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Treatment of turtle-breeding wastewater and domestic fecal sewage with soil cultivating system

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Abstract: Turtle-breeding wastewater and domestic fecal sewage were treated by means of soil cultivating system. Results indicated that more than 50% COD_{Cr} and BOD_5 of wastewaters were removed, removal rates of NH_4^+-N could reach about 70%—80%, but PO_4^{3-} could not be removed. The thesis analyzed functional mechanisms for pollutants and put forward main elements affecting treatment efficiencies, thus provided conditions for further research.

Key words: turtle-breeding wastewater; fecal sewage; soil; COD_{Cr}; BOD_5; N; P

Introduction

Land treatment system for treating municipal sewage has been fairly developed at home and abroad, which is a low cost and high efficiency sewage treatment method on certain conditions. In the past a few years artificial aquatic products breeding industry had rapid developed in Chinese rural areas, especially in the south east coastal areas of China and obtained good economic and social benefits. Breeding wastewaters contained high contents of organics, N, P, so their discharge polluted environment and affected other farming, side-line production and life of the masses in nearby regions. Growth of crops needs water and nutrients and can not leave soil medium. It could achieve success that soil cultivating system is directly applied to treat artificial breeding wastewaters according to land treatment principles of sewage and by means of engineering methods. For this purpose, the experiments for treating breeding wastewater with soil cultivating system were made. Meanwhile the domestic fecal sewage was treated with the same system as a contrast with breeding wastewater.

1 Materials and methods

1.1 Wastewater source and water quality

Production wastewaters discharged from a certain artificial hothouse soft-shelled turtle-breeding plant were used as main test wastewaters, and fecal sewages from a certain septic tank were used as a contrast test wastewaters. Main water quality parameters of two test wastewater are given in Table 1.

1.2 Experimental apparatus and crop

Table 1 Main water quality parameters of two test wastewaters

Parameter	pH	COD_{Cr}, mg/L	BOD_5, mg/L	NH_4^+-N, mg/L	PO_4^{3-}, mg/L
Turtle wastewater	7.0	140—180	100—120	50—80	5—10
Fecal sewage	6.8	100—170	90—120	15—30	3—7

Two cement tanks were used as containers for cultivating crops. Pebbles (particle diameter 2.5 cm—5.0 cm) were filled at the bottom (thickness 6 cm) of containers. Fine cinders (particle diameter 0.2 cm—0.4 cm) were filled in the middle part (thickness 2 cm) of containers. Powder-sandy loam was fully filled on the top (thickness 12 cm). Eggplant seedlings were transplanted from fields to test containers and were used as test crops. Four eggplant seedlings were uniformly distributed in every tank. Planting density was $18.5 m^{-2}$. Schematic conditions are given in Fig.1.

1.3 Influent mode and hydraulic loading in influent lasting time

Experiment was conducted continuously for 65 days and was divided into two phases. In the experimental period test wastewaters were filled to the surface of soil layer uniformly two times every week. Tank 1 was filled with turtle-breeding wastewater. Tank 2 was filled with fecal sewage. Phase I was from day 1 to 26. In this phase influent flow of every time was 3000 ml. Influent lasting time was 5 min. Hydraulic loading in influent lasting time was $0.167 m^3/(m^2 \cdot h)$. Phase II was from day 27 to 65. In this phase influent flow was 4000 ml. Influent lasting time was 13.3 min. Hydraulic loading was $0.0833 m^3/(m^2 \cdot h)$. Operation conditions for two tanks were the same.

1.4 Properties of original soil

Original soil employed in experiment was powder-sandy loam. It was taken from a certain mulberry field. This soil possessed good permeability and high aeration porosity, poor holding water capacity. But soil quality was fertile and was good for growing eggplant. The chemical characteristics of original soil were pH 7.7, NH_4^+-N 11 mg/L, quick-acting phosphorus 90 mg/L.

