Study on Vetiver's Purification for Wastewater from Pig Farm

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Abstract: Nitrogen, phosphorus and heavy metals from pig farms are key sources of water pollution. Wastewater contains nitrogen and phosphorus which are the most important plant nutrients, but is harmful when applied to agricultural land in excess amounts, thereby leading to pollution of ground water by nitrates, surface water by phosphorous (causing eutrophication) and soil by heavy metals such as copper which are used as growth promoters in the feed stuff. The main objective of this paper was to investigate the effects of vetiver (*Vetiver zizanioides*) in purifying wastewater from pig farms and design a purifying system for pig farms with a Vetiver bamboo float. The results showed that Vetiver had a very high capacity to purify wastewater. It's ratio of uptake and purification to Cu and Zn > 90%, to As and N > 60%, to P was between 59–85%, to Pb was between 30–71%, and to Hg was between 13–58%. The purifying effects of Vetiver to heavy metals, N, and P from pig farms were ranked as Zn > Cu > As > N > P > Pb > Hg. It is powerful to remove the elements of Cu, Zn, As and N for pig farms.

Key words: pig farm, wastewater, uptake, purify, *Vetiveria zizanioides*, heavy metals

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1 INTRODUCTION

China is the world's largest pig producer in the world. China has a national inventory of pigs estimated at 454 million head in 2001, accounting for 48% of the world's total. In Guangdong Province alone, there are over 1600 pig farms. There were over 130 pig farms which produced over 10,000 commercial pigs in 1998. Most wastewater from pig farms has been directly discharged into natural waters, causing worse situations for water and soil pollution. Environmental problems are becoming a worldwide concern as pig raising has changed from small farm to large scale production, particularly in the rapidly developed economies of developing countries.

Vetiver Grass (*Vetiveria zizanioides*), with its unique morphological, physiological and ecological characteristics including its tolerance to high levels of heavy metals and adverse conditions, has played a key role in the field of environmental protection (Xia and Li, 1998). *V. zizanioides* can grow normally in water, and is powerful to remove nitrogen and phosphorous from water and, therefore, is a good plant for purifying eutrophic water (Zheng *et al*., 1997), and garbage leachates (Xia *et al.*, 1999). Vetiver can absorb more heavy metals in comparison with bahia and is less likely to form secondary pollution or bio-accumulation as is bahia (Xia and Shu, 2001). The experiment site for the present study was at The Pig Breeding Center of Guangdong Academy of Agricultural Sciences (GAAS). The main aim of this project was to evaluate the ability of vetiver to absorb nutrients, phosphorus and heavy metals, and design a purifying system for a pig farm using Vetiver bamboo floats.

2 MATERIALS AND METHODS

2.1 Experimental Materials

Wastewater was taken from the Pig Breeding Center of GAAS, which was treated through 'separating solid and liquid' and 'anaerobic treatment'. The Pig Breeding Center located in the northern suburbs of Guangzhou, is about 45 km from downtown. It was established in 1997 and produces over 15,000 commercial pigs each year.

The seedlings of *V. zizanioides* were sampled from the nursery in South China Institute of Botany, Chinese Academy Sciences.

2.2 Trial Designs and Arrangements

2.2.1 The experiment of water cultivation

The experiment was conducted using a method of water cultivation in buckets. The buckets were put in the glasshouse of The Floricultural Research Institute of GAAS. The steps were as follows: preparing plastic buckets with a volume of 10 L for each one, adding 5.0 kg of the wastewater into each bucket, and putting Vetiver grass whose health and weight were basically similar into each bucket. Before the plants were put into the buckets, tops and roots of vetiver were pruned to 20 cm and 10 cm, respectively. Water cultivation lasted 5 weeks.

2.2.2 The design of bamboo float in the wastewater from pig water

The diameter of all the bamboo poles was about 10–12 cm, the length and width of raft made from the bamboo poles were 150, and 100 cm, respectively. 16 holes were dug on per raft, and the area for each hole was 48 cm^2 (8 cm_6 cm).

2.3 Observations and Analysis

2.3.1 Situations of vetiver growth in water cultivation

Including plant height, biomass of shoots, and length of new roots and their net increased weight.

2.3.2 Effects of vetiver on purifying wastewater from pig farm

The analytical testing included Cu, Zn, Pb, Hg, As, N and P in plants and wastewater, including prior to and after water cultivation.

2.4 Analytical Method

N in wastewater was determined with Zn-$FeSO_4$, reduction and alkali distillation, P was measured by potassium persulfate digestion and molybdenum-blue colorimetry, and Cu, Zn, Pb by the AAS, Hg and As by the AFS.

