Application of Effective Microorganisms for Swine Waste Treatment

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Introduction

Thailand has long been known as an agricultural country. Like other developing countries in Southeast Asia, livestock production generally provides supplementary income to crop production. It is estimated that from 1987 to 1991 livestock and livestock products provided about 17 to 24 percent of the total farm income. In recent years, however, livestock production has become a more important part of both farm income and the national economy. During this time, pig farming in Thailand has undergone considerable change from simple backyard-style systems to intensive commercial operations.

Pig farming is carried out in all regions and provinces of Thailand. The standing pig population (officially reported in 1991 as 4.6 million) has remained relatively unchanged since 1984, Numbers of pigs by region for 1991 are presented in Table 1. The Central Plain is the largest pig producing region; it has about 32 percent of the total pig production. The largest concentration of animals is located in Nakorn Pathom Province and in the neighboring Provinces of Ratchburi and Suphanburi. Approximately 27-35 percent of the pigs are grown in the northern and the northeastern regions, respectively, and only 16 percent in the south.

Table 1. Standing Number of Pigs Officially Reported in 1991

Region	Number of Pigs	Percentage
Northeastern	1,227,502	25.3
Northern	1,298,554	26.7
Central Plain	1,568,557	32.3
Southern	764,426	15.7
Whole Kingdom	4,859,039	100.0

Source: Agricultural Statistics of Thailand Crop Year 1991-1992. Center of Agriculture Stastics, Office of Agriculture Economics, Ministry of Agriculture and Cooperation.

As pig production has increased, pig manure has become a most serious environmental pollutant, particularly with the development of large commercial operations. In most cases, the pig waste is drained off without any treatment and, thus, contributes significantly to water pollution and environmental degradation. Among the waste treatment methods being studied and practiced in the country, anaerobic digestions seems especially attractive from the standpoint of energy recovery and pollution control. The advantages of anaerobic digestion include stabilization of the organic material, low nutrient requirement, odor reduction, and production of useful methane gas. Big farmers, however, are reluctant to establish such a facility because the cost would provide them with little economic gain.

The present study was designed to determine the technical feasibility of a new low-cost technology for pig waste treatment, i.e., the application of Effective Microorganism (EM).

Materials and Methods

Description of the Experimental Pig Farm

Experiments were conducted at the Experimental Pig Farm of the Animal Science Department, Kasetsart University in Bangkok, Thailand. This farm, which can now accommodate 300 animals, was established almost 20 years ago. A diagram of the experimental pig far (Figure 1) consists of confinement buildings (i.e., pigsties) and a waste-handling system including a sedimentation tank, manure drying bed, and two effluent-holding ponds (each approximately 6 m x 30 m connected by a narrow canal). This model is used on most medium-sized farms. Manure is first manually scraped onto the concrete floor and dried; the remaining manure and the pigs are washed daily with a pressure hose. The resultant slurry is flushed into a sedimentation tank and the overflow is discharged directly into effluient-holding pond 1 (Figure 1) where the solids accumulate. The depth of water in this pond ranges from about 5 cm to 50 cm. Water from effluent-holding pond 2 (approximate depth of 1 m) is pumped and recycled for washing the pigpens. Pig drinking water is tap water from the Bangkok City Waterworks.

