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Study on the model of domestic sewage resource utilization

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Abstract. In recent years, with the degree of urban-rural integration, the economic level of rural areas and the improvement of residents' health awareness, the water quality pollution of rural domestic sewage has increased year by year, and the problem of rural sewage discharge has become increasingly prominent. In order to improve the rural water environment and solve the problem of random discharge of sewage, this paper takes the rural domestic sewage as the research object, and takes the natural sedimentation and anaerobic fermentation as the main means to study the on-site resource utilization technology of sewage. It was found that after 3 hours of sewage sedimentation, organic suspended solids settled naturally, resulting in a significant decrease of COD in the upper sewage to 93.29 mg/L. Because of the special bimolecular structure of LAS, the concentration of LAS in surface sewage increased sharply to 7.68mg/L, but it was lower than 10mg/L, which met the irrigation water standard.

1 Introduce

China is a big country in water resources. By 2017, the total water resources in China is about 2,876.12 billion m^3, including groundwater resources, which is about 83.91 billion m^3. At the same time, China is a big water user. It is predicted that by 2030, China's annual average water consumption will exceed 700 billion m^3, or reach the upper limit of the total amount of available water, which will also exceed the extreme value of water environmental carrying capacity. At the same time, China is also a large agricultural country. In 2017 alone, agricultural water consumption exceeded 376.64 billion m3, accounting for about 62.3% of the total water consumption, much higher than industrial and domestic water consumption. With the promotion of new rural construction in China, the degree of integration of urban and rural areas is gradually improved, a large number of factories and companies moved to the suburbs and rural areas near the city, so in the future more than 80% of the sewage will come from the villages and rural areas. In 2017, the annual discharge of rural sewage has reached 1.48×10^{10}t. However, the current domestic sewage collection and treatment system in China's rural areas is not perfect. In 2006, the sewage treatment rate in China's rural areas was less than 1%, and the treatment rate reached 9.98% in 2014. Although the sewage treatment rate in rural areas increased by nearly 9 percentage points in 8 years, most of the sewage is still not treated. Most water sources are concentrated in rural areas, which can easily lead to a wide range of water health problems.

Rural water consumption increases sharply year by year, and water quality gradually deteriorates. Single sewage treatment method has been unable to meet the needs of sewage treatment, so now the sewage is mostly two-stage or multi-stage treatment, and sand settling tank or sedimentation tank will be set up. Compared with urban sewage, the pollution content of rural domestic sewage is relatively less, so after a period of free precipitation, the upper part of sewage reaches the agricultural water standard or discharge standard, and can be directly discharged or used to reduce the amount of sewage treatment and reduce the sewage treatment load. In order to determine the free precipitation time and discharge amount of rural domestic sewage, the physical and chemical indexes such as suspended matter, chemical oxygen demand and anionic surfactant in different water layers after precipitation for different times were determined in this chapter, and the settling time and discharge water layer height were determined by comparing with the irrigation water standard.

2 Materials and Methods

2.1 Test materials

Rural domestic sewage is obtained from household sewage such as garment waste water, which is collected in batches and times, including kitchen waste water, flushing waste water, bath waste water and washing. After collected and mixed, it is stored in a refrigerator at 4℃ for reserve. Physical and chemical properties are shown in Table 1.

Table1. The physical and chemical indicators of rural domestic sewage

Index	SS/mg·L^{-1}	TN/mg·L^{-1}	COD_{Cr}/mg·L^{-1}	LAS/mg·L^{-1}
Content	650±23	118.90±18.36	316.67±51.23	6.13±0.28

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The inoculum was taken from the fermentation liquid in the household biogas digester in normal operation. Cow dung was used as the main raw material for fermentation. After sampling, the inoculum was stored at room temperature for no more than 10d.

