Non-point Pollution Estimation of Zhouhe River Basin

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Abstract. The non-point source pollution is serious in the Zhouhe River Basin. There is a large amount of nitrogen and phosphorus load running into the Yuqiao Reservoir, which causes the water eutrophication and even algal blooms. Experience estimate method was taken to calculate the pollutants generation, loss and discharge into rivers based on the economic statistics in the year 2012 of each town. A total of 5887.3 ton COD, 526.5 ton NH_3-N, 1665.8 ton TN and 463.1 ton TP is discharged into rivers in the river basin. The pollutant contribution rates of different sources in different polluting process were also analyzed and it suggests that the live stocking is the main pollution source.

1. Introduction

The Zhouhe River Basin contains Jixian of Tianjin City and Zunhua, Yutian and Xinglong of Hebei Province. The Yuqiao Reservoir which is the important drinking water sources is located in the basin. There are many rivers in the basin which come together into three main rivers running into the Yuqiao Reservoir. However, the non-point pollution becomes serious and the main transnormal items are total nitrogen(TN) and total phosphorus(TP). The Yuqiao Reservoir eutrophication is severe, which caused algal blooms these years. It is a threat to the water supply safety of Tianjin City. So, it's necessary to analyze the non-point pollution load and the main sources and to make water environment regulation.

2. Materials and methods

Non-point source pollution refers to domestic sewage and waste, livestocking, fertilizers and pesticides in rural regions, the quantity of which can be multiplied by an empirical coefficient to work out the yield, loss (emission) and discharge into the river of all the pollutants including TN, TP, COD and ammonia nitrogen(NH3-N).

2.1 Domestic life

2.1.1 Amount of generated by domestic life

(1) Rural domestic sewage

The yield of a pollutant in rural domestic sewage is calculated by multiplying the rural population by the pollutant discharge coefficient. As per *the Supplementary Technical Instructions on the Survey and Evaluation on Surface Water Quality and Pollutant Discharge for National Water Resource Plan*,thedischarge coefficients of the pollutants in domestic sewage are 50g/d COD per person, 3.2 g/d NH_3-N per person, 6.4 g/d TN per person and 1.3 g/d TP per person.

(2) Domestic waste

Wang Xiaoyan [1] classified common village, tourism village and township village and worked out their monthly per capita yields of domestic waste. The estimation is based on their average, that

is, 10.9 kg/month per person, as the per capita yield of rural domestic waste. The pollutants in rural domestic waste (solid waste) are mainly NH_3-N, TN and TP and the corresponding weight percentages are 0.021%, 0.21% and 0.22% [2]. The discharge percentage of COD is 1%.

2.1.2 Loss of rural domestic pollutants

According to previous research, the loss rate of domestic sewage in the south of China falls between 30% and 40% [2-4], that in the Northeast China is about 20% [6], that in Beijing [1] and Shandong [7] is about 30% and that of Hutuo River is 26%. On balance, the loss rate of the pollutants in domestic sewage in this report is 50%.

The loss of rural domestic waste is the amount of generated.

2.1.3 Quantity of rural domestic pollutants discharged into rivers

The coefficients of pollutants of domestic sewage and waste into rivers are 0.1 and 0.07 respectively.

2.2 Livestocking

2.2.1 Yield of the pollutants for livestocking

The yield of the pollutants for livestocking is calculated on the basis of the quantity excretion coefficient and growth cycle of livestock.

The formula used to calculate the annual yield of pollutants for livestocking is as follows:

$$PT=C\times n\times T \tag{1}$$

In it, PT means the yield of pollutants, C means the daily faeces (urine) emission, n means the quantity of livestock and T means the growth cycle.

The quantity of the livestock raised can be either the quantity of marketable fattened livestock or the quantity of livestock raised on hand. The average raising period of pigs is 199 days, so the quantity of the livestock raised is the quantity of marketable fattened livestock. The average raising period of cattle is 365 days, so the quantity of the livestock raised is the quantity of livestock on hand at the end of the year. The growing period of sheep and other domestic animals is usually longer than one year; therefore, the quantity of the livestock raised is also the quantity of livestock on hand at the end of the year. The average raising period of chicken and duck is 210 days, so the quantity of the livestock raised is the quantity of marketable fattened livestock in the current year.

The excretion coefficient of livestock and poultryand the average pollutant load in faeces and urine are subject to relevant research findings [8,9].

Multiply the excretion coefficients of livestock and poultry by corresponding pollutant loads of faeces and urine to obtain the daily discharge of pollutants in the faeces and urine of livestock and poultry. Refer to Tables1 for the details.

Table 1 Daily Discharges of Pollutants in Urine of Poultry [kg/d]

	COD	NH_3-N	TN	TP
pig	0.2255	0.0177	0.0365	0.0144
cattle	0.841	0.0809	0.1973	0.0339
sheep	0.0117	0.002	0.0224	0.0062
rabbit	0.0005	0.0001	0.0009	0.0003
poultry	0.0046	0.0003	0.001	0.0006

2.2.2 Loss of pollutants for livestocking

The loss of pollutants for livestocking equals the product of the yield of pollutants times the loss rate.