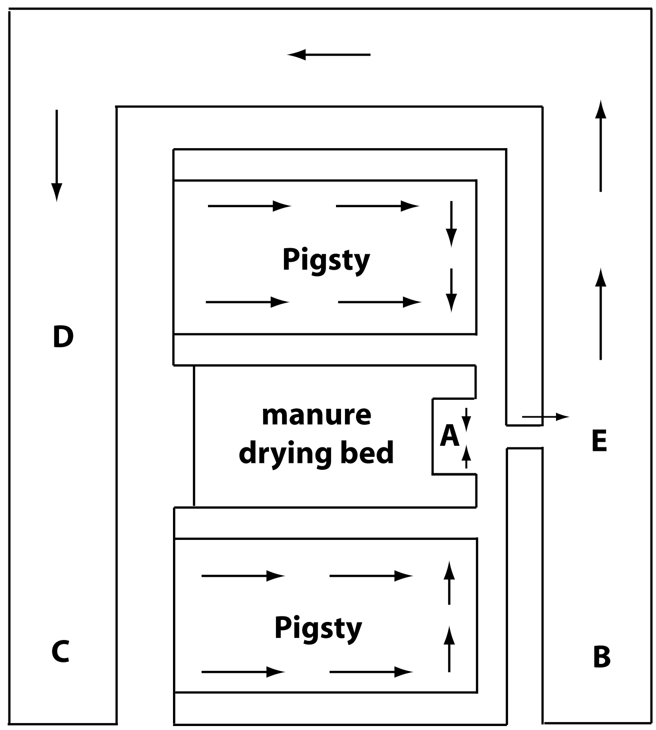

Figure 1. Plan View of Experimental Pig Far. A = sedimentation tank; B = effluent holding pond 1; C = effluent holding pond 2; D = effluent sampling site 1; E = effluent sampling site 2.

Mass Culture of EM ad Experimental Treatments

In this study, 200-liter metal tanks were used to culture EM. Mass-culturing of EM was done by mixing 2 liters of molasses with 20 liters of tap water in the 200-liter tank. Two liters of EM stock suspension were used as the inoculant and tap water was then added to fill the tank. To prevent exposure to sunlight, the tank was covered with a plastic sheet and pieces of wood. After 3 days of incubation, the EM solution was ready to use. The remaining liquid at the bottom of the tank (about 10-cm deep) was used as an inoculant for the next batch-culture of Em. Two litters of molasses and enough tap water to fill the tank were all that was required to restart the incubation process. Since EM was used routinely in this study, batch-culture of EM were prepared at 4-day intervals.

EM was used to treat pig waste in the following ways:

1. Mixed with wash water at a dilution of 1:1000.
2. Mixed with wash water and drinking water at dilutions of 1:1000 and 1:100, respectively.

Prior to EM treatment, water samples from the two assigned sampling sites and manure samples from the sedimentation tank (Figure 1) were taken on three consecutive days. After washing the facilities for 7 days with EM, samples of the treated water and manure were collected in the same manner. For the wash water and drinking water treatments, samples were taken after EM had been used for 7 days.

Water samples were analyzed for quality and waste characteristics while sample of manure were tested for fertilizer and nutritional values.

Analytical Methods

Analyses were determined by the following methods and laboratories:

1. Chemical analyses of water quality were determined using colorimetric methods at the Water Quality Analytical Laboratory of the National Inland Fisheries Institute.
2. Wastewater characteristics were determined according to the American Public Health Association (1971) at the Central Laboratory of Kesetsart University in Bangkok.
3. N, P and K analyses were determined by spectrophotometric methods at the Central Laboratory of Kasetsart University in Bangkok.
4. Nutritional values of dry manure were determined by "proximate analysis" according to the Association of Official Analytical Chemists (1980) at the Nutritional Laboratory, National Swine Research and Training Center, Kasetsart University, Kamphaeng Seang Campus.
5. Amino acids were analyzed using an amino acid analyzer at the Nutritional Laboratory, Ajinimoto Co., Bangkok.

Results and Discussion

General characteristics of treated and untreated water such as temperature, pH, transparency, dissolved oxygen, carbon dioxide, alkalinity and hardness are summarized in Table 2. The mean values for biochemical oxygen demand (BOD), chemical oxygen demand (COD), total solids (TS), total volatile solids (TVS, N, P, and K) are reported in Table 3. Fertilizer and nutritional values of untreated and treated dry pig manure, and reported in Tables 4 and 5; amino acid composition is shown in Table 6.