Table2. Physical indicators of inoculation

Index	TS/%	VS/%	TOC/mg·L^{-1}	TN/mg·L^{-1}
Content	14.37±0.58	6.51±0.16	3871.25±256.13	3189.14±212.25

2.2 Test scheme and determination method

Sedimentation test: domestic sewage collected by nearby farmers was stirred evenly and poured into the self-made precipitation injection to make the water surface reach 2.4m in height and 78.5L in volume. Domestic sewage samples of the same volume were collected at different water sample orifice and mixed as initial water samples. After the precipitation time was 0.5h, 1h, 1.5h, 2h, 2.5h and 3h, an appropriate amount of sewage was collected at the sampling port S5,S45,S85,S125 and S165(representing 5cm, 45cm, 85cm, 125cm and 165cm from the bottom of the precipitation column, respectively) to determine the suspended matter, chemical oxygen demand and LAS concentration of the sample.

Biogas fermentation test: the test was divided into three treatments with three replicates for each treatment. After precipitation for 3h, 500mI of sewage was taken from the sampling port S5, S85 and S165, 500g of inoculant was added to the biogas fermentation device, and the fermentation temperature was 37±0.5℃ for 18d. The gas production and methane volume fraction were determined.

2.3 Test apparatus

Precipitation device: homemade sedimentation column, based on six inches of PPR sewer pipe (three type polypropylene pipe), to 20 cm inner diameter, height of 2.5 m, the effective volume of 78.5 L to precipitate the column bottom cover for the baseline, respectively in height is 5 cm, up to 35 cm, 65 cm, 95 cm and 125 cm sample set, set to S5, S45, S85, S125 and S165, sampling mouth for screw tap, switch, convenient to obtain sewage water samples.

Fermentation device: the biogas anaerobic device is composed of a fermentation bottle, a gas collecting bottle and a collecting bottle. Glass conduit and latex tube are used to connect each device, and the effective fermentation volume is 700mL. In order to maintain a relatively constant fermentation temperature, a constant temperature water bath was used to heat the fermentation bottles in water bath.

3 Results & Discussion

3.1 Variation of suspended solids in rural domestic sewage with different sampling points

Suspended solids concentration is an important index of farmland irrigation water, suspended matter concentration is too high, in the process of irrigation farmland will most insoluble precipitate in the channel or pipe material, easy to cause water pipeline jam, damage to the pump and pipeline, so the irrigation water quality standard for irrigation water suspension made strict rules: dry farmland irrigation water suspension can't more than 100 mg/L, water for farms require no more than 80 mg/L, raw vegetables, melons and herbal fruit more strict, not more than 60 mg/L.

Table3. Changes in Concentration of Rural Domestic Sewage Suspended Solids

Settling time/h	S5	S45	S85	S125	S165
0	650	650	650	650	650
0.5	1052	780	585	393	275
1	997	680	425	315	210
1.5	956	598	338	252	165
2	908	533	273	183	130
2.5	886	473	225	142	102
3	871	417	203	116	84

Note: S5,S45,S85,S125 and S165 represent 5cm, 45cm, 85cm, 125cm and 165cm from the bottom of the precipitation column, respectively.

When the natural settlement of rural domestic sewage occurs, the variation of suspended solids at different water layers is shown in Table 3. The variation trend of suspended solids at sampling points of different water layers with settling time is not completely the same.

Suspended matter in the S5 domestic sewage sample at the sampling port rapidly increased to 1052mg/L within 0.5h, which was 1.62 times that of the initial water sample. After 0.5h, the concentration of suspended matter in the domestic sewage gradually decreased. After 3h, the concentration of suspended matter reached 871mg/L, which was still greater than that of the initial water sample and 1.34 times that of the initial water sample.

The variation trend of the suspended matter concentration of the sewage sample at the sampling outlet of S45 was similar to that of the sampling outlet of S5, which increased rapidly at first and then decreased gradually, but the variation trend at the later stage was greater than that of the latter. After 0.5h, the water sample increased to 780mg/L, and after 0.5h, the suspended matter decreased slowly. After 1.5h, the suspended matter concentration of the water sample was lower than that of the initial water sample. After 3h, the suspended matter concentration of domestic sewage was reduced to 417mg/L, reaching 64.15% of the initial water sample.