3 RESULTS AND DISCUSSION

3.1 Concentration and Content of N, P and Heavy Metals in Wastewater from Pig Farm

Table 1 shows that N, P, and heavy metals concentration of wastewater from pig farms were all different, and the highest concentration of heavy metals was Zn with the lowest concentration, Hg.

3.2 Concentration and Content of N, P and Heavy Metals in Vetiver Roots

Table 2 showed the concentration and content of N, P, and heavy metals of vetiver roots and their changes prior to and post being cultured by wastewater from the pig farm. Results showed that the

lowest concentration from Hg; the concentration of N was higher than that of P in the Vetiver roots. The amount of pollutants absorbed by vetiver was similar to their concentrations in wastewater.

Table 1 Concentration (mg/kg), content (mg/bucket) of N, P and heavy metals in wastewater from pig farm prior to and after planting Vetiver

Elements	Prior to planting vetiver		After planting vetiver		Reduction
	Concentration	Content	Concentration	Content	
Cu	0.0736	0.368	0.008	0.020	0.348
Zn	0.878	4.39	0.086	0.215	4.175
Pb	0.0501	0.2505	0.029	0.0725	0.1780
Hg	3.02_10^{-4}	1.51_10^{-3}	2.52_10^{-4}	0.63_10^{-3}	88_10^{-3}
As	0.0366	0.1830	0.011	0.0275	0.1555
N	33	165	15	37.5	7.5
P	13	65	8	20	45

Table 2 Concentration ($mg.kg^{-1}$), Content (mg/pot plant) of N, P and heavy metals in Vetiver roots prior to and after incubation in wastewater from pig farm

Element	Prior to incubation		After incubation		Net uptake
	Concentration	Content	Concentration	Content	
Cu	8.12	0.812	8.90	1.157	0.345
Zn	118	11.80	122	15.86	4.06
Pb	3.758	0.3758	3.484	0.4529	0.0771
Hg	5.26_10^{-3}	0.526_10^{-3}	0.0422	5.46_10^{-3}	0.2_10^{-3}
As	4.48	0.448	4.44	0.5772	0.1292
N	225	22.5	945.4	122.90	100.4
P	156	15.6	415.5	54.02	38.42

3.3 Uptake Rate

Ratios of uptake and purification were key indices to estimate the absorption effect. The following formulas are used to calculate the uptake rates of vetiver to pollutants of wastewater (Xia and Shu, 2001):

$$\text{Uptake rate}^1 = \frac{\text{Uptake amount by roots}}{\text{Purification amount (Reduction)}} \times 100\%$$

$$\text{Uptake rate}^2 = \frac{\text{Uptake amount by roots}}{\text{Amount in original liquid}} \times 100\%$$

$$\text{Purification rate} = \frac{\text{Purification amount (Reduction)}}{\text{Amount in original liquid}} \times 100\%$$

The results showed that vetiver had a very high capacity to purify wastewater from pig farms, removing over 92% of Cu and Zn, over 60% of As and N, 59-85% of P, 30-71% of Pb, and 13-58% of Hg (Table 3).

3.4 Growth Situation of Vetiver in the Bamboo Float for Pig Farm

The trial results confirm that Vetiver has extremely high tolerance to wastewater, and can last at least 10–12 months in wastewater with COD < 400mg/L, and BOD_5 < 150mg/L. Young shoots and roots of vetiver sprout 3 and 7 days after in wastewater.

Table 3 Uptake and purification ratios of Vetiver to N, P and heavy metals in pig-farm wastewater (%)

Wastewater	Cu	Zn	Pb	Hg	As	N	P
Rate[1] of uptake to purification	99.1	97.2	43.3	22.7	83.1	78.7	85.4
Rate[2] of uptake to original liquid	93.8	92.5	30.8	13.2	70.6	60.8	59.1
Purification: rate of purification to original liquid	94.6	95.1	71.1	58.3	84.9	77.3	69.2

4 SUMMARY

The result of this study showed that the purification of wastewater from a pig farm by the culture of *V. zizanioides* was practical. It found that removal percentage of Cu, and Zn by vetiver was the highest, more than 92%, followed by of As and N, up to 60%, and then of P between 59–85%, Pb between 30–71%, and Hg between 13–58%. The purifying effects of Vetiver to heavy metals, N, and P from a pig farm were ranked as Zn > Cu > As > N > P > Pb > Hg. In addition, the Vetiver bamboo float technology can provide a workable method for a large-scaled purification. Therefore, the environmental pollution from pig farms can be further controlled.

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A Brief Introduction to the First Author

Xuhui Kong, an Associate Professor for Engineering in Landscape-Gardening, is a Vice-Director of the Floricultural Research Institute of GAAS. He has undertaken a wide range of Landscape-Gardening and environmental protection related research projects, including new ornamental plants introduction, acclimatization, wastewater purification and slope work. He has had over 15 academic papers published in this area.