Ecological Effectiveness of Vetiver Constructed Wetlands in Treating Oil-Refined Wastewater

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1 Why did we conduct the work?

Firstly, the Maoming Petro-Chemical Company (MPCC), China Petro-Chemical Corporation discharges lots of waste water each year. For example, it discharged 13 million tons of oil refined wastewater in the year 1999 alone. However, only 63% of them reached the effluent standard in that year, in spite of the fact that the company invested substantially in building new purifying plants and in enlarging the capacity of old plants. This indicates that the company still has a major task with special reference to wastewater purification.

Secondly, it seems that there has been no document on the purification of wetland systems using vetiver for oil-refined wastewater, although it has been well documented that vetiver is an excellent species for wastewater treatment.

2 How was the work conducted?

2.1 The tested species

Phragmites australis, Typha latifolia, and Lepironia articutala were used as control compared with vetiver. The former two species are quite common, and have also been proved to be highly effective in pollutant removal through wetland. As to *L. articutala*, it is probably a potential pollutant-purifying plant, as it grows mainly on natural wetlands nearby local mine tailings or industrially polluted areas.

Lepironia articutala and its natural habitat

2.2 The experimental method

Simulated artificial wetlands were constructed in large earthen containers, filled with wastewater for purification. Three water treatments (highly concentrated wastewater (HCW), low concentrated wastewater (LCW), and clean water (CW)) and 4 plant treatments (*V. zizanioides*, *P. australis*, *T. latifolia*, and *L. articutala*) were used.

HCW

LCW

After plants, 18 clumps of same species for each pot, were planted in the pots, clean water was loaded until the water level was 10 cm higher than the soil surface.

2.2 The experimental method

After the first 2 months of establishment period was over, the soil was let to dry out. Then the 3 treatment waters were loaded. Samples of wastewater were collected from the drains for chemical analysis 8 days after loading. After each test wastewater was discharged and containers were left open until the soil become almost dry, then the second and third batches of wastewater were loaded, and the same operation as the first batch was repeated.

A part view of the mimic constructed wetlands

Water samples were being collected for chemical analysis

Soil samples were also collected after the soil became almost dry

3 Results and Conclusion

- The concentrations of pollutants, ammonia nitrogen, oil, sulfide, volatile phenol, benzene, COD, and BOD, in oil-refined wastewater were quite high, especially in HCW; they exceeded the second grade of Wastewater Discharge Limits (WDL) in Guangdong, China. For example, the content of oil in HCW can reached 60 mg/L, while its WDL is only 5 mg/L.

- In the beginning, the wetlands could remove almost all pollutants in wastewaters, but their purifying efficiencies became lower and then became relatively stable with time. For instance, the mean removal rates of COD in the first, second, and third batches of LCW were 71.5%, 35.8%, and 39.6%, respectively.

3 Results and Conclusion

◆ At the start of the trial, the purifying function of plants was quite weak. As time passed, however, the function gradually increased with acceleration of plant growth and increase of biomass. But there were only small variations among purifying abilities of different species (Table 1).

Table 1 The net removal of BOD by plants in the three batches of wastewaters

Treatment	Species	First batch	Second batch	Third batch
HCW	*V. zizanioides*	-0.3	3.1	3.1
	T. latifolia	0.3	1.9	4.6
	P. australis	0.8	4.1	3.6
	L. articutala	2.1	6.9	3.5
LCW	*V. zizanioides*	0.8	0.1	2.6
	T. latifolia	0.8	-1.1	2.4
	P. australis	0.8	-0.3	2.6
	L. articutala	0.8	-0.5	2.5

The data are expressed by mg/L; “-” indicates an increase of pollutants after being “purified” by plants

3 Results and Conclusion

◆ During the phase of clean water cultivation, the tiller producing rate of *V. zizanioides* was lowest among the four species. This was associated probably with their original habitats, as *V. zizanioides* was sampled from the xeric environment while other three species were from the hydrophytic one. During the phase of treatment water cultivation, however, *V. zizanioides* possessed stronger tiller-producing ability than the other three species after it had acclimatized itself to the hydrophytic environment (Table 2).