Sampling mouth S85 water suspension change rule and the former two are not the same, and in the 0 to 0.5 h, a slight drop in suspended solids, fell by 65 mg/L, 0.5 to 1 h settlement efficiency increases, decline to rise, fall 160 mg/L, the decline range is 0 to 0. 2.46 times that of h after 1 h, suspended solids, slow down, settling efficiency decreases gradually over time, settlement after 3 h, concentration to 203 mg/L for S5 sampling mouth final concentration of 23.31%, 31.23% of the original water concentration.

Suspension sampling mouth S125 and S165 sewage similar change trend, all is within 0.5 h drops rapidly, but a bigger drop, sampling mouth S165 trend is more obvious, dropped to 42.31% of the original water samples, and sampling mouth S125 for 60.46% of the raw water samples, 0.5 h after two sampling mouth sewage concentration of suspended solids are slow decline, natural sedimentation after 3 h, the concentration of the sampling mouth S125 dropped to 117 mg/L, 17.85% of the original water samples, and the concentration of S165 dropped to 84 mg/L, only 12.92% of the original samples, It has reached the standard of irrigation water quality for upland field, slightly higher than that for paddy field.

3.2 Variation of chemical oxygen demand of domestic wastewater from different sampling points

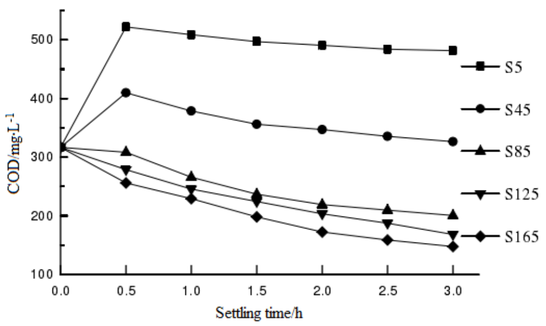

Fig. 1. Changs of COD of wasterwater samples from different sampling ports

Chemical oxygen demand (COD) is one of the important indicators of sewage. COD_{Cr} refers to the amount of organic matter in sewage oxidized by potassium dichromate, which is converted into oxygen consumption. It not only includes the oxygen consumption of almost all organic substances by oxidation, but also includes the oxygen consumption of reducing inorganic substances (nitrite, sulfide and ferrite, etc.) in sewage by oxidation, but the oxygen consumption of the latter is very small, almost miniscul. According to the Water Quality Standard for Farmland Irrigation, COD_{Cr} of dryland irrigation water is no more than 200mg/L. This is because the high concentration of organic matter in irrigation water can easily cause the intergranular space clog in soil, reduce the ventilation function of soil, and affect the normal metabolism of soil microorganisms and plant roots.

The COD change trend of rural domestic sewage at sampling sites S5 and S45 was similar, both of which increased sharply in a short period of time and then gradually decreased. Within 0.5h, the COD of S45 water sample increased to 409.65mg/L, which was 1.29 times that of the initial water sample, while the COD of SS water sample was 1.65 times that of the initial water sample, reaching 521.78mg/L. This is because in the sedimentation process, most of the insoluble particles under the action of gravity, to the bottom of the sedimentation column, the lower the horizontal height, the deposition of suspended particles, and most of the organic particles, resulting in a short time of a sharp rise in chemical oxygen demand. After 0.5h, the chemical oxygen demand of water sample decreased slowly, and the decrease range decreased with the extension of precipitation time. After 3h precipitation, the chemical oxygen demand of S5 water sample reached 481.33mg / L, which was 1.52 times of the initial water sample. Compared with 0.5h, the chemical oxygen demand decreased by 40.45mg/L, and only decreased by 7.75%.

