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# Technology of Swine Manure Treatment on Intensive Scaled Swine Farms

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**Abstract** In accordance with the characteristics of swine manure discharging way and the property of swine wastewater on intensive scaled swine farms in China, a new technology of swine wastewater treatment and swine manure fermentation to produce organic fertilizer was presented. This technology includes cleaning manure by manpower, solid-liquid separator + sedimentation basin + Upper-flow Anaerobic Sewage Bed (UASB) + SBR + aquatic plant pond. The project practice of swine wastewater treatment in Shanghai Jiading Breeder Farm showed that the new technology could save 35% of the project investment, 65% of the operating electricity charges with good direct economic benefit, on condition of guaranteeing the prerequisites that the discharged swine wastewater reached the state standard all-sidedly and swine manure was pollutionlessly treated.

**Key words:** swine manure treatment; solid-liquid separation; sedimentation; anaerobic digester; aerobic digester; pile fermentation

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Now, the swine manure of most large-scale swine farms in China is not effectively treated, which seriously polluted surrounding environments. This situation has not only restricted the sustainable development of agriculture, but also done harm to the health of people. It is high time that the swine manure and wastewater should be treated comprehensively before discharging into environment.

## 1 The Present Situation of Swine Manure Treatment on Large-Scale Swine Farm in China

At present, there are mainly the following ways of swine manure treatment.

### 1.1 Cleaning Away Swine Manure by Manpower

Swine manure is cleaned away by manpower on most small swine farms in China, among which large parts of fresh manure are applied in farmland as fertilizer, and swine wastewater is carried into swine waste slurry digesters for simple treatment. The COD of the discharged slurry in this way is

about 4500 mg/L and seriously exceeds the standard, which seriously pollutes the surrounding environments.

### 1.2 Ecological Cycle Treatment of Swine Manure

The way of ecological cycle treatment of swine manure was adopted by some rural swine farms as shown in Fig. 1.

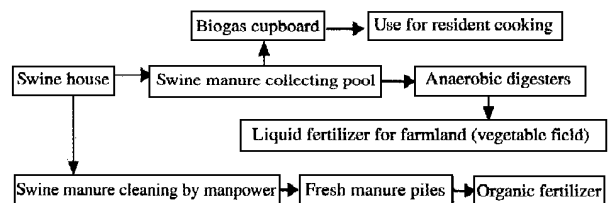


Fig. 1 Ecological cycle treatment of swine manure

This kind of ecological circulatory treatment is better undoubtedly, because not only environmental pollution is eliminated, but certain economic benefits are also obtained. However, because of the larger raising scale of swine farms, the total manure discharging amount does not always match with around farmland area and the digestive ability of crops. Moreover, the volume of water and fertilizer demand of crops in different growth periods is not identical. Thus, some swine manure can not be digested and absorbed by crops.

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immediately, which causes serious pollution of underground water

### 1.3 Fresh-Water Flush to Remove Swine Manure

A few large-scale swine farms apply fresh-water flush to remove swine manure. Since there is no plenty of farmland (vegetable land) to accommodate the sewage from swine farms, the following treatment technology is normally adopted as Fig. 2

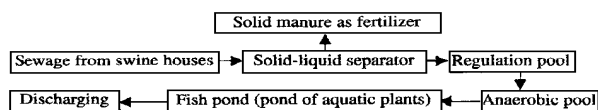


Fig. 2 Removing swine manure by fresh-water flush

The discharged water of this kind of treatment way normally can reach the national secondary standard of sewage emissions of domestic animal and poultry. There still exist the following problems because of the lack of systematical and thorough research on the manure treatment technology of swine farms

1) Project investment is large. The total project investment of manure treatment on a swine farm with an annual output of 10 thousand swines reaches 1 million Yuan.

2) Because the area of fish pond (the pond of water plant) is large, the fish raising is also affected by the climate, it is difficult to popularize this technology on a large scale. For instance, a swine waste treatment project of a swine farm with 20 thousand pigs in Shenzhen, has 7 000 m<sup>2</sup> of water plant pond and 132 000 m<sup>2</sup> of fish ponds.

3) The direct economic benefits are poor comparatively. The selling price is low because of the few contents of active ingredient N, P and K in the solid manure residue.

This shows that now the manure treatment on a large-scale swine farm has not been solved yet. Except for properly regulating and controlling the raising scale and swine waste discharging capacity in the ecological cycle treatment of swine waste, the key to most manure treatment ways on swine farms is the improvement of the technology of

manure and wastewater treatment

## 2 Research on the Technology of Swine Manure Treatment on Large-Scale Swine Farms

The research on the property and the water quality of the entire manure-discharging system was carried out and a new technology of swine manure treatment was put forward so as to reach sewage emission standard, to save project investment and operation cost and to raise the direct economic benefits of the project substantially.

