A NEW TREATMENT SYSTEM FOR ANIMAL WASTE WATER USING MICROORGANISM, SOIL AND VEGETATION

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Summary

A new treatment system for animal waste water has been developed as an alternative to the activated sludge process. It consists of two treatments; one is operated with 7 tanks, and the other is soil and plant cultivation bed. Aerobic microorganisms are added to the influent water in the tanks where the water is aerated so that the microbes utilise the pollutants, while sedimentation removes the indigestible solids. In the secondary treatment the water, which has already received a primary treatment, is filtered through soil where it also receives treatment by soil organisms. In addition there is transpiration of water and absorption of minerals by plants. In the primary treatment BOD, SS, coliforms (*E. coli*), TP and total bacteria were removed 79-99%, but COD and TN were removed only 58% and 36%, respectively. In the secondary treatment removal of nutrients proceeded further, and 93-99% of pollutants were removed. The treated waters met the quality standard of discharge water in Japan except for TN, which was in too great a concentration to meet discharge standards. This problem requires further study.

(**Key Words**: Animal Waste Treatment, Land Application System, Reuse of Treated Water, Water Purification, Water Quality)

Introduction

In most of Asian countries land area is so small that there are difficulties of environmental conservation in animal husbandry. Among them animal waste treatment is the biggest problem and without resolution development of animal husbandry may not proceed. Conventional system of waste water treatment, such as the activated sludge process require much of labor, technology and money for the construction of the facility and maintenance. In addition, discharge of waste water into waterways is not only bad biological practice, but is often proscribed by regulation. Therefore a closed system (Oshida, 1991) which does not discharge waste matter from the system, is required in waste water treatment. Recently, the treatment of sewage by passage through soil, has attracted special interest in Japan. This system has been given a practical application in a domestic sewage disposal plant (Matsumoto, 1984).

Oshida, et al. have studied the mechanism and efficiency of a land application system with regard to the role of disinfectants (1991b), microorganisms (1992a, 1992b), the effect of soil and plants (1992c), waste water treatment agents (1992d) and the distribution of animal waste products in a plant cultivation bed (1992e). The present report describes a new treatment plant which was constructed in Azabu University (Oshida et al., 1990 and 1991a) and the effects of the treatment on water quality from 1987 to 1988.

Materials and Methods

1) The animal waste water treatment plant is described as follows: It consists of two main

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parts as shown in figure 1; one has 7 tanks through which the waste water flows and to which microorganims are added, and aeration (1st-3rd tanks) and sedimentation (4th-6th tanks) is carried out. Aerobic digestion of the waste is performed in the tanks. The other consists of a soil and plant cultivation bed, of which the cross section is shown in figure 2. It has an area of 200 m^2, and is constructed with zeolite and clinker ash. Installed inside it are 20 water flowing pipes which infiltrate the primary treatment water and also the primary treatment water receipt bin. The plant cultivation bed furnished upon the soil bed and consists ando-soil and perlite. Plants such as barnyard millet (*Echinochloa utilis* Ohwi et Yabuno) and Italian ryegrass (*Lolium multiflorum* Lam.) were grown on the plant cultivation bed.

