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Water Quality Analysis and Treatment Plan of Typical Swags

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Swags as typical agricultural lands are widely distributed in rural areas. They also act as the important water storage ponds in rural areas in Northern China. But unfortunately, a big heap of pollutants is often dumped into swags due to industrial revitalization, population growth and for other reasons, coupled with man-made sabotage and backward infrastructure, the water pollution is ubiquitous everywhere. A survey has been conducted on typical swags in a county of Hebei, China, for developing a preliminary treatment program, which provides the clues to the treatment of swags in the area. Water in these swags generally has poor quality, even falls short of Class V surface water standard. Rainwater swag holds the best quality, followed by the domestic sewage + rainwater swags, while the pollution of the aquaculture wastewater + rainwater swags are heavy, pertaining to the sewage with high organic matter and high ammonia nitrogen wastewater. For the specific projects, this is the program designed on the principle of “select a reasonable combination process based on the pollution situation of the swags and sustainable treatment effect”, and with the “decontaminate to cut off pollution – purify and treat water to control pollution – purify microbial activation water, restore water body self-purification function – intensify plants for water self-purification function – perform scientific management” as the basic idea.

1. Introduction

Swags are typical agricultural lands widely distributed in rural areas. According to its formation, swags can be classified into natural, artificial and semi-artificial types. There are more typical man-made, semi-artificial swags in rural areas of Hebei, China, made up of historically abandoned kilns and borrow pits with puddles from the rain, of different areas and sporadically distributed. These swags can be used for water storage, irrigation, fish culture, etc., serving as an integral part of the water environment system and playing an important role in rural areas. However, due to industrial revitalization, population growth, etc., the pollutant emissions in these areas increase, coupled with the man-made sabotage and backward infrastructure, many swags have been heavily polluted since they have to meet more untreated industrial effluent, domestic sewage, rainfall runoff, domestic garbage, agricultural waste and building rubbish (Yang et al., 2018). On the other hand, with the improvement of living standards, the rural residents have set a higher demand for living environment, they are more intense in their desires for renovating used pits and ponds to build a beautiful countryside. The important content for ecological civilization construction is no doubt to Improve the rural ecological environment and build an ecologically livable beautiful village. A survey has been conducted on typical swags in a county of Hebei, China, for developing a preliminary treatment program so as to provide the clues to the treatment and transformation of the swags in the area.

2. Materials and methods

2.1 Overview of study area

In a county located in the central part of Hebei Province, there are continental monsoon climate and four distinct seasons, annual average temperature of 12.8 °C, the extreme minimum air temperature of -20.9 °C, annual average rainfall of 517.8 mm and the maximum precipitation of 893.9 mm, mostly concentrated in summer, so that the water resources there are abundant. More than 130 independent swags are located there. According to the field survey, there are some issues: (1) Exogenous sewage pollution: there are

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sewage outfall in many swags; (2) Eutrophication: the COD, NH_3-N or TP in each swag slightly exceed the standard; (3) Garbage: there are widespread garbage accumulated or sporadically distributed.

1.2 Sample collection

In order to survey the water environment quality of the contaminated pits in the area, representative swags are chosen for sampling and testing, as applicable to the specific situation. Samples are collected in dry season, and at the sampling points, as shown in Figure 1.

Figure 1: Distribution of sampling points

Sampling swags contain three types, i.e. rainwater swags, domestic sewage + rainwater swags, aquaculture sewage + rainwater swags. See Table 1 for details.

Table 1: Typical swags

Samples No.	Types of swags	Water level / m^3	Refuse quantity / m^3
1	rainwater	19320	865 (landfill, floating)
2	Domestic sewage + rainwater	5985	1000 (landfill, floating)
3	Domestic sewage + rainwater	10895	60 (landfill, floating)
4	rainwater	3000	20 (fragmented, floating)
5	Domestic sewage + rainwater	360000	10 (fragmented, floating)
6	rainwater	1000	15 (fragmented, floating)
7	rainwater	7500	25 (fragmented, floating)
8	rainwater	2000	500 (landfill, floating)
9	rainwater	40000	180 (landfill, floating)
10	rainwater	2000	15 (fragmented, no floating)
11	rainwater	2000	35 (landfill, floating)
12	Domestic sewage + rainwater	4000	25 (fragmented, floating)
13	Domestic sewage + rainwater	25000	330 (landfill, floating)
14	Aquaculture sewage + rainwater	2000	5 (fragmented, no floating)

