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A Study on the Water Pollution of Poultry and Livestock Breeding and the Resource Utilization of the Wastewater in Sonln Village

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Sonln Village is located in Songliao Plain and the upstream of Yitong River. The village takes non-professional scattered chicken-raising as the main source of incomes, and the annual raising number of the birds is about 3 million. Large-scale raising produces a large number of organic pollutants such as feces of livestock and poultry, so the pollution is concentrated and difficult to handle. A large number of feces are directly poured into the Yitong River, causing serious harm to the environment. In this study, Sonln Village is used to study the environmental pollution of livestock and poultry raising industry in Sonln Village. The study focuses on the composting of feces of livestock and poultry, the resource utilization of methane fermentation, and the resource utilization of the livestock wastewater, to purify the livestock wastewater, reduce the content of COD, nitrogen, phosphorus and other pollutants, meet the discharge standards and reduce the water pollution on the surface of the earth.

1. Introduction

In recent years, with the rapid development of large-scale livestock and poultry breeding industry, the amount of the excretion of livestock and poultry and other wastes has been increasing rapidly, causing environmental pollution, and making the contradiction between the development of the livestock and poultry industry and the environmental pollution become increasingly prominent (An et al., 2015). Sonln Village is located in Yitong River Terrace of Songliao Plain, in which all of the 28 households of farmers take chicken raising as the main source of incomes, with non-professional scattered raising being the stress, the annual number of the birds is about 3 million. Large-scale raising produces a large number of organic pollutants such as feces of livestock and poultry, so the pollution is concentrated and difficult to handle. A large number of feces are directly poured into the Yitong River, causing serious harm to the environment (Zhao et al., 2015).
The sewage of feces on the livestock and poultry farms is organic wastewater in high concentration, rich in organic matters, and it is also very suitable for composting (Motoyama et al., 2011). The methane technology is used for biochemical treatment. If the feces are processed with anaerobic fermentation, not only will the problem of environmental pollution in rural areas be solved, but also the problem of energy in rural areas will be solved, which is an effective way to conduct a reasonable and sustainable development and utilization of natural resources (Zhao et al., 2016).

2. The situation of the water pollution in Solon Village

Sonln Village is located on the upper reaches of Yitong River, having an average precipitation of 600mm annually. As for agriculture, the main crop is corn. The sample-collecting sites are set on a tributary flowing through Sonln Village of the upper reaches of Yitong River. A total of 9 sites for monitoring the surface water

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are set, and the sampling sites are as shown in Figure 1 in which 1 is the downstream area; 2 is the slow flow area, surrounded by scattered sources of pollution; 3 is the slow flow area; 4 is the rapids area; 5 is the clean water, and the flow is slow; 6 is the rapids area; 7 is the polluted area of the chicken farm; 8 is the clean water, whose flow is slow; 9 is the irrigation water for the field; Sonln Village is located on the sampling site 7 in the figure. Sampling work started in May, 2016. The river water was collected using clean bottles of mineral water, and water samples should be 2,000ml at each sample site, and then CODcr was tested. The water samples of nitrogen and phosphorus were acidified to a pH value of 2 or less by adding concentrated sulfuric acid. The water samples of the coliforms were tested without any treatment. And the water samples were analyzed as soon as possible after they were collected.

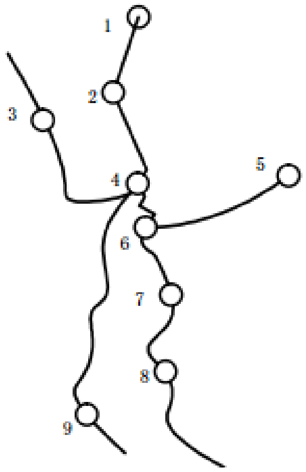

Figure 1: The distribution of the sampling sites

It can be seen from Figure 2 that the content of ammonia nitrogen in most of the sampling sites is 0.5mg/L or less, and the content of nitrate nitrogen is 1mg/L or less, meeting the standard of Water Quality II of the surface water. As the sampling sites 2 and 9 had scattered sources of pollution and the irrigation water for the field, the content of ammonia nitrogen and nitrate nitrogen is slightly higher than that on other sampling sites. Sampling site 7 is a polluted area of chicken farms, and the direct discharge was conducted without any treatment. The measured content of ammonia nitrogen is 1mg/L or more, and the content nitrate nitrogen is 1.5mg/L or more, belonging to Water Quality IV of the surface water.

