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Pollution control of outfall of rainwater-sewage confluence in old town

Huang Yongqiang Shi Kai Zhu Yan Liu Rongping

(School of Environmental and Safety Engineering, University of Jiangsu, Zhenjiang 212013, China)

Abstract: In order to improve water quality of middle ancient canal in Zhenjiang city, a pollution control project was carried out. The research area is the middle catchment area of the ancient canal river system in the old town of Zhenjiang. The specific research object is the runoff of the outfall of rainwater-sewage confluence in the area. On the basis of detecting and analyzing the water yield and water quality of the runoff of rainwater-sewage confluence, a combined technology which contains four independent continuous processes for lowering pollution load was developed, and system equipment was established and put into operation. The processing effects of the project were monitored and analyzed. The results show that the pollution control project of outfall runoff is efficient, which decreases the pollution load including chemical oxygen demand (COD), total phosphorus (TP), suspended solids (SS), and ammonia-nitrogen (NH_3-N). As a result, the water environment of the ancient canal is protected.

Key words: urban rainwater; confluence of rainwater and sewage; outfall; rainwater runoff; pollution load; processing equipment

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The ancient canal flows across the old town of Zhenjiang city from east to west [1]. There are several problems in its drainage system. For example, the drainage facility is old and many sewer lines are connected in a wrong way. As a result, much more serious pollution is caused. In order to improve the water quality of the ancient canal, the government has renovated the drainage pipeline network of the middle ancient canal since 2011[2]. There are 25 outfalls at the middle ancient canal. By field investigations, 24 of them could be transformed to the distribution system of rain and sewage, while the pipeline network of the eastern catchment area of old railway bridge outfall was not qualified to the condition [2]. In order to control the pollution of rainwater-sewage confluence at the outfall of old railway bridges, we set up a rainwater-sewage confluence pollution control demonstration project at the old railway bridge outfall, and did some research on the effect of the project[3].

The eastern catch ment area of the old railway bridge outfall lies in the semi-urban area, and the area of catchment is about 1.2×10^6 m^2. The design treatment flow rate is under the flow of torrential rain considering that the frequency of torrential rain is rather low and its processing is uneconomical [4]. The runoff coefficient of suburb areas was 0.6, and the upper limit of 12 h overflow quantity was 10 000 to 22 000 m^3 [2]. According to the monitored data, the sewage quantity of the outfall in dry days is about 780 m^3/d. The measured quantity of overflow through the outfall on rainy days is about 1 153 to 16 547 m^3 per time[3]. Its pollution concentration is high [5]. In the area, the project team carried out the overflow pollution control demonstration project. The processing scale of the project is 2 600 m^3/d.

The research purpose is to control the pollution of rainwater-sewage confluence at the outfall of old railway bridges in Zhenjiang, so as to protect the ancient canal which receives the confluence. In the research field, Jiang et al. [6] made a study on domestic urban rainwater runoff pollution, and found that the planning of the urban drainage system should integrate the requirement of urban rainwater pollution control and make arrangements on the counter measures and land use. Zhang[7] made a study on the combined sewer overflow pollution of Jizhuangzi drainage system in Tianjin. By collecting the data of the drainage pipelines and pumping stations, combined with the specific characteristics of rainfall in Tianjin, the combined sewer system of Jizhuangzi was established. Xu[1] proposed the combined sewer overflows pollution prevention and treatment techniques, which were fit for Zhenjiang.

In this paper, on the basis of detecting and analyzing the water yield and water quality of the runoff of rainwater-sewage confluence, a combined technology which contains four processes for lowering the pollution load is developed, and then the processing effects of the project are analyzed.

1 Treatment Process of Project

1.1 Process overview

The acreage of the processed area is about 1.2×10^6

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Biography: Huang Yongqiang (1968—), male, master, associate professor, yqhuang@ujs.edu.cn.

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m^2. During the rainy days the overflow rate is ceaselessly changing, so the treatment method cannot be single[7]. In order to reduce the pollutant content which would be discharged into the ancient canal, the whole pollution treatment process is made up of four independent continuous processes, which can help to achieve the general objective of the overflow pollution control project [2]. Four treatment processes, respectively, are as follows:

Process 1 Unpowered overflow pollution treatment equipment + ecological moderative pollutant-reduction system.

Process 2 Accurate hydrocyclones + bidirectional rotational flow-precipitate integrated purifier + adsorbent clean-up bed[8].

Process 3 Meshed rotational flow treater[9].

Process 4 Accurate hydrocyclones + rotational flow magnetism defecator + adsorbent clean-up bed.

1.2 Introduction of four processes and flow chart

Four processes are detailedly introduced, including the processing efficiency of several parameters.