2.2 Analysis of samples

Table 2: Test water quality indicators and analysis methods

Analysis item	Determination method	Main instruments and models
COD	Potassium dichromate digestion - ferrous sulfate titration	1KW electronic universal furnace / acid burette
Ammonia nitrogen	Nessler reagent colorimetry	Spectrophotometer / HACH DR5000
Total phosphorus	Ammonium molybdate spectrophotometry	Spectrophotometer / HACH DR5000
pH		Shanghai Kangyi PHB series pen type pH meter
Turbidity		Shanghai Shanke WGZ-800 scattered turbidity meter

Given that there may be organic and nitrogen-phosphorus pollution in water, and as required by the treatment program, the COD, ammonia nitrogen, total phosphorus, pH and turbidity are chosen for water quality determination. Each indicator should be tested in accordance with the Water and Wastewater Determination and Analysis Method (E. 4) (Addition). Refer to Table 2 for measurement method and testing instruments. In order to further clarify the types of organic pollutions, the COD is divided into total COD (hereinafter referred to as TCOD) and dissolved COD (hereinafter referred to as SCOD). For the test method for SCOD, the water sample is filtered via a 0.45 μm filter, and then tested according to the national standard.

3. Results and analysis

3.1 Water quality test results

3.1.1 Test on water quality in aquaculture sewage swags

Major quality indicators for aquaculture swags (14# sample point) are listed in Table 3.

Table 3: Main water indicators in sampling points

Sampling site	COD	Ammonia nitrogen	Total phosphorus	pH	Turbidity
14	1250	211.1	19.6	7.1	-

14# sampling point has ever accepted the aquaculture sewage from nearby livestock farms. Water there is heavily polluted by organic matter and ammonia nitrogen. COD, NH3-N and TP reaches as high as 1250mg/L, 211.1mg/L and 19.6mg/L, respectively, pertaining to the sewage with high ammonia nitrogen and high organic matters.

3.1.2 Water quality test in other swags

The COD content in every sampling point is shown in Fig. 2.

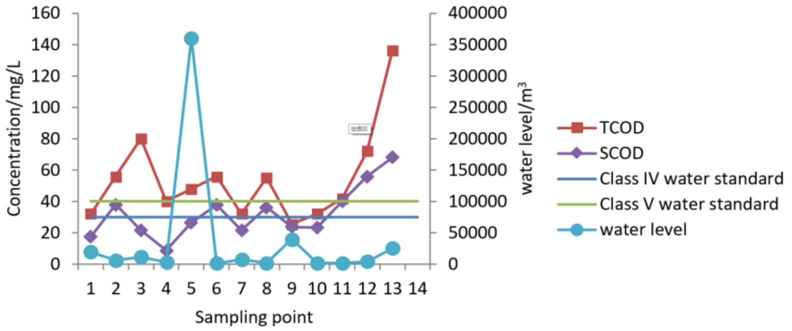

Figure 2: Content of COD in sampling swags

Test results show that the content of COD in the 9# sampling swag is the lowest, only 25.6mg/L, in accordance with the Class IV water quality standard; except for the sampling points 1, 7, 9, and 10, the CODs in other swags all exceed the Class V standard, in which the COD in 13# sampling point reaches as high as 136mg / L. Except for 12# and 13# swags, the SCODs of other swags are less than 40mg/L. The COD in water pertains to the type of sewage received, and is correlated to the water level. Several swags where the water quality is relatively good are rainwater types since they have a relatively high water level. The COD in the swags receiving domestic sewage is the highest, which suggests that domestic sewage is an important source of pollution. The areas near 3#, 12#, 13# sample swags are densely populated. There are more than 700 people in the community and schools, from where, domestic sewage is directly discharged into the swags via the pipelines. 5# Sampling swag receives less sewage thanks to its high water level, so that there is better water than in other swags that receive domestic sewage.