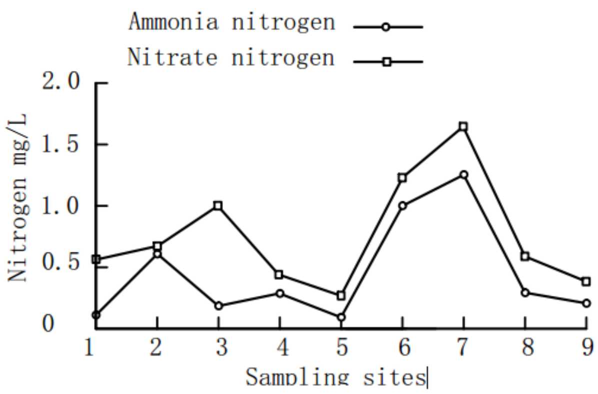

Figure 2: Contents of ammonia nitrogen and nitrate nitrogen in the water samples

Table 1 shows the total content of nitrogen, total content of phosphorus, as well as the content of CODcr in the water sample. It can be seen from Table 1 that the polluting situation of total nitrogen is much more serious than that of ammonia nitrogen and nitrate nitrogen, especially on the sampling site 7, far exceeding the limited value of Water Quality V of the surface water. The total nitrogen includes compounds of organic nitrogen and inorganic nitrogen. The content of total nitrogen on sampling site 7 and the downstream sampling site is higher than the sum of the content of ammonia nitrogen and nitrate nitrogen, indicating that the nitrogen in the water is mainly organic nitrogen. The reason for the analysis should be that the excreta of animals and nitrogen of the residual feed exist in the form of organic nitrogen compounds. The content of total phosphorus in sampling site 7 and the downstream exceed the limit value of Water Quality V of the surface water; the concentration of CODcr on the sampling site 7 is up to 1710 $mg\ /\ L$, which is far beyond the limited value of Water Quality V.

Table 1: Contents of the total nitrogen, total phosphorus and CODcr in the water sample

	1	2	3	4	5	6	7	8	9
Total N (mg/L)	5.1	5.2	5	3.1	0.45	7.9	13.3	0.9	1.8
Total P (mg/L)	0.16	0.17	0.16	0.26	0.05	0.59	1.2	0.11	0.09
COD_{cr} (mg/L)	245	256	246	210	9.5	430	1710	18	22
Conliforms ($\times 10^4$/L)	22	20	21	24	1.2	326	536	6.2	4.2

As shown in Table 1, there are the irrigation water and the sewage from the villagers on sampling sites 2 and 9 respectively, and the total number of coliforms increases; the total number of coliforms is up to 536$\times 10^4$ / L on sampling site 7. The number of total coliforms on sampling site 6 is more than 106 / L, which is related to the location on the sampling site, which is not far from the downstream of the sewage of the chicken farm as well as the long-term effect of the direct discharge of sewage. The coliforms in the sewage grow and multiply easily and the number is extremely high, resulting in a rapid increasing number of the coliforms in the water near the sewage. Table 2 shows the content of heavy metals in feces of the livestock and poultry. It can be seen from Table 2 that untreated feces of livestock and poultry are discharged into the environment, causing different degrees of pollution to soil, water and crops. The contents of Cu, Zn and As in the soil of chicken farms were significantly higher in Sonln Village than those without manure application in the control group, and the contents of Cu, Zn and As were 10, 5 and 2 times as in the control group at the highest level respectively, exceeding standard by 135%, 53%, 12% at the highest level.

Table 2: Contents of heavy metals in the feces of the livestock and poultry

Type	Zn	Cu	As	Ni	Cr	Pb	Cd	Hg
Pig manure	1770.2	1039.4	15.76	10.98	6.6	2.45	0.51	0.05
Fowl manure	380.6	274.2	5.03	5.47	7.09	4.9	0.74	0.05
Cow dung	176.2	90.24	3.30	7.84	6.57	9.4	0.34	0.04

2. Resource utilization

3.1Resource utilization of composts

Based on the treatment and disposal of feces of livestock and poultry and resource utilization, a small compost reactor is designed. Chicken manure and corn stalks are used as compost raw materials. The initial C / N ratio and the initial moisture content of the compost are adjusted. The ventilation and the amount of oxygen of the compost are controlled. The reactor composting and the outdoor composting are combined. The initial C / N ratio and the effects of different composting methods on the fixed composting of chicken manure and the crops stalks are to be ensured by studying changes of the physicochemical indexes of the composting process.

