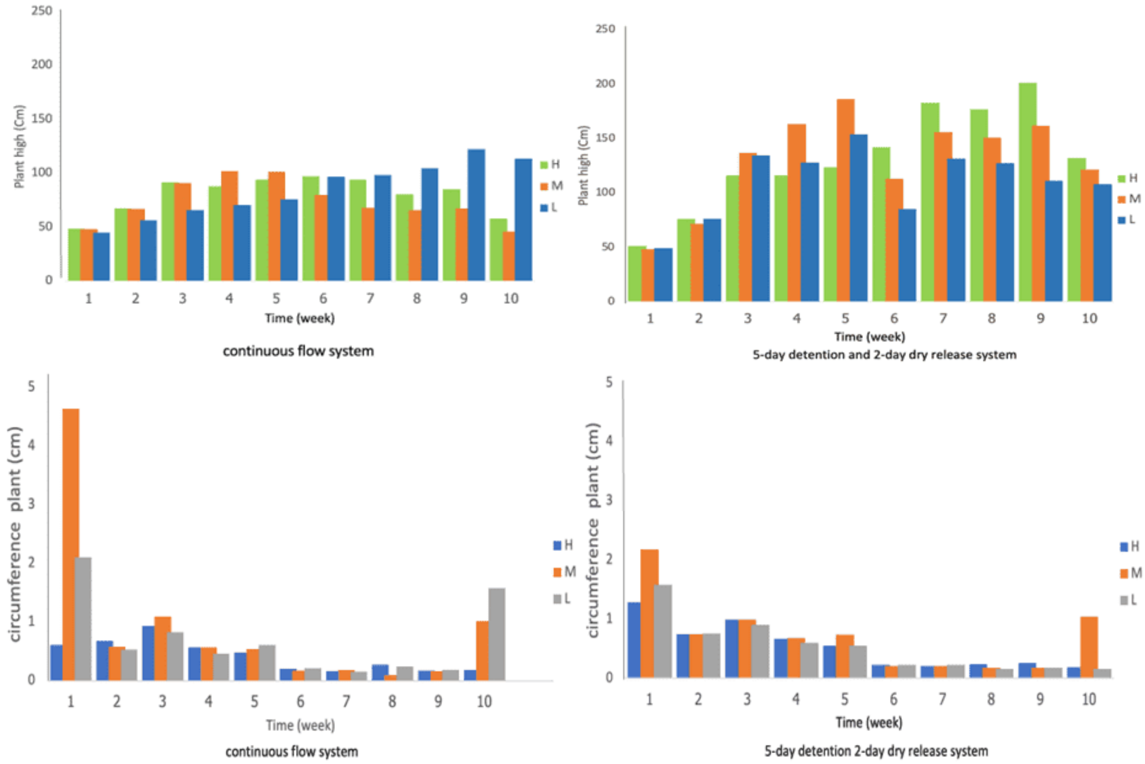

Fig. 6: High and circumference of *Phragmites australis*

Plant plots of wastewater-treatment systems using Phragmites australis

The plant plots of the wastewater-treatment system using *Phragmites australis* are shown in Fig. 5:

(a) Nursery plant plot, (b) Nursery plant plot, (c) Plant plot continuous flow system, (d) Plant plot 5-day detention–2-day dry release system, (e) Stem of *Phragmites australis*, (f) Stem of *Phragmites australis,* (g) Flower of *Phragmites australis*, (h) Flower of *Phragmites australis*, (j) Flower of *Phragmites australis*.

The plant growth measurements include the height and circumference of *Phragmites australis*. The height and circumference of plants increased from week 1 to week 10. Comparing the two constructed wetland systems showed that the 5-day detention–2-day dry release system plants grew better than the continuous flow system (L, H, and H, respectively). However, the plant circumference decreased from week 1 to week 10. The continuous flow system plant circumferences were 4.64–1.01 cm (M), 2.1–1.58 cm (L), and 0.61–0.19 cm (H), and the 5-day detention–2-day dry release system delivered 2.18–1.04 cm (M), 1.58–0.16 cm (L), and 1.29–0.18 cm (L) (Fig. 6).