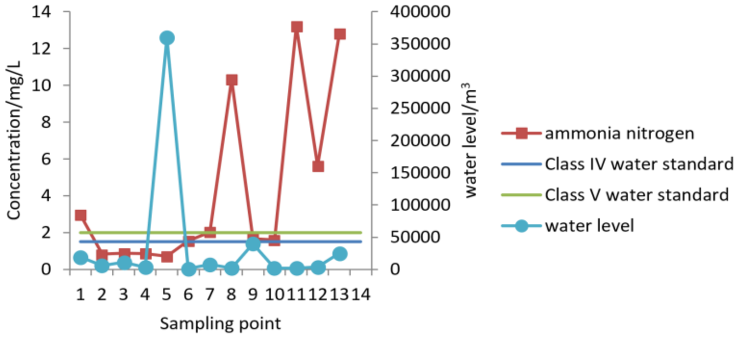

Figure 3: Content of ammonia nitrogen in sample swags

Ammonia nitrogen is an important indicator for determining surface water quality. On the whole, it is superior to the COD indicators for measuring the pollution level. In 2#, 3#, 4#, 5# sampling swags, ammonia nitrogen indicators measured is subject to the Class IV standard; in 6#, 9#, 10# sample swages, ammonia nitrogen indicator meets the Class V standard. 1# Sample swag has ammonia nitrogen slightly higher than the value specified by the Class V standard; in 8#, 11#, 12#, 13# swags, ammonia nitrogen is many times the standard value, reaches up to 13.22mg / L, which may pertain to domestic sewage and garbage emissions.

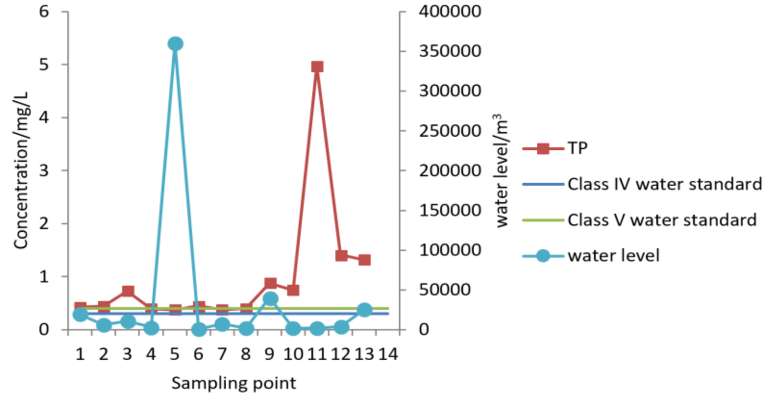

Figure 4: Content of TP in sample swag

TP is an important indicator for measuring eutrophication in water bodies. Test data shows that 4#, 5#, 7#, 8# sample swags contain the TP as required by the Class V standard, of which 4#, 7#, 8# are rainwater types, and 5# converges a little amount of domestic sewage, but has a high level in total, so that the TP concentration meets the requirements of Class V standard. In the other swags, the TPs exceeded 0.4 mg/L of the Class V water quality standard, and climbs up the maximum in the 11# swag, reaching 4.97 mg/L, far higher than 0.4 mg/L. 11# swag has a lower water level, so that the ammonia nitrogen and TP are far greater than the standard values.

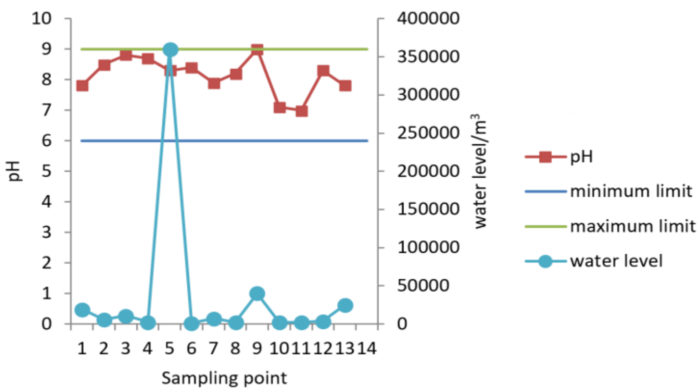

Figure 5: pH in sample swag

The pHs in the sample swags 7~9 meet the water quality requirements since the swags mainly converge rainwater and less domestic sewage, and there is no special industrial effluent discharged.