Three composts are designed in the test, which are marked with P1, P2 and P3 respectively. According to the initial data of the chicken manure and the corn straws, the initial C/N ratios of the composts P1, P2 and P3 are adjusted as 14, 22 and 30 respectively. And the effects of different initial C / N ratios on the mixed composting of chicken manure and corn straws are studied. The experimental design and initial properties of the compost are shown in Table 3. The composting experiment is carried out in a laboratory-made compost reactor. The duration of the composting test is 32 days. Three replicates are carried out at the same time.

Table 3: The experimental design and the initial properties of the composts

composts	chicken manure: corn straws	C/N	MC
P1	3.2:1g	14	65.5(1.25)
P2	0.94:1	22	68.4(1.16)
P3	1:2	30	66.7(1.23)

Figure 3 shows the dynamic changes of composts' temperature during the composting of chicken manure and corn straws. In Fig.3, 1 is the acclimation stage, 2 is the growth stage at the middle temperature, 3 is the high temperature stage, and 4 is the maturity stage; the process A is the primary fermentation, and the process B is the secondary fermentation. From Fig. 3, the dynamic changes of the temperature of the composts P1, P2 and P3 show a similar changing trend. Seen from the primary and secondary fermentation, the main fermentation stage is from 0 to 13 days, and the secondary fermentation stage is from 14 to 32 days. Most of the organic matters in the compost are degraded by microbes during the main fermentation stage. Composting produces a little energy in the secondary fermentation stage, the temperature of the composts decreases slowly, and the products of composts become stable and reach deep maturity. The highest composting temperature should reach 50 ~ 55 ℃ and maintain 5 ~ 7days, or above 55 ℃ for 3 days.

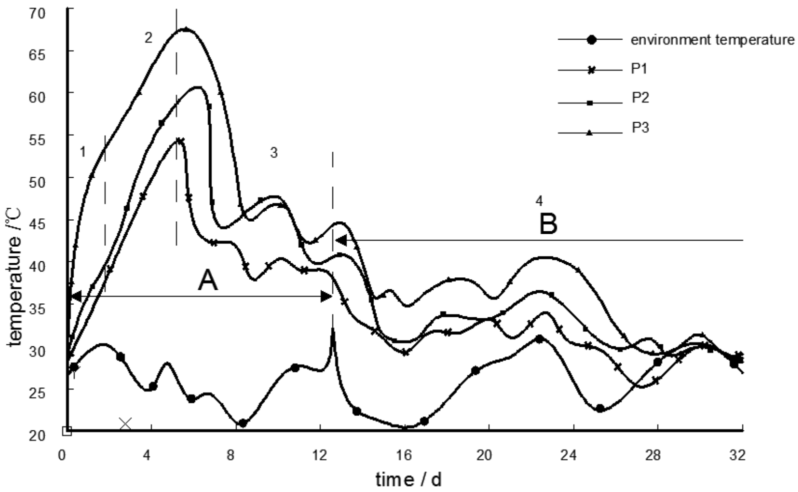

Figure 3:The temperature dynamic variation of composts in the composting process

3.2Resource utilization of methane fermentation

Mixed fermentation of manure and straws can not only solve the problem of the shortage of raw materials in digesters of rural areas, but also regulate the carbon-to -nitrogen ratio of raw materials to improve the efficiency of the fermentation. Therefore, the mixture of corn stalks and chicken manure is used as the raw material for fermentation and anaerobic fermentation is adopted. Schematic diagram of the test's devices is shown in Figure 4, mainly composed by three parts including the fermentation devices, gas gathering devices and temperature controlling devices.