1.2.1 Process 1

Process 1 contains two consecutive parts. The first is unpowered overflow pollution treatment equipment. Its design processing capacity is 40 m^3/d, and the processing efficiency(removal rate) is 40% to 60% of SS.

The second is an ecological moderative pollutant-reduce system. Its design processing capacity is 100 m^3/d, and the processing efficiency (removal rate) is above 40% of COD, above 20% of NH_3-N, and above 20% of TP. The process flow diagram of process 1 is shown in Fig. 1.

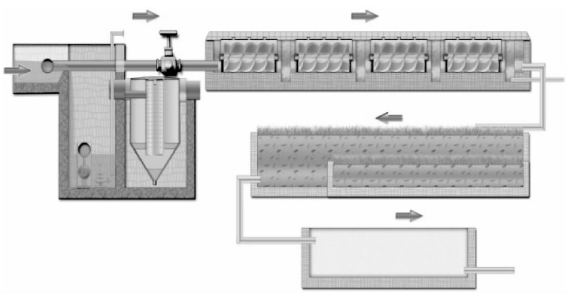

Fig. 1 Technology process 1

1.2.2 Process 2

Process 2 contains three consecutive parts. The first is accurate hydrocyclones. Its design processing capacity is 500 m^3/h, and the processing efficiency (removal rate) is 50% to 70% of SS.

The second is bidirectional rotational flow-precipitate integrated purifier. Its design processing capacity is 40 m^3/h, and the processing efficiency (removal rate) is 70% to 80% of SS, and 20% to 30% of COD.

The third is an adsorbent clean-up bed. Its design processing capacity is 40 m^3/h, and the processing efficiency (removal rate) is above 40% of COD, above 20% of NH_3-N, and above 20% of TP. The process flow diagram of process 2 is shown in Fig. 2.

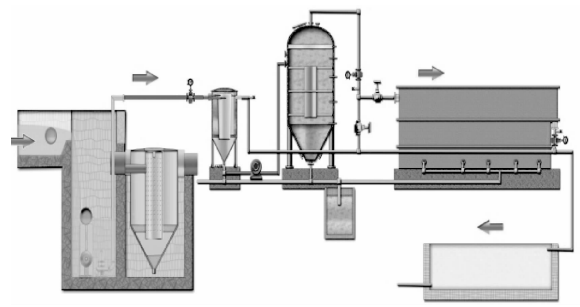

Fig. 2 Technology process 2

1.2.3 Process 3

Process 3 contains one piece of equipment which is a meshed rotational flow treater. Its design processing capacity is 1 000 m^3/h, and the processing efficiency (removal rate) is 30% to 50% of SS. The process flow diagram of process 3 is shown in Fig. 3.

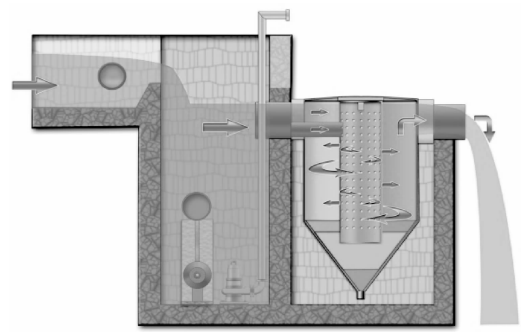

Fig. 3 Technology process 3

1.2.4 Process 4

Process 4 contains three consecutive parts. The first is accurate hydrocyclones. The second is a rotational flow magnetism defecator, and the third is an adsorbent clean-up bed.

The design processing capacity of process 4 is 40 m^3/h, and the processing efficiency (removal rate) is 60% to 80% of SS, and 30% to 40% of COD. The process flow diagram of process 4 is shown in Fig. 4.

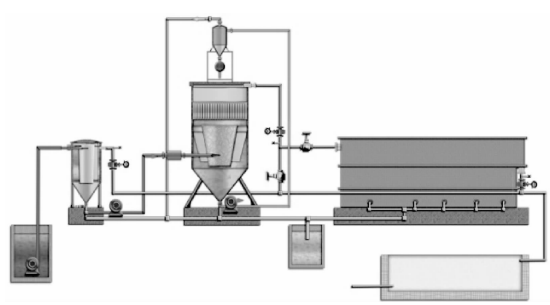

Fig. 4 Technology process 4

1.3 Actual picture of the project

The combined technology is composed of the four processes and it was put into operation at the outfall of old railway bridges in 2011. The actual picture of the project is shown in Fig. 5.

Fig. 5 Actual picture of overflow pollution control project

2 Operation Effect of the Project

After construction and debugging of the project, it was put into operation. By means of monitoring the processing effect of five rain times, it is found that the effect of reducing the overflow pollution of rainwater-sewage confluence of the processed area is good. During the five rains, the inflow and outflow of the system was monitored to obtain several parameters, including COD, NH_3-N, TP and SS[10]. The results and the calculated removal rate are listed in Tabs. 1 to 4.