Table 2 Tillering rates of the four plants before and after wastewater irrigation

Stage	*V. zizanioides*			*P. australia*			*T. latifolia*			*L. articutala*		
	CW	LCW	HCW	CW	LCW	HCW	CW	LCW	HCW	CW	LCW	HCW
Clean water stage	1.50	1.57	1.63	2.10	1.95	1.70	3.40	3.30	3.60	3.18	3.46	3.38
Treatment water stage	1.20	1.87	1.71	1.17	1.64	1.47	1.26	1.88	1.61	1.11	1.66	1.97

4 Further Application of Constructed Wetlands

According to the above research results, two real constructed wetlands for the purpose of treating oil-refined wastewater were set up in the spring of 2003. The process of design and construction is as follows.

◆ Construction site

It is also in the Wastewater Purifying Plant of Maoming Petro-Chemical Company, China Petro-Chemical Corporation.

◆ Wetland area

The total area of wetlands is 72 m^2£¨divided equally into 2 wetlands (No.1 and No.2), 36 m^2 (4 m°Ø 9 m) for each one.

4 Further Application of Constructed Wetlands

- Method of planting plants and time

The applied plant species were still *V. zizanioides*, *P. australis*, *T. latifolia*, and *L. articutala.* In wetland No.1, all the four species were planted, identical amount and area, or 25% for each species. In wetland No.2, only *V. zizanioides* and *L. articutala* were planted, also same amount and area, or 50% for each species. All plants were planted on May 8th.

4 Further Application of Constructed Wetlands

- Performance of plants

In the first two months (May 8th – July 7th) after wetlands were established, only tape water was irrigated into the wetlands to ensure plants to return green and grow. As a result, vetiver grew best, further indicating that vetiver has the strongest adaptation to the hydrophytic environment after it acclimatizes itself to the kind of environment.

4 Further Application of Constructed Wetlands

◆ Performance of plants

Since 8 July, LCW was pumped into the wetlands with the loading rate of 250 t/day for each wetland. As a result, vetiver grew better and better; *P. australis* was also good; *L. articutala* seemed not to be bad, either; while *T. latifolia* became worst and eventually died out two months later (Table 3).

Table 3 Growing performance of 4 plants in the new constructed wetland*

Species	At planting (May 8)	60 days after planting (July 8)	90 days after planting (August 11)	130 days after planting (September 24)
T. latifolia	30/2	91/3.0	102/2.4	0
P. Australis	30/3	63/3.3	77/4.1	101/9.0
V. zizanioides	30/4	122/7.5	135/16.0	179/29.4
L. articutala	30/5	93/13.3	78/16.1	97/19.2

Data lied in the left of the slants are plant height, and data in the right are tiller numbers

Vetiver grew very luxuriately

Phragmites australis also grew quite good

Typha latifolia died out 4 months after planting

4 Further Application of Constructed Wetlands

◆ Purifying efficiency

As to the purifying efficiency to pollutants, the two wetlands only had minor disparities, no matter what time it was, at the beginning or later on (Table 4). This infers that bio-diversity may be more important even if some species cannot grow very well. On the whole, the purifying efficiency was not so high probably due to too large water flow.

Table 4 Comparison of purifying efficiencies to 5 pollutants in the 2 wetlands

	July 23, 2003					September 12, 2003				
	Oil	volatile phenol	COD	BOD	Ammonia N	Oil	volatile phenol	COD	BOD	Ammonia N
Entrance water	2.9	0.19	58.0	1.0	20.5	3.3	0.06	75	2.1	9.5
Exit water from wetland No.1	2.0	0.11	55.0	1.0	17.5	2.7	0.02	70	1.6	6.8
Exit water from wetland No.2	2.0	0.04	52.0	1.0	16.5	2.2	0.06	69	2.9	7.3

From the above experiment and application, it therefore can be concluded that vetiver is relatively a better plant species, compared with the other species tested in the project, in reference to oil-refined wastewater treatment with constructed wetland. Therefore vetiver is worth disseminating for oil-refined wastewater purification.

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