Within 0.5h, the COD concentration of sewage from sampling port S85 remained basically unchanged, only decreased by 7.55mg/L and 2.38% of the original concentration. After 0.5h, the COD concentration decreased slowly and reached 200.69mg/L after 3h of sedimentation, which was 63.38% of the initial water sample.

The COD concentration of sewage from S125 and S165 sampling sites decreased slowly all the time, and decreased the fastest within 0.5h of settling, and basically remained stable after 2.5h. After settling for 3h, COD of S165 decreased to 147.66mg/L, which was lower than the standard of irrigation water of 200mg/L. However, from the point of view of COD, S165 could be used as irrigation water in uplands.

3.3 Variation of domestic sewage LAS in different sampling orifice

LAS is one of the main components of washing products, and its main function is to remove stains and stains. Due to the increasing improvement of rural economic level and farmers' health awareness, the content of LAS in rural domestic sewage is getting higher and higher. The initial concentration of LAS in rural domestic sewage used in this study is 6.13mg/L.

The LAS concentration on the liquid surface increased rapidly within 0.5h and then increased slowly, reached a peak of 8.07mg/L at 1.5h, and then decreased slowly after 1.5h. This is firstly because LAS is composed of hydrophilic and hydrophobic groups, and hydrophobic groups cannot combine with water. Part in the process of natural sedimentation, LAS sampling mouth after a slight decline in the rise of 0.5 h, precipitation concentration of 5.88 mg/L, after 3 h is slightly lower than the initial concentration, this is due to the hydrophobic group of anionic surface active structure, namely the lipophilic group, attached to the organic suspended matter, with the subsidence to the lower layer, causing the concentration of LAS to rise and fall.

The concentration of LAS in the sampling port of S165 and S45 remained basically unchanged within 0.5h, and decreased slowly after 0.5h, while that of S85 and

S125 decreased continuously. Among them, the final concentration of S165 was the lowest, which decreased to 4.33 mg /L, a decrease of 29.36%. This is because the concentration of LAS in the middle water layer of sewage decreased significantly under the dual effects of floating and adhesion settlement.

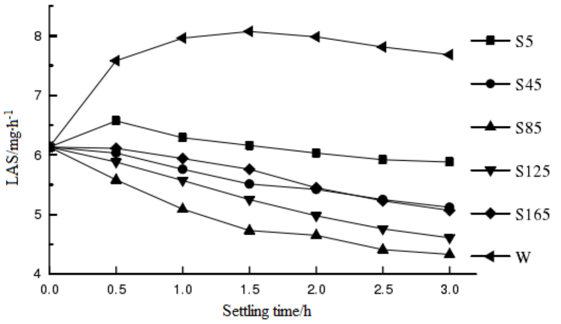

Fig. 2. Changes of LAS of wastewater samples from different samples ports

4 Conclusions

(1) After the settlement of rural domestic sewage for 3h, the concentration of suspended matter in sewage with different sampling heights tended to balance, and most of the suspended matter settled to the bottom water layer of sewage, and the suspended matter in the upper clear liquid decreased most obviously. In the process of settling, the change trend of chemical oxygen demand in rural domestic sewage is similar to that of suspended matter concentration.

(2) Due to the hydrophobic group in the molecular structure of LAS and the role of foaming agent in detergent, part of LAS quickly floated up in a short time, so the concentration of LAS on the sewage surface reached the highest after settling for 3h, reaching 7.68mg/L, less than 10mg/L. Part of LAS will also attach to the macromolecular organic suspended matter and settle to the bottom of sewage. Therefore, after the primary settlement, the concentration of LAS in sewage will be the highest at the liquid level, the higher at the bottom and the lowest in the middle water layer.

(3) After settling for 3h, SS concentration, COD and LAS concentration in the S165 sampling outlet sewage were reduced to 84mg/L, 93.29mg/L, and the highest concentration of LAS agent on the liquid level was 7.68mg/L, both of which reached the standard of irrigation water, indicating that 31.25% of the upper layer of rural domestic sewage after primary settling could be used as irrigation water.

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