Research on the non-point source pollution characteristics and water environmental capacity within small river basin of agricultural areas a case study of the small watershed near Gan village, Tanxia town

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Abstract. A small watershed of a tributary of the Gantang River was chosen as the study object. The water environment capacity and the amount of non-point source pollutants entering the river were calculated by combining field measurements and survey data. The results reveal that the water quality in the basin exceeds the standard severely, with 23.12t of TN, 1.64t of TP, 58t of CODMn, and 12.05t of NH3-N exceed during the plentiful period; The watershed exceeded the TN standard by 14.3t, TP by 1.64t with 17.489t of CODMn remaining in water environmental capacity and 0.71t of NH3-N exceed during the drought period. Finally, suggestions for the prevention and control of the water environment in the watershed were proposed in response to the pollution characteristics, which are of great significance for improving the water environment of the agricultural area.

Keywords: Non-point source pollution, water environmental capacity, water quality analysis.

1 Introduction

Non-point source pollution is the main cause of surface water pollution, with agricultural non-point source pollution contributing the most. Due to its large spatial and temporal variation, the uncertainty and randomness of pollutants and emission pathways, and the complexity of the composition and process, it has become a major source of pollution to the surface water environment. Non-point source pollution is well recognized by humans, but not well researched, and even less quantitative study. For the quantitative research need in order to evaluate its impact, the current research is dominated by non-point source pollution, while water environment capacity research of rivers is also relatively small. In this research, a small river basin in a tributary of the Gantang River in Tanxia Town, Lingchuan County, is selected as the research object. Based on the actual local situation and the characteristics of agricultural non-point source pollution, the main pollutants are identified as TN, TP, NH_3-N and COD_{Mn}, and combined with the water quality monitoring results, suitable parameters are selected for the calculation of the water environment capacity, the amount of pollutants entering the river, as well as the achievement of control targets and the amount of pollutants to be reduced, is intended to provide a method and reference basis for the management of non-point sources and water pollution control.

2 Overview of the research watershed

Tanxia Town belongs to the northwestern part of Lingchuan County, Guilin City, Guangxi Zhuang Autonomous Region, and the watershed within the area is a tributary of the Gantang River. The study of small watershed is located near Gan Village, Tanxia Town, with a river length of about 8 km and a total watershed area of about 12 km^2. the soil in the research area has a low organic matter content, contains less nitrogen, phosphorus and potassium, and has low fertility. The vegetation cover in the area is well established, reaching over 70%. The watershed is located in the central subtropical monsoon climate zone, with an average annual rainfall of 2011.1 mm, with rainfall mainly concentrated from March to August and the most rainfall for the year in May. November to January is the drought period and April to June is the plentiful period.

The watershed is a typical agricultural area with no industrial pollution sources or large-scale farms. Local agriculture is mainly based on citrus and rice cultivation, and farming is dominated by swine and poultry. Agricultural surface sources are the main source of pollution in the river. Two monitoring sections were set up in the upper and lower

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reaches of the river basin, 1300m apart, with no tributaries flowing between the two sections. Based on the characteristics of agricultural surface pollution, four monitoring items were identified, including TN, TP, COD_{Mn} and NH_3-N. Six months of field sampling and monitoring were carried out in accordance with the monitoring technical standards of the "Analytical Methods for Water and Wastewater Monitoring". The monitoring results showed that the concentrations of TN and COD_{Mn} in the water body of this river section far exceeded the pollution concentration values for Class III water in the "Environmental Quality Standards for Surface Water". The results of the experiment monitoring are shown in Table 1.

Table 1 Tanxia town watershed monitoring results（mg/L）

	Time	TN	TP	COD_{Mn}	NH_3-N
Upstream monitoring cross-sections	Plentiful period	4.58	0.1	7	0.14
	Drought period	5.93	0.13	15.8	0.82
Monthly average pollutant levels	Plentiful period	4.39	0.09	7.3	0.13
	Drought period	5.88	0.12	17.3	0.99

3 Computational model of the water environment capacity

3.1 Watershed monitoring objectives

Through the field monitoring results, it could be seen that the pollutants in the basin are mainly TN, TP, COD_{Mn} and NH_3-N. To make the total water environment in the basin effectively controlled, then the amount of pollutants entering the river must be controlled. In this paper, TN, TP, COD_{Mn} and NH_3-N will be selected as the calculation factors of the water environment capacity from the problem of total pollutant control. Based on the field measurement data, and the surrounding monitoring information and field survey results, the water environment capacity of this small watershed is calculated.

3.2 Computational model

The calculation of the water environment capacity requires consideration of the dilution effect of the water body and the biochemical decontamination effect. Only the impact of non-point source pollution on the environmental capacity is considered in the river. For rivers with predominantly non-point source pollution, it could be assumed that pollutants enter the river in a uniform form along the river, then the river water environmental computational model can be expressed as:

$$W = 365 \times 86.4 \times Q_0 \times \left[C_S \times \exp\left(\frac{KL}{86400u} \right) - C_0 \right]$$

Where: W is the water environmental capacity of the river section; Q0 is the average flow rate of the river section; CS is water quality standard concentration in the basin; C0 is upstream incoming pollutant concentration; K is overall attenuation coefficient; u is average flow rate of the river section; L is length of the river section. Stream flow and cross-sections are based on measured data. The cross-sectional flow rate in the basin during the drought period is 0.01m/s; the cross-sectional flow rate in the basin during the plentiful period is 0.08m/s.