In regard to the treatment of wastewater with EM (Table 2 and Table 3), it was unfortunate that after the samples of water and manure for the EM treatment were taken, the drainage canal near the pig farm was re-excavated. Consequently, the level of water in comparison of values for untreated water with those of water treated with EM only. The values for EM-treated wash water and EM-treated drinking water are, however, reported in the tables.

The average temperature during the experiment ranged from 28ºC to 34ºC. The pH values varied from 6.6 to 8.0. These are optimal conditions for the growth of EM cultures. It appears that washing pig pens with diluted EM can improve the quality of pig wastewater. Table 2 shows that the transparency values for untreated water were 10 cm at site 1 and 6 cm at site 2 compared with EM-treated water which were 16 cm at site 1 and 9 cm at site 2. The dissolved O_2 in EM-treated wash water was 1.3 mg/liter at site 1 while no dissolved O_2 was detected in untreated water at the same site. The CO_2 content decreased from 123 mg/liter to 47 mg/liter at site 1 and from 446 mg/liter to 215 mg/liter at site 2 after treatment of pig waste by washing the pens with diluted EM for 7 days.

Table 2.
Chemical Analyses of Untreated Water and EM-Treated Water at Two Sampling Sites.

Parameter	Site	Untreated Water (No EM)	Wash Water (EM)	Wash and Drinking Water (EM)
Temperature (C)				
Water	1	28.6	28.3	28.3
	2	29.3	29.8	29.3
Ambient	1	34.0	28.3	28.3
	2	33.3	29.8	29.3
pH	1	7.5	7.5	8.0
	2	6.8	7.3	6.6
Transparency (cm)	1	10.0	16.3	10.0
	2	6.0	9.0	4.0
Dissolved O_2	1	0.0	1.3	3.2
	2	0.0	0.0	0.0
CO2 (mg/l)	1	123	47	57
	2	447	215	300
Alkalinity (mg/l)	1	422	453	485
	2	687	919	1319
Hardness (mg/l)	1	212	251	223
	2	283	295	277

The chemical properties of water before and after EM treatment of the pig pens are shown in Table 2. In general, the BOD, COD, TS and TVS contents were reduced by the EM treatment. The reduction of BOD in EM-treated wash water was 46 percent for site 1 and 91 percent for site 2. The COD values for untreated wash water were 257 mg/liter and 3,481 mg/liter, respectively, for the samples taken at sites 1 and 2 compared with those fore EM-treated wash water which were 229 mg/liter and 807 mg/liter, respectively, Total solids in water at the highest concentration (site 2 were reduced from 15,000 mg/liter to 1,721 mg/liter after EM treatment. It is noteworthy that the beneficial effect of EM on the treatment of pig waste is greatest in water with a high organic matter content.

The reduction in total volatile solids (TVS) of EM-treated wash water was 30 percent at site 1 and 89 percent at site 2. This is associated to some extent with malodors in animal wastes. Most people working and living near the pig farm are convinced from experience that the EM treatment can effectively control odor problems. In this study, the EM-treated dry pig manure was essentially odorless.

The content of macronutrients (N-P-K) in dry pig manure depends on the source of the material. The macronutrient content of EM-treated and untreated pig manure is shown in Table 4. The mean values for total N, P and K of untreated manure were 35.6, 15,8 and 12.8 mg/g of dry matter, respectively. The values for mature treated with EM were 36.7, 14.2 and 15.4 mg/g of dry matter compared with those of the EM-treated wash and drinking water which were 40.0, 16.1 and 7.9 mg/g, respectively.

The nutrient content and digestibility of animal wastes depend largely on the kind and age of the animals, feeding regimen, litter management, conditions under which the animals are kept, and waste handling practices. In this study, the chemical composition of untreated and EM-treated pig manure is shown in Table 5. The main nutritional values such as crude protein, crude fat, crude fiber and ash fall in the range documented by Muller (1980). The pig manure treated with EM-wash and drinking water, and manure treated with EM-wash water alone, had a higher crude protein content than untreated manure; the values were 23.9 and 22.6 percent compared with 21.7 percent.