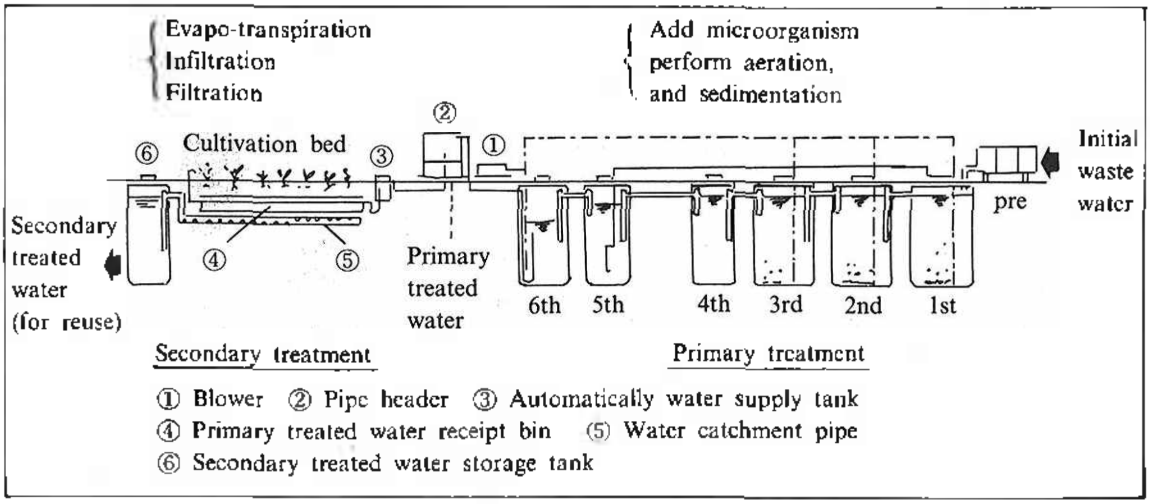

Figure 1. Structure of land application system constructed at Azabu University.

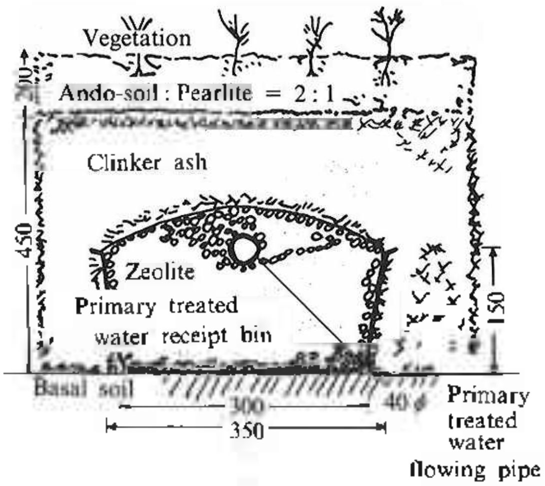

Figure 2. A view of cross section of secondary treatment.

Two to three tons of animal waste water, namely, urine of cattles and pigs and a large amount of wash water, flow into the tanks, the capacity of which is 24 tons in total every day. Water for dilution is never added during this process. The primary treatment in the tanks finishes in 8 days, then it is injected into the soil and plant cultivation bed. In the soil and plant cultivation bed the waste water is treated by microbes, by absorption of minerals by plant and by filtration through soil. In addition its volume is decreased by evaporation and transpiration.

2) The influent, the primary treated and the secondary treated water was collected every month from October, 1987 to October, 1988 and analysed the following 10 items; Water temperature, pH, transparency, biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), Coliform group (*E. coli*), variable bacteria count (bacteria), total nitrogen (TN) and total phosphorus (TP). Method of analysis was followed by the method of analysis of sewage water (Japan Sewage Works Association, 1984).

Results and Discussion

1. Primary treatment

Quality of water of the influent, the primary treated and the secondary treated waste water is shown on table 1. No seasonal effect was found all items. Removal percentage of the primary and secondary treatment of animal waste water is shown on the table 2 and figure 3. Removal percentage (RP) is calculated by the following formula;

RP=(Initial water-Treated water)/Initial water × 100(%)

E. coli counts were highly variable in the influent water, depending on the month of sampling. The count were reduced by 99% in the primary treatment, but the counts were a little higher than the quality standard of discharge water in Japan (table 3). Similarly, SS, and TP were removed efficiently with the removal percentage of 93-94% (table 2). BOD and bacteria had removal percentages of 79-84% (table 2).

However, removal of COD and TN and 58 % and 36%, respectively. TN in the primary treated water was 285 mg/l (table 1) which is higher than quality standard of discharge water which is 120 mg/l.

2. Removal of pollutants in the secondary treatment

E. coli, SS, bacteria, TP, BOD and COD of the secondary treated water were only 0.1-7% (table 1) of the initial water and it was recognized that 93-99% (figure 3) of these items were removed by the primary and secondary treatments. As a result, value of these items were only 1/5-1/50 of the quality standard of discharge water.

Removal of these items in the secondary treatment was 67-90% (table 2), and indicated that efficiency of soil and plants in the secondary treatment was fairly high. The removal of *E. coli*, COD and bacteria was especially effective.

However, TN was not removed efficiently. TN in secondary treated water was 189 mg/l (table 2), higher than the quality standard of discharge water. Removal percentage of TN in the secondary treatment was only 34% (table 2) and that of the total of primary and secondary treatment was 58% (figure 3).