### 2.1 Reducing the Total Amount of Manure Discharging From the Manure-Discharging Means of the Swine Farms

In accordance with the investigation of each region of Sichuan, Hubei, Guangdong, Shanghai and Beijing, the daily swine manure-discharging amount of a swine farm with an annual output of 10 thousand swines is as follows:

150~ 200 m<sup>3</sup>öd by the method of fresh water flush to clean away swine waste; 100~ 120 m<sup>3</sup>öd by swine manure cleaning by soaking in water; 50~ 60 m<sup>3</sup>öd by swine manure cleaning by manpower.

It can be seen from this that the way of swine manure cleaning by manpower can reduce the total amount of swine waste discharging by 1/2~ 2/3 in comparison with the other two ways in the light of Chinese national conditions. This will lay a solid foundation for reducing project investment and operation cost greatly, making good organic fertilizer and increasing economic benefits. If the rain and swine sewage can be separated well, some unnecessary operation cost and construction scale can be reduced, which will be "half the work with double results."

### 2.2 Strengthening Firmly the Effect of Solid-Liquid Separation

Plenty of experiments showed that the sediment property of the sewage of swine farm is very good, so it should be fully used.

1) Allocation of suitable solid-liquid separators

The distribution of the particle size of fresh swine manure was surveyed (see Tab. 1), and the results showed that the particle size of swine manure is bigger, screening with 40 screen meshes can remove 82% of the pellet of the swine manure.

**Tab 1 Measurement of the particle size of swine manure**

The number of screen eye hole mesh	20	40	80	100
Screen hole diameter (gap) mm	0.9	0.45	0.18	0.15
Particle weight on the sifter g	73.42	43.51	5.12	0.82
Particle size distribution percentage %	52	30.85	3.55	0.57
The accumulated particle size distribution percentage %	52	82.85	86.4	86.97

The "oblique board sift + extrusion" type solid-liquid separator we chosen is a kind of cheap and effective equipment. The moisture content of separated dregs can fall to 60% ~ 65%, which is helpful for the pile composting.

2) Setting up sedimentation basin

The swine wastewater after screening was undergone sedimentation experiment, the results are as follows in Tab. 2.

**Tab 2 Experimental results of sedimentation of swine wastewater after screening**

	Five-day biological & chemical oxygen consumption	The total solids	Suspension solid	Volatility suspension solid
Original waste water $\text{mg} \cdot \text{L}^{-1}$	15320	17640	18230	14300
Separated water $\text{mg} \cdot \text{L}^{-1}$	6682	8064	7260	5370
Sediment effluent $\text{mg} \cdot \text{L}^{-1}$	3066	4070	1600	1260
Rate of sediment excluding %	54	49.5	80	76.5
Total excluding rate %	80	77	91	91

note: The original dung water are fresh dung water; the separated water is the dung water after screening by the screen with 60 screen meshes. The sediment was tested with sediment column, and the sediment time is 15 minutes.

The test results showed that the suspension solids and COD can be removed by 90% and 80% respectively after being separated by solid-liquid separator and 15 minutes' sedimentation. Although there exists the error between the

experimental results and practical production values, the good sediment property of dung water (especially fresh swine wastewater) is affirmed. After the greater solids were removed when swine waste water going through the solid-liquid separator, the swine manure water underwent the sedimentation of the sedimentation basin, which can not only discharge the small swine sludge with high fertility as fertilizer, but also can reduce the organic load of later biological equipment greatly. All those created a good condition for using high efficiency anaerobic equipment.

### 2.3 Selecting Advanced and Reliable New-Type Anaerobic Digester Proved by Practical Application

So far, this kind of new anaerobic digestion installation includes Upper-flow Anaerobic Sewage Bed (UASB), Anaerobic Filter (AF) and UBF (UASB + AF). The practice showed that the running effects of AF and UBF installation were very good, but after 1 ~ 2 years, because of coagulation in the bed, the digestion surface became less and less rapidly, thus, the anaerobic digestion efficiency drops, and this coagulation phenomena was hard to be repaired and made damage to pool body. So, the selection of UASB installation is the best choice, which saves investment comparatively (save plenty of packing material and maintenance cost of supporting frame); The excluding rate of organic matter can reach over 80%, matching with UBF and AF. However, it is required that the technical level of its design and adjustment is higher.

### 2.4 Selecting Reasonable Aerobic Facility According to the Condition on-the-Spot

In the light of the analysis of sewage water quality from pig farms, the ammonia nitrogen ( $\text{NH}_3\text{-N}$ ) content in raw sewage water is as high as 500  $\text{mg/L}$ . After passing through the technologies of solid-liquid separation and anaerobic digestion, the sewage  $\text{NH}_3\text{-N}$  content is still higher than the national sewage emission secondary standard in the poultry and domestic animal breeding industry.

(existing). How to select reasonable aerobic facility according to the condition on the spot is also a difficult technical problem. Our practical consideration is as follows

1) If swine farms have enough water surface (or ground) as well as higher temperature in most time of winter, the water surface (ground) should be fully used to make the pond of aquatic plants. The special function of aquatic plants (such as water hyacinth) should be fully used for the adsorption of  $\text{NH}_3\text{-N}$  to make emission water reach the standard all-sidedly, which is the best scheme.