2.2.1 Overall attenuation coefficient

A section of the river basin with a length of 400m, a straight channel, stable water flow, no tributaries in the middle and no outfalls was selected and sampling points were placed upstream and downstream to monitor pollutant concentrations.

$$K = 86400 \times \ln \frac{C_1}{C_2} \times \frac{v}{l}$$

Where: K is the pollutant attenuation coefficient; C_1 and C_2 are the pollutant concentrations at the upstream and downstream sections of the river; l is the distance between the upstream and downstream sections; and v is the average velocity of the water. Due to the small amount of monitoring data and large errors, the pollution attenuation coefficient was combined with the actual local conditions and empirical formulas, and the final calculation of the overall attenuation coefficient is shown in Table 2

Table 2 Overall attenuation coefficient

K	TN	TP	COD_{Mn}	NH_3-N
Plentiful period	0.732	1.821	-0.725	1.281
Drought period	0.018	0.173	-0.196	-0.407

3.3 Sewage discharge quantity

The people income of Tanxia town is mainly agriculture, forestry, livestock farming and fishing, etc. There are no industrial factories in the area. The survey mainly includes the agricultural population, the livestock breeding quantity, agricultural fertilizers and pesticides quantity. In this paper, we will calculate the quantity of pollutants entering the river from three aspects: pollution from agricultural life, livestock breeding and fertilizers and pesticides on farmland.

The questionnaire investigation of the local population and the monitoring data of the water quality around the toilets in the watershed, in which the content of pollutants contained in human excretion of faeces and urine is used to determine the discharge coefficients through the regulations of the National Health Bureau study, and the visit to seven survey points in the study area. The survey shows that the actual population living in the area is about 3,600 people, the cultivation area is about 12,000 mu, about 400 hogs are kept, and the total number of chickens and ducks is about 200. Referring to the calculation method in the 《Fertiliser Manual》 and combining the results of the Guilin part of the

2016 National Pollution Source Census, the regional pollutant emissions are shown in Table 3 below.

Table 3 Agricultural domestic pollution emission statistics

Item	TN	TP	COD_{Mn}	NH_3-N
Agriculatural domestic sewage entering the river quantity (g/a)	2102.4	578.16	78840	9198
pesticides and chemical fertilizers entering the river quantity (kg/a)	8280	432	36000	7200
livestock manure entering the river quantity (g/a)	5756	1573	33530	2358
pollutants entering the river quantity (t/a)	11.15	1.22	77.02	11.42

3.4 Calculation of water environment capacity

The estimation of the water environmental capacity took into account the amount of non-point source pollution entering the river along the river as the background value of pollutants in the water bodies of the small watershed, reflecting only the impact of non-point source pollution on the water bodies of the watershed, and the results of calculating the amount of water environmental capacity entering the river in this section and the remaining water environmental capacity are shown in Table 4.

Table 4 Water environment capacity for various pollutants

Time		TN	TP	COD_{Mn}	NH_3-N
Plentiful period	Water environment capacity	-11.972	-0.630	18.902	-0.630
	Remian	-23.122	-1.847	-58.118	-12.050
Drought period	Water environment capacity	-3.150	-0.630	94.509	10.710
	Remian	-14.300	-1.847	17.489	-0.710

4 Conclusions and recommendations

4.1 Conclusion

Through the study of the characteristics of the water environment capacity of the small watershed near Gancun in Tanxia Town during the plentiful period and the drought water period, the monitoring results show that the pollutant TN and COD_{Mn} concentrations are higher than the water quality standard of category 3. According to the calculation results of the water environment capacity, the water environment capacity of the small watershed near Gancun is almost always exceeded throughout the year, with an excess of about 23 tonnes of TN, 1.64 tonnes of TP, 58 tonnes of COD_{Mn} and 12 tonnes of NH_3-N during the plentiful period, and an excess of about 14 tonnes of TN, 1.64 tonnes of TP, 0.7 tonnes of NH_3-N and 58 tonnes of COD_{Mn} remaining during the drought water period.

From the above research content, it can be concluded that the water environment capacity of the basin shows a large difference in the remaining water environment capacity during the dry season and the wet season. Only the TP water environment capacity remains stable throughout the year. TN, COD_{Mn} and NH_3-N all have a higher residual capacity in the drought period than in the plentiful period. The area to which the basin belongs has higher summer temperatures, rainfall and amounts of pesticides and fertilisers required for crop growth, considering that the increase in pollutant concentrations should be significantly related to rainfall and temperature.

4.2 Recommendations

Rural agricultural non-point source pollution seriously restricts the development of the agricultural economy and the improvement of the local ecological environment. To eradicate environmental pollution problems, the starting point is to cut off the source of water environment pollution. The discharge of production and domestic sewage should be treated accordingly, first of all, sewage will be directly introduced into sewage treatment plants, rather than directly dumped such as rivers in farmland; the application of chemical fertilizers and pesticides in farmland should also be based on the actual local situation, the local soil survey sampling, according to local conditions, the choice of suitable fertilizer products, fixed-point quantitative application of fertilizers, rather than a single excessive application of fertilizers. Introduce advanced planting techniques, develop ecological agriculture, encourage farmers to use efficient and non-polluting green fertilisers and organic fertilisers, develop and promote new pesticides with high efficiency, low toxicity, low residue and easy decomposition; for pollution from livestock farming, it is recommended to realise the separation of humans and animals, implementing a pond and three changes, promoting four-in-one and other college agro-ecological models, harmless treatment and comprehensive use of livestock manure, developing clean farming. In addition, it is recommended to develop clean aquaculture, and attach importance to environmental protection requirements in areas such as circle structure, manure cleaning, and source matching.

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