Benthos

The benthos species diversity and abundance in the constructed wetlands found two phyla, two classes, and seven species comprising one species of *Phylum Annelida* and six of *Phylum Arthropoda*. *Phylum Arthropoda* and *Annelida* were higher in the 5-day detention–2-day dry release system than in the continuous flow system. The 5-day detention–2-day dry release system has a higher benthos species diversity and abundance than the continuous flow system (Table 4).

Benthos can be used as a wastewater indicator for environmental or water quality assessment because they are sedentary and play a role in cycling nutrients (Carretero *et al*., 2016). Tubifex worms are known for tolerating polluted and oxygen-depleted waters (Hurley *et al*., 2017). They are frequently found in sediments and can feed on OM, including wastewater

Table 4: Benthos species diversity and abundance in the constructed wetlands

Benthos	Constructed wetlands					
	Continuous flow			5-day detention–2-day dry release		
	A	B	C	E	F	G
Phylum Annelida						
Class Oligochaeta						
Order Plesiopora						
Family Tubificidae						
Tubifex sp.	51	33	45	481	58	471
Phylum Arthropoda						
Class Insecta						
Order Diptera						
Family Chironomidae						
Ablabesmyia sp.	66			22	88	
Chironomus sp.	83	381	22	88		37
Pseudosmittia sp.	44	455	270	66	577	46
Family Ceratopogonidae						
Culicoides sp.			33	22		79
Order Hemiptera						
Family Corixidae						
Corisella sp.	37	26	44	88	108	62

pollutants. However, their role in contaminant removal from wastewater is more related to OM decomposition and nutrient cycling than direct pollutant removal. *Ablabesmyia* larvae are aquatic midges typically found in freshwater habitats. They play a role in wastewater treatment by consuming OM, including bacteria and other microorganisms, in the wastewater, reducing the organic load and improving water quality (Rae, 1989). *Pseudosmittia* larvae are part of the nonbiting midge family in various freshwater environments and contribute to the decomposition of OM, including wastewater contaminants. While they might not have specific pollutant removal mechanisms, their feeding habits and role in nutrient cycling indirectly improve the water quality. *Culicoides*, commonly known as biting midges, are not typically associated with wastewater treatment and are more commonly known as vectors for diseases in animals, and their presence in wastewater might not contribute significantly to contaminant removal. *Corisella* are small aquatic beetles found in freshwater environments. They feed on OM, including detritus and microorganisms, and contribute to the breakdown of pollutants in the wastewater. However, their overall impact on wastewater is limited compared to other species specifically adapted to such environments. *Chironomus* larvae, also known as bloodworms, are frequently found in polluted and eutrophic waters and are effective in organic pollutant removal. *Chironomus sp*. has been used in constructed wetlands and wastewater-treatment systems to enhance OM degradation and pollutant removal. In summary, the *Chironomus sp*. and *Ablabesmyia sp*. in the family *Chironomidae* show more potential for wastewater treatment due to their ability to consume OM and contribute to pollutant removal. Therefore, the family *Chironomidae* was a bioindicator used to assess pollution in aquatic ecosystems. They are strongly related to ammonium-N and are the highest pollution (Akyildiz *et al*., 2018). The density of the family *Chironomidae* in the wetlands decreased from week 1 to week 10 and was not found at week 9 because of the lower OM (Carretero *et al*., 2016). The *Chironomidae* in the continuous flow system and the 5-day detention–2-day dry release system was compared, showing that *Chironomidae* was higher in the continuous flow system than the 5-day detention–2-day dry release system (Fig. 7) because NH_3 in the continuous flow system is higher (Table 1). The decreasing *Chironomidae* in both constructed wetland systems showed that the wastewater-treatment system is effective for treating wastewater. Comparing the system types showed that the continuous flow system has higher