2 Results and discussion

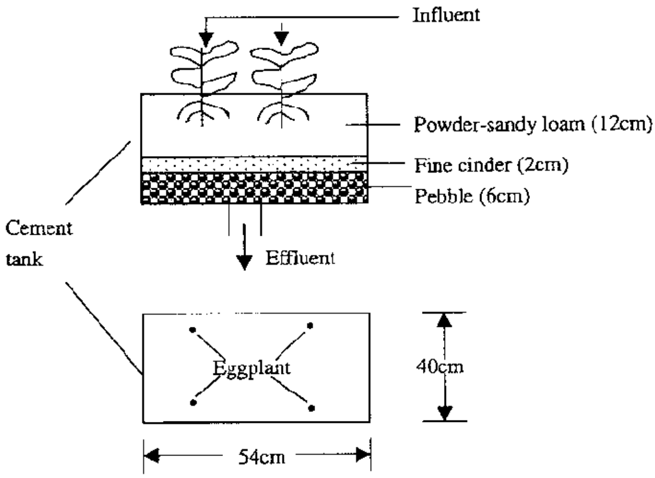

Fig.1 Schematic diagram of experimental apparatus and crop arrangement

2.1 Treatment efficiencies of wastewaters

In the experimental period water quality monitoring for influent and effluent were conducted with COD_{Cr}—2 times, BOD_5—1 time, NH_4^+-N—2 times, PO_4^{3-}—2 times every week. Examination results are given in Table 2.

According to the results in Table 2 in Phase I (the early days of experiment) COD_{Cr} removal rates were only more than 30%. In Phase II (the middle and later period of experiment) through purification of soil cultivating system organic (COD_{Cr} and BOD_5) removal rate of turtle-breeding wastewater reached about 54%. Removal of organic matter was accomplished through physical action, physicochemical action, microbial action and crop absorption. Organic suspended matters were filtered and intercepted by means of pores among soil particles. Soil colloidal particles with huge surface area could adsorbed organic and inorganic colloids physically. Soil particles with negative charge produced ion exchange with organic ions in wastewater. These actions made suspended and colloidal organic matters to be transferred to soil surface, and they were separated with wastewater. A large number of heterotrophic microbes in soil biodegraded suspended, colloidal and dissolved organic matters. Then these matters were mineralized into inorganic nutrients which were absorbed by root system of crop. From Table 2 COD_{Cr} removal rate of fecal sewage was almost the same with that of turtle-breeding wastewater. BOD_5 removal rate of the former was high than the latter. It could be reason that microbial contents in fecal sewage was more than the latter. In general organic removal mechanisms of either were basically the same.

Table 2 Main examination results for influent and effluent parameters

Parameter	COD_{Cr}, mg/L		BOD_5, mg/L		NH_4^+-N, mg/L		PO_4^{3-}, mg/L	
	inf.	eff.	inf.	eff.	inf.	eff.	inf.	eff.
Phase I (day 1 to 26)								
Turtle-breeding wastewater	154.3	99.3						
Removal rate, %	35.6							
Fecal sewage	186.6	126.7						
Removal rate, %	32.1							
Phase II (day 27 to 65)								
Turtle-breeding wastewater	164.1	76.0	111.5	51.5	62.4	19.7	7.9	14.5
Removal rate, %	53.7		53.8		68.4		Leaching	
Fecal sewage	141.8	68.2	105.0	36.5	21.1	4.3	4.0	12.0
Removal rate, %	51.9		65.2		79.6		Leaching	

Note: all values were average of several samples

Table 2 shows that NH_4^+-N content in turtle-breeding wastewater was very high and reached 62.4 mg/L. Through purification of this system its removal rate reached 68.4%. Absolute removal content of NH_4^+-N was 42.7 mg/L. Removal rate and absolute removal content of NH_4^+-N in fecal sewage were 79.6% and 16.8 mg/L respectively. These results showed that this system possessed good denitrifying function. The function was mainly concerned with systemic characteristics and sorts of crop. Cultivating medium of the system was powder-sandy loam. Soil layers possessed good permeability and ventilated function. Oxygen content in soil layers was rich. The great part of the organic nitrogen in wastewater was transformed to NH_4^+-N through mineralization of heterotrophic microbes. Under neutral condition few of NH_4^+-N was transformed to NH_3 gas scattered. In aerobic condition a part of NH_4^+-N was nitrified into NO_3^-. Finally NO_3^- and NH_4^+ were absorbed and used together by crops. Eggplant needed a large number of nitrogen in growth phase. Especially in Phase II when eggplant blossomed and produced fruits a great quantity of nitrogen in the system was absorbed. In this time removal rate of NH_4^+-N reached about 90%.