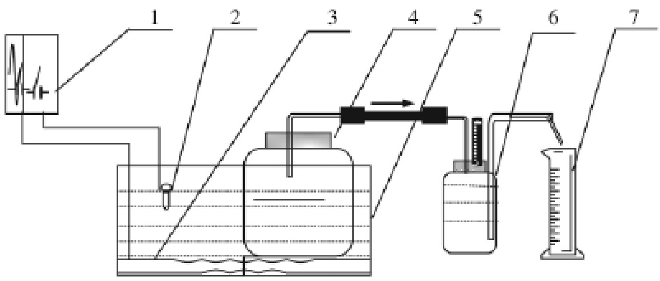

Figure 4: The constant temperature anaerobic fermentation devices with controllability

In the figure, 1 is the temperature control box, 2 is the temperature sensor, 3 is the heating wire, 4 is the fermentation tank, 5 is the constant temperature tank, 6 is an air collector, and 7 is the cylinder. The chicken manure-to-corn straws ratio is set to be 2:1 and the ratio of C / N is approximately 25 : 1, which is the best theoretical value of the fermentation. The results show that the mixture of chicken manure and corn stalks is used as the raw material conducting the methane fermentation at 20-40 ℃. The fermentation liquid in which the ratio of chicken manure to corn stalks is 2: 1 and the concentration of the initial fermentation is 20% has the largest gas production. The wastewater containing high nitrogen can be treated by the anaerobic digestion and the resource utilization. If it is necessary to take into account the optimum requirements between the maximum methane production and biodegradability, the time for anaerobic digestion should not exceed 6 days. The ratio of BOD5 / COD and C / N of the liquid can be adapted to the requirement of the aerobic treatment.

3.3 Sewage treatment system

Livestock wastewater belongs to the organic wastewater whose biodegradability is favourable with medium and high concentration. The ratio of BOD and COD is high, which is easy to conduct the biochemical treatment. The quality of wastewater is mainly organic matters. The air flotation-biological contact oxidation process is adopted in the test. The waste water flows into the grids through the drain pipe of the collecting system, and the impurities such as the large-volume suspended solids are removed into the bio-selection area, then into the oxygen-poor acidification regulating tank. The wastewater after the anaerobic biological treatment is added to appropriate flocculant getting into the air flotation system. The non-soluble proteins, fat, and other macromolecular organic matter are supposed to be removed. After acidification and the flotation treatment, the wastewater gets into the two-stage of aerobic biochemical reaction tank, and the method of biological contact oxidation is used for aerobic treatment. After the two-stage aerobic biochemical treatment, the sewage gets into the sediment. Then the clean water flows into the clear pool, and then is added sodium hypochlorite to conduct the disinfection, realizing the removal of coli bacillus in the water, through which the discharge standards can be achieved. It can be seen from Table 4 and Table 5 that the quality of the livestock wastewater can reach the standard through the wastewater treatment system.

Table 4: The quality of the inflow water

Item	PH	COD_{cr}	BOD_5	Suspended solids
Indexes of the water quality	6.0-8.5	1800mg/L	900 mg/L	800 mg/L

Table 5: The efficiency of treatment in all units and the outflow quality

Structures	Inflow mg/L	COD outflow mg/L	Efficiency (%)	Inflow mg/L	BOD outflow mg/L	Efficiency (%)	Inflow mg/L	SS outflow mg/L	Efficiency (%)
Pre-processing	1800	1620	10	900	810	10			
Flotation	1610	650	60	800	325	60	800	320	60
Pprimary oxidation	650	130	80	325	50	85	320	100	70
Secondary oxidation	130	65	50	50	20	60	100	50	50
Discharge standards		≤80			≤30			≤60	

3. Conclusion

In this study, Sonln Village is being the research object, the situations of the environment pollution of livestock and poultry breeding industry in Sonln Village is investigated and studied. Using the theory of circular economy to control environmental pollution caused by the livestock and poultry feces, to change the harm into the benefit and to make its resources have a positive significance.

(1) The analysis of 9 sampling sites shows that total nitrogen, CODcr and total coliforms are the main factors of pollution. And CODcr, the content of total phosphorus and the number of the coliform groups in the sewage discharged from the farm (sampling site 7) are all higher than the limited value of the two-class discharging standard, especially the number of the coliform groups exceeds 100 times. The sewage from the farms to the downstream water causes serious microbial contamination.

(2) The livestock wastewater containing high nitrogen in chicken manure can be treated by anaerobic digestion and resource utilization. If the optimum requirements between maximum methane production and the biodegradability of biogas slurry are satisfied, the time for anaerobic digestion should not exceed 6 days. And the BOD5 / COD and C / N ratio of biogas slurry can be adapted to the requirement of aerobic treatment.

(3) The air flotation-biological contact oxidation process is used, and the livestock wastewater can meet the discharge standards absolutely through the two-stage oxidation wastewater treatment system.

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