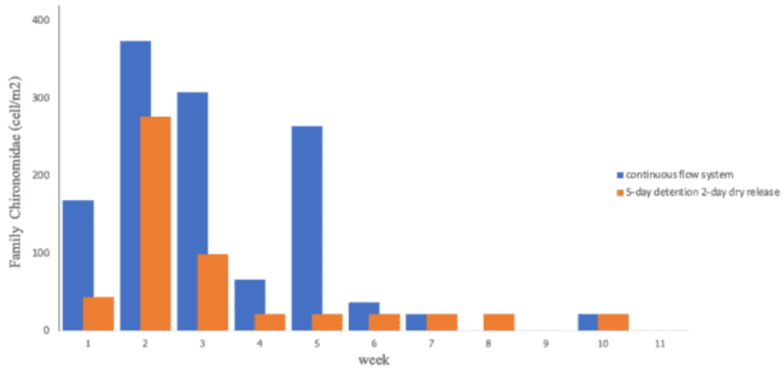

Fig. 7: Density of the family *Chironomidae* in the constructed wetlands

Table 5: Statistical testing of water quality in the wastewater-treatment systems

Parameters	Continuous flow		5-day detention–2-day dry release		*t*-test	Sig.
	Mean	SD	Mean	SD		
Temp	26.74	1.738	26.20	1.961	1.377	0.172
pH	7.63	0.560	7.91	0.695	−2.087	0.040
EC	523.22	35.810	526.58	39.540	−0.422	0.674
DO	2.41	2.155	4.81	2.860	−4.493	0.000
BOD	13.20	14.533	8.68	12.740	1.569	0.120
TP	1.20	0.203	0.61	0.164	14.993	0.000
PO_4^{3-}	2.03	0.325	1.05	0.396	12.913	0.000
SS	15.91	9.660	23.84	12.244	−3.412	0.001
NO_3^-	−0.03	0.403	0.07	0.477	−1.055	0.294
NH_3	1.07	0.705	0.47	0.374	5.106	0.000
TKN	4.37	1.716	2.59	1.130	5.816	0.000
Salinity	0.20	0.000	0.20	0.000	0.000	1.000

Chironomidae than the 5-day detention–2-day dry release system, showing it was more wastewater treatment efficient than the continuous flow system.

Statistics

The statistical water quality testing of two constructed wetlands was the independent sample *t*-test and showed that the temp., EC, BOD, and salinity have Sig greater than 0.05, indicating that the wastewater-treatment systems were not significantly different. The wastewater-treatment systems can reduce organic compounds to decrease the BOD (Charkhestani and Yousefi Kebria, 2022). While the pH, DO, TP, OP, SS, NH_3, and TKN lower than 0.05 indicate that the wastewater-treatment systems differed significantly (Table 5).

Table 6: Statistical testing of soil properties in the wastewater-treatment systems

Parameters	Continuous flow		5-day detention–2-day dry release		*t*-test	Sig.
	Mean	SD	Mean	SD		
OM (%)	2.06	0.386	2.29	0.386	−2.928	0.004
EC (µS/cm)	177.83	66.666	296.61	123.147	−5.690	0.000
pH	8.33	0.492	7.87	0.543	4.219	0.000
Salinity (dS/m)	0.18	0.067	0.30	0.123	−5.690	0.000
Avail. P (mg/kg)	13.86	3.026	17.78	5.044	−4.478	0.000
K (mg/kg)	164.75	75.219	165.30	73.391	−0.035	0.972
Ca (mg/kg)	658.66	224.510	694.35	198.549	−0.799	0.427
Mg (mg/kg)	172.32	196.088	141.08	146.472	0.856	0.394