2.2 Leaching reason of phosphorus

According to test results when turtle-breeding wastewater and fecal sewage passed through test system PO_4^{3-} contents in the system were leached with 6.6 mg/L and 8.0 mg/L respectively. Leaching reason was mainly concerned with characteristics of soil medium in the system. In general under acidic condition dissolvable PO_4^{3-} in soil cultivating system could be adsorbed and fixed by Fe, Al oxides, and could be adsorbed and fixed by $CaCO_3$, $MgCO_3$ under alkali condition. Above processes could be accomplished in upper layer soil whose thickness must be more than 0.3m—0.6m. Employed soil in this experiment was neutral (pH 7.7) and powder-sandy loam. Its thickness was only 0.12m, and possessed big soil porosity, good permeability. Thus PO_4^{3-} content adsorbed by soil colloids was a little. Whereas quick-acting phosphorus in this neutral soil (the great part was mono – calcium phosphate and bi-calcium phosphate) highly reached 90 mg/L. In this case when test wastewaters passed through soil layers of the system PO_4^{3-} content in wastewater was not adsorbed and fixed, contrarily some of original PO_4^{3-} content in the system was leached under a certain hydraulic loading. As a result purpose of removing PO_4^{3-} could not be achieved.

2.3 Hydraulic loading effect on removal rate

When hydraulic loading of Phase I was high ($0.167\ m^3/(m^2\cdot h)$), COD_{Cr} removal rate was low (about only more than 30%). In Phase II hydraulic loading was decreased to half as large as that of Phase I ($0.0833\ m^3/(m^2\cdot h)$). As a result COD_{Cr} removal rate rose obviously and reached more than 50%. This case indicated that hydraulic loading possessed larger effect on removal rate of organic matter.

2.4 Growth state of crop

At the beginning of experiment height of eggplant seedings transplanted was about 20 cm. After one month of test the eggplant which was supplied with turtle-breeding wastewater grew up to 25 cm, the eggplant which was supplied with fecal sewage grew up to 22 cm. After two months of test all of eggplants produced results. At the end of experiment eggplants continued to blossomed and produced results. In general the eggplant of Tank 1 grew better than that of Tank 2. The reason was that contents of organic matter, N, P in turtle-breeding wastewater were richer than those in fecal sewage. Therefore the former grew better than the latter.

3 Conclusions

On the basis of ecological principles soil cultivating system was applied to treat artificial turtle-breeding wastewater and domestic fecal sewage, and obtained good results. Organic removal rates in two wastewaters reached more than 50%. NH_4^+-N removal rates reached 70%—80%. If effluent treated was properly retreated it could be reclaimed to breeding ground or other fields. Test results indicated that this system did not possess function of removing phosphorus and showed hydraulic loading effect on removal rate. According to above cases following several issues were put forward for further research.

3.1 Effect of soil properties

In considering treatment system proper sort of soil must be selected according to treated wastewater quality. If necessary properties of soil medium have to be improved and regulated. Thus the desired results can be achieved.

3.2 Effect of crop physiological characteristics

The crops absorbed and used several nutrient matters (N, P) in wastewater is different. Nutrient quantity required by the same crop in different growth period is differential. Therefore when treatment system is designed proper crop must be selected in accordance with purifying objective of wastewater.

3.3 Effect of soil layer thickness

For thinner soil layer HRT (hydraulic residence time) of wastewater in soil medium is shorter, and is easy to cause short pass. Thus purification process can not be fully conducted, and removal rates are poor. According to some reference materials soil layer thickness of related treatment system must be more than 1.0m.

3.4 Effect of hydraulic loading

Different hydraulic loadings can obviously affect treatment efficiency of wastewater. This parameter must be determined through several tests concerning soil properties, climatic condition and water requirement of crop. In designing engineering project treatment system scale and other operating parameters can be determined on the basis of determined hydraulic loading and wastewater flow.

3.5 Pretreatment of wastewater

When suspended solid content is exceeding high, or harmful materials are contained in wastewater pretreatment of wastewater must be considered, so that normal operation of treatment system can be preserved and the desired results can be achieved.

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