3.2 Analysis of results

Test data shows that the water quality in the swags in this area is generally poor, and falls short of the Class V water quality standards. The water quality has a direct bearing on the type of water inflowed. The water quality of rainwater swags is better than that of the domestic sewage + rainwater swags. The aquaculture sewage + rainwater swags have the worst quality. Most of them are polluted by organic matters and nitrogen and phosphorus, and have water quality in a state of eutrophication. Except for 12# and 13# swags, the SCODs in other swags are less than 40mg/L. 2# and 12# swags are located in an area where there is a well-established sewage pipe network system. The domestic sewage converges into the water body after collecting. 14# swag is heavily polluted by organic matter and ammonia nitrogen, pertaining to sewage with high ammonia nitrogen and high organic matters. There is an abominable environment around swags. Some of the swags heaps up much garbage, and so much garbage floating on the water surface has a bad effect on the senses.

4. Discussion on treatment program

4.1 Treatment principle

Swag is an important pondage body in the rural areas of the north China. The water management should retain the water storage function of the existing pits for rainwater storage and landscape; a set of the most appropriate treatment technologies should be determined depending upon specific pollution situation in the water bodies to be treated, striving to make it reliable, easy to manage, efficient and energy-saving, as applicable to local conditions (Jin, 2001). For the specific projects, this is the program designed on the principle of “select a reasonable combination process based on the pollution situation of the swags and sustainable treatment effect”, and with the “decontaminate to cut off pollution – purify and treat water to control pollution – purify microbial activation water, restore water body self-purification function – intensify plants for water self-purification function – perform scientific management” as the basic idea. The combination technology and measures against pollution are adopted to intensify the removal of nitrogen and phosphorus (Goda,1981), inhibit the growth of algae with the growth competition of dominant plant community, restore and strengthen the self-purification function of water bodies, and underline the follow-up scientific management (Schonach et al., 2018) (such as plant harvesting, etc.), and finally realize the long-term sustainability goal of governance effect.

4.2 Treatment program

According to the above-mentioned pollution situation, and with pollution characteristics, this program selects different water treatment technologies (including different plant species) and measures for organic combination, in the light of different pollution situation, landform and depth characteristics of each swag, while allowing for the bidding requirement (Val Klump et al., 2018; El-Hattab, 2015). See Table 4.

Table 4: Different types of water treatment technologies and measures

Pollution situation	For combined technologies and measures	Major functions
Specially polluted swags	The biochemical purification technology performs bypass treatment on the sewage.	Removal of residues of COD, ammonia nitrogen and TP in sewage
Exogenous sewage pollution	Set up sewage treatment facilities to treat it on site after the interception of domestic sewage discharged into the swags	Removal of COD, ammonia nitrogen and TP from exogenous domestic sewage
Water eutrophication	High-efficiency purification and algae removal technology, microbial activation combined with biological filtration technology (integrated with microbial activation, aeration, running water circulation, microorganisms	Reduce water suspended matters, algae, colloid, COD, ammonia nitrogen and TP to improve transparency and dissolved oxygen;
Garbage	Thoroughly cleanup and transit for landfill after screening.	Restore and strengthen the self-purification capacity of water bodies, clean up the foreign transport
Other integrated management	Set up the enclosures; strengthen management and training; Underline plant harvesting	Perform scientific management

14#Pitang water body pertains to sewage with high ammonia nitrogen and high organic sewage, and can be treated by garbage clearance – cut pollution - biochemical bypass treatment - microbial activation combined with biological filtration - aeration - aquatic plants - maintenance management. For 12#, 13# swags, etc., algae fully cover on the surface; for swags where NH3-N and TP greatly exceed the standard can be treated by the garbage clearance – cut pollution – mobile efficient algae removal clarification (bypass)-microbial activation combined organism filtration - aeration - aquatic plants - maintenance management program. 7#, 9# and others have the better quality; those swags without algae on the surface can be treated by the garbage clearance – cut pollution -microbial activation combined with biological filtration – aeration - aquatic plant-maintenance management program.

5. Conclusion

Water in the swags in this area is generally poor, and even falls short of the Class V surface water quality standard. Rainwater swag is the best in water quality, followed by domestic sewage + rainwater pond. The pollution of the aquaculture sewage + rainwater swags is heavy, where water pertains to high organic matter and high ammonia nitrogen wastewater. Various types of swags are surveyed to develop appropriate treatment program for them.

Long-acting maintenance of the swag treatment effect is based on the “30% construction and 70% management”. It is recommended that new pollution sources in the swags should be cut off after the completion of the treatment project. It is proposed that rainwater-based swags are used for aquaculture to facilitate the long-acting ecological effects and functions of the swags.

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