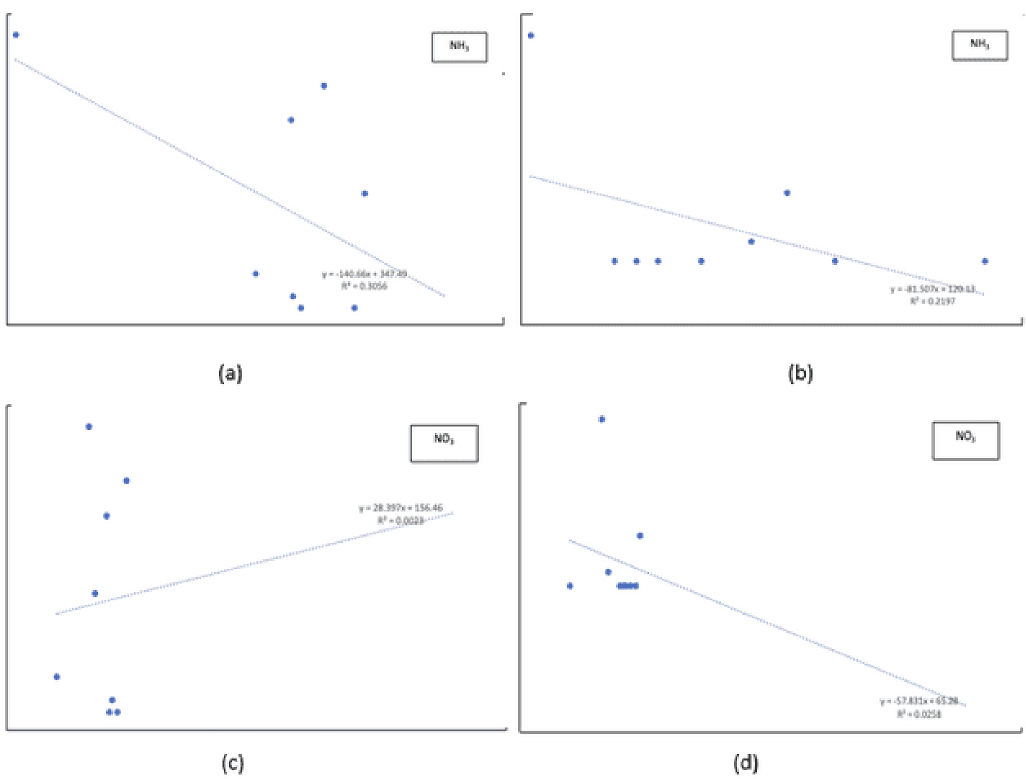

Fig. 8: Correlation between the family *Chironomidae* and N nutrients
(a) Correlation between the family Chironomidae and NH_3 in the continuous flow system
(b) Correlation between the family Chironomidae and NH_3 in the 5-day detention–2-day dry release system
(c) Correlation between the family Chironomidae and NO3 in the continuous flow system
(d) Correlation between the family Chironomidae and NO3 in the 5-day detention–2-day dry release system

K has a significance greater than 0.05 in the soil properties, indicating that the wastewater-treatment systems were not significantly different. OM, EC, pH, salinity, avail. P, Ca, and Mg were lower than 0.05, indicating that the wastewater-treatment systems differed significantly (Table 6).

The major elements (P, K, Ca, and Mg) in the soil are critical for plant growth. If they are lacking, normal development does not occur. P and Ca in the 5-day detention–2-day dry release system is higher than in the continuous flow system, causing the plants in the 5-day detention–2-day dry release system to be higher than in the continuous flow system.

Benthos and nutrients

Benthos (family *Chironomidae*) and nutrients, such as NH_3 and NO_3^- were used to analyze the relationship shown in Fig. 8. The relationship between benthos and NH_3 and benthos and NO_3 were compared in the continuous flow and 5-day detention–2-day dry release systems. The results showed that benthos has a higher correlation with NH_3 than NO_3, and the continuous flow system has a higher correlation between benthos and the continuous flow system than the 5-day detention–2-day dry release system. Therefore, the family *Chironomidae* has a better relationship with NH_3 and the continuous flow system.