Table 3.
Chemical Properties of Untreated Water and EM-Treated Water at Two Sampling Sites.

Parameter	Site	Untreated Water (No EM)	Wash Water (EM)	Wash and Drinking Water (EM)
pH	1	7.9	7.8	7.9
	2	7.2	7,7	7.5
BOD (mg/l)	1	203	108	153
	2	4160	363	1597
COD (mg/l)	1	257	229	441
	2	3481	807	3830
TS (mg/l)	1	773	809	1161
	2	15000	1721	8347
TVS (mg/l)	1	441	289	488
	2	7863	903	4534
K (mg/l)	1	99	166	156
	2	366	294	295
P (mg/l)	1	12.4	21.3	31.7
	2	140	52.1	139
N (mg/l)	1	ND	ND	24.3
	2	ND	ND	221

ND = Non-detectable by colorimetric method
BOD = Biochemical oxygen demand
CD = Chemical oxygen demand
TS = Total solids
TVS = Total volatile solids

Table 4.
Content of Macronutrients, N-P-K, in EM-Treated and Untreated Pig Manure.

Plant Nutrient	Untreated Water (No EM)	Wash Water (EM)	Wash and Drinking Water (EM)
	(mg g^{-1} dry weight)		
N	35.6	36.7	40.0
P	15.8	14.2	16.1
K	12.8	15.4	7.9

Table 5.
Nutritional Value of EM-Treated and Unteated Pig Manure.

Value	Untreated Water (No EM)	Wash Water (EM)	Wash and Drinking Water (EM)
	(%)		
Moisture	6.4	7.2	7.3
Crude Protein	21.7	22.6	23.9
Crude Fat	2.5	2.2	2.6
Ash	28.9	33.3	25.5
Crude Fiber	19.8	18.7	21.7
Ca	5.2	5.0	4.6
P	1.7	1.0	1.6

Summary

Waste management and processing systems have a great impact on changes in the amino acid composition of pig waste, This study showed that treatment of pig waste with EM-wash and-drinking water markedly improved the content of amino acids, especially the essential amino acids, in the dry manure as shown in Table 6. Moreover, pig manure treated with EM-wash water alone contained relatively higher levels of amino acids than the untreated manure.

Pig manure is one of the most serious agricultural and environmental pollutants in Thailand, particularly in recent decades as pig production has become increasingly more intensive.
The present study was designed to determine the technical feasibility of using Effective Microorganisms (EM) for solving the manure problem. EM was cultured in a semi-continuous mass culture and was utilized for treating the pig waste. In one treatment, EM was mixed with the wash water for cleaning the pigs and the pens; in another treatment, EM was mixed with wash water and drinking water.

Results of chemical analyses show that EM is practicable for treating the pig waste water. The reduction in BOD was found to be 91 percent at the high solids concentration site and 46 percent at the dilute concentration site. It was found in this study that washing the pigs and the pens daily with dilute EM can satisfactorily control odor problems. EM- and EM-wash and drinking water contained 23.9 percent crude protein and significant quantities of essential amino acids.

Table 6.
Amino Acid Composition of EM-Treated and Untreated Pig Manure.

Value	Untreated Water (No EM)	Wash Water (EM)	Wash and Drinking Water (EM)
	(%)		
Total Nitrogen	3.5	3.6	3.8
Crude Protein	21.7	22.6	23.9
Aspartic acid	1.68	1.78	2.11
Threonine	0.85	0.88	1.01
Serine	0.86	0.88	1.02
Glutanic acid	2.11	2.24	2.90
Proline	0.70	0.65	0.79
Glycine	1.08	1.10	1.20
Alanine	1.19	1.28	1.46
Cystine	0.36	0.32	0.40
Valine	0.98	1.04	1.24
Methionine	0.38	0.38	0.49
Isoleucine	0.67	0.69	0.88
Leucine	1.41	1.43	1.86
Phenylalanine	0.60	0.60	0.82
Lysine	0.86	0.90	1.06
Arginine	0.68	0.73	0.92

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