2) If swine farms don't have the above mentioned condition, the aerobic pool should be added for conducting forced aerobic measures. There are various aerobic technologies. The SBR aerobic installation should be adopted which can save electricity and has good effect of removing nitrogen and phosphorus according to the water quality of pig house sewage, and the pond of aquatic plants with certain areas should be arranged (using simple greenhouse to keep warm for lower temperature areas). With this kind of combination facility, it can be ensured that sewage emission reaches the standard all-sidedly and water surface can be economized, which can extend the accommodation of this technology to the north areas of China.

### 3 The Way to Raise the Direct Economic Benefits of the Project of Swine Farm Sewage Treatment

Because of the lower economic benefits of swine farm and greater investment of swine sewage treatment project, besides reducing operation cost and the investment of project, great efforts should be made to raise the direct economic benefits so as to ensure that the project can be run for a long period and the swine farm can make profits.

#### 3.1 Adopt Technology of Reusing Flushed Water

In general, especially for the large-scale swine farms that are short of water, it is very helpful to adopt the technology of returning to use the

flushed water, which can realize zero emission. The changeover cost of pig farm flushed water pipe can be returned generally in 1~2 years. Its social and economic benefits are desirable.

#### 3.2 Adopt Power Generation Technology With Biogas

It is desirable to generate power by using mixed burning unit to burn oil and biogas in the areas with high electrical price. This power generation set is reequipped with diesel oil, by which the oil-saving rate can reach 80%. When biogas is not enough, diesel oil can be used to generate electricity. The surplus hot water of generation set can be added to warm up the anaerobic digester, which is helpful for anaerobic fermentation. The reequipped oil-gas mixed burning power generation set is reliable to operate and long in service life, which can satisfy the normal power consumption of swine farm and sewage treatment factory (illumination and water supply).

#### 3.3 Suggestion on the Treatment of Swine Manure (dregs) to Produce Organic Fertilizer by Using Pile Fermentation Technology

In the swine farm of manure-cleaning by manpower, after mixing fresh manure and separated manure dregs, efficient biological bacteria for pile fermentation are utilized to produce organic fertilizer or bait, which will produce considerable economic benefits. In general, a farm with 10 thousand swine can produce 800 t of organic fertilizer in a year, and the returned profits can reach 240 thousand Yuan. The investment is small and the effect is good by using this kind of treatment technology. At present, the bacteria that we screened can shorten the time of pile fermentation to 10 days.

### 4 A New Technology of Swine Wastewater Treatment on a Farm

In accordance with our experimental research, a new technology of swine wastewater treatment on a large-scale farm is shown in Fig. 3.

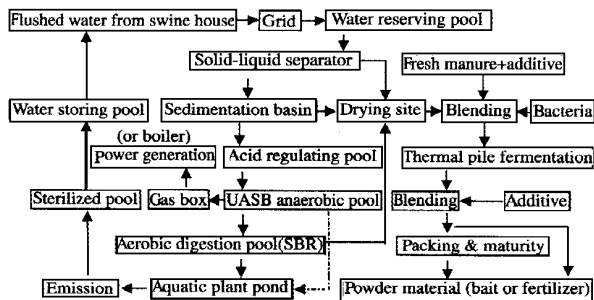


Fig 3 New technology of swine wastewater treatment on intensive scaled swine farms

### 5 Conclusion s

1) The swine wastewater discharging capacity should be reduced as little as possible for the newly built swine farms and partially rebuilt swine farms. One way is to clean swine manure chiefly by manpower and secondarily by flushing manure, which can not only reduce the project investment for sewage treatment and operation costs considerably, but also can increase the output and improve the quality of the organic fertilizer. On the other hand, the separation of swine sewage and rainwater can reduce the rainwater to mix.

2) The reequipment with the sedimentation basin in the pre-treatment stage is the key to the new technology.

3) The application of SBR technology and installation according to local conditions deployed the aquatic plant pond with certain areas, can not

only ensure that sewage emission reaches the standard all2sidedly, but also can reduce specific power consumption

4) Adopting as far as possible the technical measures that can raise project economic benefits, so as to ensure that the project can be operated stably for a long period, and that it is helpful for investment return.

5) The new technology has the characteristics of simple operation, investment saving, convenient maintenance and repair and higher economic benefits. The project practice of swine wastewater treatment in Shanghai Jiading Breeder Farm showed that the new technology can save 35% of the project investment, and 65% of the operating electricity charges with good direct economic benefit in comparison with the traditional technology.

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## 集约化猪场粪污处理工艺的研究

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摘要: 根据我国集约化猪场排粪方式和粪水的特性, 提出了采用人工清粪方式、固液分离机+沉淀+UASB+SBR+水生植物塘的污水处理工艺和猪粪(渣)堆沤发酵生产有机肥新的粪污处理工艺。经上海市嘉定种畜场污水处理工程实践证明: 在保证污水全面达标排放和猪粪(渣)无害化处理的前提下, 新工艺比常规工艺节约工程投资 35%、节约运行电费 65% 左右, 经济效益好。

关键词: 猪粪处理; 固液分离; 沉淀; 厌氧池; 好氧池; 堆沤发酵