TABLE 1. QUALITY OF WATER OF THE INFLUENT, THE PRIMARY TREATED AND THE SECONDARY TREATED BY WASTE WATER (AVERAGE OF EXPERIMENTAL PERIOD)

Items (Unit)		Water		
		Initial	Primary treated	Secondary treated
pH	Mean ± SD	7.69 ± 0.39	7.72 + 0.41	7.21 ± 0.43
DTP[1] (cm)	Mean ± SD	2.1 ± 1.79	5.7 ± 4.43	37.0 ± 11.56
BOD (mg/l)	Mean ± SD	677 ± 383.8	108 ± 89.9	33 ± 26.2
	RV[2]	100	16	5
COD (mg/l)	Mean ± SD	379 ± 291.6	160 ± 112.9	27 ± 14.2
	RV	100	42	7
SS (mg/l)	Mean ± SD	641 ± 782.4	41 ± 26.4	11 ± 7.7
	RV	100	6	2
E. coli[3] (10^n CFU/ml)	Mean + SD	4.85 ± 0.96	3.04 + 0.72	2.00 + 0.54
	RV	100	21	2
Bacteria[4] (10^n CFU/ml)	Mean ± SD	6.58 ± 0.61	6.07 ± 0.50	4.75 ± 0.51
	RV	100	21	2
TN (mg/l)	Mean ± SD	448 ± 107.4	285 ± 101.6	189 ± 93.9
	RV	100	64	42
TP (mg/l)	Mean ± SD	14.9 + 7.8	1.1 ± 1.1	0.3 + 0.3
	RV	100	7	2

[1] Degree of transparency.
[2] RV: Relative value of treated water against initial water.
[3] Coliform group (*Escherichia coli*).
[4] Variable bacteria count.

TABLE 2. REMOVAL PERCENTAGES OF THE PRIMARY AND THE SECONDARY TREATMENT OF THE WASTE WATER

Items	Treatment of	
	Primary[1]	Secondary[2]
BOD	84	69
COD	58	83
SS	94	67
E. coli[3]	99	97
Bacteria[3]	79	90
TN	36	34
TP	93	71

[1] Removal percentage of primary = (Initial-Primary)/Initial × 100 (%).
[2] Removal percentage of secondary = (Primary-Secondary)/Primary × 100 (%).
[3] Refer to table 1.

TABLE 3. THE QUALITY STANDARD OF DISCHARGE WATER IN JAPAN

Items	Maxim value	Average in a day
pH	5.8 - 8.6	
BOD (mg/l)	160	120
COD (mg/l)	160	120
SS (mg/l)	200	150
E. coli[1] (CFU/ml)	3,000	
TN (mg/l)	120	60
TP (mg/l)	16	8

[1] Refer to table 1.

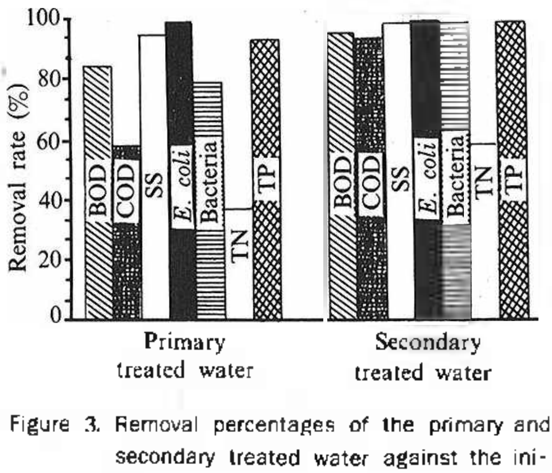

Figure 3. Removal percentages of the primary and secondary treated water against the initial waste water.

3. **Some problems in the system**

1) TN : It may be possible to decrease TN more efficiently by stronger aeration and increasing the activity of denitrification bacteria which are artificially inoculated into the primary treatment.

2) SS : SS is important since it has correlations with BOD and TP, both of which should be reduced during treatment of animal waste water. A high concentration of SS exists in waste water and impedes filtration so as much SS as possible should be removed by the primary treatment. As shown in table 2, 94% of SS is removed, but 6% still remains. In order to treat the influent water and reduce the concentration of SS, microorganisms given the trade name "Rose scumless" is added in the primary treatment. While this is an effective treatment it is hoped that greater efficiencies can be obtained (Oshida et al., 1992a and 1992b).

3) Reuse the treated water : The quality of the secondary treated water is such that it may be possible to use it as cleaning cow shed, car washing, toilet flushing, water sprinkling and fish farming, etc. From the point of environmental conservation and also resources utilization, the emphasis is on finding the way to recycle the animal waste water.

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