CONCLUSIONS

The constructed wetlands of the continuous flow and 5-day detention–2-day dry release systems can reduce the organic compounds, BOD, NH_3, TN, TP, and PO_4^{3-} by 95%, 97%, 35%, 67%, and 75%, respectively. However, the BOD is higher than the wastewater-treatment standard (<20 mg/L), while SS increased by 68% and the DO rate increased from 5.88 to 6.54 mg/L, showing that this wastewater-treatment system can increase oxygen into the plant plots. The wastewater-treatment mechanism is the interaction between plants, soil, and microorganisms in the plots. Moderate OM and pH of soil occurred in the system, and the *Phragmites australis* height increased. Furthermore, the benthos diversity and abundance in the constructed wetland systems, especially *Chironomidae*, were bioindicators used to assess wastewater. The average NO_3^- concentration increased while the average NH_3 concentration decreased. The removal of NH_3 was primarily due to the increasing nitrification process and the growth of nitrification bacteria that converted nitrogen from NH_3 to NO_3^-. Consequently, the nitrate concentration increased and NH_3 decreased in the continuous flow system. Benthos can be used as a wastewater indicator for environmental or water quality assessment because they are sedentary and play a role in cycling nutrients. *Chironomidae* was a bioindicator used to assess pollution in aquatic ecosystems. They are strongly related to ammonium-N and are the highest pollution in the continuous flow system. Therefore, the 5-day detention–2-day dry release system is more efficient in treating wastewater than the continuous flow system. *Chironomidae* has been the focus of extensive research due to their significant role in sediment–water interactions. These have been found to influence the movement of N compounds across the sediment–water interface. The results show that *Chironomidae* can enhance the release of ammonium to 97% from the sediment into the overlying water, thereby increasing its availability. However, contrasting findings have also been reported, proposing that *Chironomid* larvae can have the opposite effect on nitrogen dynamics. Specifically, this study has shown that *Chironomidae* increases the release rates of nitrate nitrogen to 94%, indicating that the presence of *Chironomidae* can influence the release of different forms of inorganic nitrogen, depending on the specific environmental conditions and factors at play. The influence of Chironomidae on the exchange of inorganic nitrogen is yet to be fully understood and might be subtle. The effects can vary depending on sediment characteristics and the availability of OM. In summary, *Chironomidae* has garnered significant attention in research primarily due to their involvement in sediment–water interactions. They have been found to affect the outflow of nitrogen compounds, including ammonium and nitrate, across the sediment–water interface. However, the exact nature of their impact on nitrogen dynamics remains complex and context-dependent, necessitating further investigation.

AUTHOR CONTRIBUTIONS

K. Seethong designed the experiment, conducted field study water quality analyses in the laboratory, contributed in the data analysis, interpreted the results and preparing the manuscript. K. Chunkao participated in the interpretation of the wáter quality results and manuscript preparation. N. Dampin contributed in the benthos data analysis and interpretation of the results. W. Wararam, the corresponding author, has contributed in supervising the second author in the data analysis wáter quality and benthos, interpreted the results.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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ABBREVIATIONS

%	Percent
°C	Degree Celsius
µS/cm	MicroSiemens per centimeter
dS/m	DeciSiemens per meter
Avail. P	Avaiable phosphorus
APHA	American Public Health Association
BOD	Biological oxygen demand
cm	Centimeter
Ca	Calcium
COD	Chemical oxygen demand
DO	Dissolved oxygen
EC	Electrical conductivity
H	Head of plant plot
K	Potassium
km	Kilometer
L	Last of plant plot
LERD	the King's Royally Initiated Laem Phak Bia Environmental Research and Development Project
m	Meter
M	Middle of plant plot
Mg	Magnesium
mg/kg	Milligrams per kilograms
mg/L	Milligrams per liters
NH_3	Ammonia
NO_3^-	Nitrate
OP	Orthrophosphate
OM	Organic matter
pH	Potetial of hydrogen
PO_4^3	Phosphate
PVC	Polyvinyl chloride
Sp.	Specie
SS	Suspended solid
Temp	Temperature
TKN	Total kjedahl nitrogen
TP	Total phosphorus

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