Tab. 1 System removal rate of COD

Date	COD of inflow/ (mg · L^{-1})	COD of outflow/ (mg · L^{-1})	Removal rate/%
2011-06-18	728.00	456.00	37.36
2011-07-11	378.00	251.00	33.60
2011-08-22	301.00	203.00	32.56
2011-09-23	287.00	196.00	31.71
2011-09-30	423.50	314.00	25.86

Tab. 2 System removal rate of NH_3-N

Date	Concentration of NH_3-N of inflow/(mg · L^{-1})	Concentration of NH_3-N of outflow/(mg · L^{-1})	Removal rate/%
2011-06-18	9.25	6.48	29.95
2011-07-11	8.08	6.06	25.00
2011-08-22	7.10	5.18	27.04
2011-09-23	6.83	5.19	24.01
2011-09-30	7.82	5.73	26.73

Tab. 3 System removal rate of TP

Date	Concentration of TP of inflow/ (mg · L^{-1})	Concentration of TP of outflow/ (mg · L^{-1})	Removal rate/%
2011-06-18	4.96	3.37	32.06
2011-07-11	3.85	2.89	24.94
2011-08-22	2.39	1.89	20.92
2011-09-23	2.49	2.04	18.07
2011-09-30	3.42	2.55	25.57

Tab. 4 System removal rate of SS

Date	Concentration of SS of inflow/ (mg · L^{-1})	Concentration of SS of outflow/ (mg · L^{-1})	Removal rate/%
2011-06-18	1 730.00	321.00	81.45
2011-07-11	882.00	224.00	74.60
2011-08-22	750.00	140.00	81.33
2011-09-23	117.00	52.65	55.00
2011-09-30	869.75	215.00	75.28

The implementation of the project can effectively control the overflow pollution of the confluence of outfall, and the pollution load which can be discharged into the ancient canal is reduced.

In order to further realize the proposed regularity of the project during rainy days, researchers monitored the momentary data of four parameters during a time of rain, and then figured out the momentary removal rate. The results are listed in Tab. 5.

Tab. 5 System momentary removal rate

Sampling time/min	Removal rate/%			
	COD	NH_3-N	TP	SS
0	68.30	70.99	21.43	80.60
5	72.73	76.72	37.98	93.40
10	71.72	80.32	40.22	94.89
15	73.94	76.53	51.18	89.49
20	70.06	76.05	56.16	94.09
30	71.72	69.92	58.06	88.10
40	75.00	75.85	59.86	89.47
50	72.73	76.36	53.68	92.26
60	72.59	73.07	64.24	86.61
70	71.33	69.22	57.93	88.84
80	66.91	68.54	70.55	83.60
90	74.65	73.36	68.87	81.03
120	74.02	78.06	71.32	86.08

With the extension of rainy time, the results indicate that the removal rates of four parameters are continuously increased. The pollution load of overflow is significantly lower than that before.

3 Conclusion

The outfall overflow pollution control project can effectively reduce the pollution load of various contaminative parameters of rainwater-sewage confluence. We mainly made two groups of monitoring. In the first, we sampled and monitored five rains. For each rain, we figured out one removal rate of pollution parameters including COD, TP, NH_3-N and SS. In the second, we sampled one rain and figured out a series of momentary removal rates of pollution parameters.

From the monitor results, it is easily found that the positive effect of the project is obvious, which drastically reduces the content of COD, TP, NH_3-N and SS of the rainwater-sewage confluence. Besides, the process can control the overflow quantity of the rainwater-sewage confluence during rainy days, reduce the pollutant con-

centration which would be discharged into the ancient canal, and effectively protect the water environment of the ancient canal. The model of the pollution control project can be used as a reference for other similar river pollution control[11].

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老城区雨污合流排口污染控制

黄勇强　史　凯　朱　艳　刘荣平

(江苏大学环境与安全工程学院,镇江 212013)

摘要:为改善镇江市古运河中段水质,实施了相应污染控制工程,选择镇江市老城区古运河水系为研究区域,以古运河中段汇水区雨污合流排口的径流为研究对象.在分析该区域晴天和雨天雨污合流排口水量、水质的基础上,针对该区域的径流特点,确定了降低污染负荷的组合处理工艺,该组合处理工艺由4个连续的独立处理工艺流程组成.然后根据所确定处理工艺开发了系统成套设备并投入运行.对工程处理效果进行了监测和分析,结果表明,此雨污合流排口污染控制工程可行,并有效降低了排入古运河的降雨径流的各项污染指标,包括化学需氧量(COD)、总磷(TP)、悬浮物含量(SS)、氨氮(NH_3-N),从而有效保护了古运河的水环境.

关键词:城市雨水;雨污合流;排口;降雨径流;污染负荷;处理设备

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