According to previous research, the loss rate of faeces in the south of China falls between 30% and 40%[3-5], that in the Northeast China is about 20% [6], that in Beijing [10] and Shandong[7] is about 30% and that of Hutuo River is 26%. On balance, the loss rate of the pollutants for livestocking in this report is 28%.

2.2.3 Quantity of pollutants for livestocking which are discharged into rivers

The quantity of pollutants for livestocking which are discharged into rivers refers to the amount of pollutants entering the ground water, whose ratio to the loss of pollutants is the inflow coefficient. In accordance with previous studies, the inflow coefficient is 0.25.

2.3 Estimate diffused pollution for fertilizer

2.3.1 Application amount of fertilizers (net amount) and pollutant load

The content of TN, TP, NH_3-N and COD in fertilizers is calculated by the following formulas:

$$TN=nitrogenfertilizer+compound\ fertilizer\times0.3 + phosphatefertilizer\times0.185 \quad (2)$$

$$TP = (phosphatefertilizer + compound\ fertilizer\times0.3)\times0.437^{1} \quad (3)$$

$$NH_3\text{-}N = TN\times0.1 \quad (4)$$

$$COD = TN\times0.3 \quad (5)$$

2.3.2 Loss of pollutants for fertilizers

The discharge of pollutants for fertilizers, also loss of pollutants for fertilizers, equals to the product of pollutant content in fertilizers times the loss rate.The loss rate of TN, NH_3-N and COD is 20% and that of TP is 15%.

2.3.3 Quantity of pollutants for fertilizers discharged into rivers

The quantity of pollutants for fertilizers discharged into rivers equals the product of the loss times the inflow coefficient which varies a lot with the conditions. Most of the studies limit it between 0.1 and 0.2 [7,11]. The report takes the inflow coefficient of pollutants for fertilizers as0.15.

2.3.4 Estimate diffused pollution for persticides

According to the Research on the Plan for the Internal and Non-point Source Pollution Control in the Water Source Regions Directly Subordinated to Haihe River Water Conservancy Commission, in the pesticides, the content of the carbamates (regarded as NH_3-N) and organophosphorus (regarded as TP) equals the products of the application amount of the pesticides in the region times the percentage of 19.14% (for NH_3-N) or 39.09% (for TP). The loss rate (discharge rate) of pesticides is 70%. The inflow coefficient of pollutants for pesticides is 0.07.

2.4 Data

The basin covers 11 towns of Jixian County, 22 towns of Zunhua City, 4 towns of Xinglong County and 1 town of Yutian County. The data in the pollution loads calculation are from statistical yearbook for 2012 of Jixin County, Zunhua City, Xinglong County and Yutian County. The data contain agricultural population, the amounts of slaughtered and on hand of the pigs, cattle, sheep and poultry, pure fertilizer quantity of nitrogenfertilize, compound fertilizer and phosphatefertilizer; amount of application of pesticide.

3. Results and discussion

3.1 Yield of pollutants

There is a total of 90851.0 ton COD, 7415.0 ton NH3-N, 34099.6 ton TN and 9649.3 ton TP generated in the river basin.In terms of sources, livestocking yields the most diffused pollutants, particular COD and NH3-N; pesticides and fertilizers mainly cause the pollutants of TN and TP; rural domestic waste mainly contains the pollutants of COD and NH3-N. See Table 5.

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1 Note: In the statistical materials, nitrogen is calculated by N and phosphorus by P205 to work out the net quantity of fertilizers. To figure out TP, multiply the result by the coefficient of 0.437.

3.2 Loss of pollutants

The total loss in the river basin includes 28652.8 ton COD, 2582.0 ton NH_3-N, 8757.1 ton TN and 2499.7 ton TP. See Table 5 for details. It can be seen that the main source of all the pollutants is still livestocking.

3.3 Quantity of pollutants discharged into rivers

A total of 5887.3 ton COD, 526.5 ton NH_3-N, 1665.8 ton TN and 463.1 ton TP is discharged into rivers in the river basin. See Table 2 for details. It can be seen that the main source of all the pollutants is still livestocking.

Table 2 Pollutant Contribution Rates of Different Sources in Different Polluting Process [%]

Pollution source	Yield				Loss				Inflow			
	COD	NH_3-N	TN	TP	COD	NH_3-N	TN	TP	COD	NH_3-N	TN	TP
Domestic waste	15.7	11.8	5.6	5.8	26.6	17.3	12	15.3	12.5	8.4	6.0	6.9
Livestocking	78.6	81.8	43.8	47.8	69.8	65.7	47.8	51.7	84.9	80.6	62.8	69.7
Fertilizer and pesticide	5.6	6.4	50.6	46.4	3.6	16.9	40.1	33	2.6	11.0	31.2	23.4

See Fig.1 for details of the loss of COD, NH_3-N, TN and TP. The diagram of the distribution of pollutants in all the towns and townships is drawn on the basis of the yield of pollutants per unit area. The pie covered by a town or township represents the percentages of various pollutants. The size of the pie is in direct proportion to the amount of pollutants. It can be seen from the figure that COD, NH_3-N and TP are mainly from livestocking. The TN discharged into rivers in all towns is mainly from livestocking, pesticides and fertilizers.

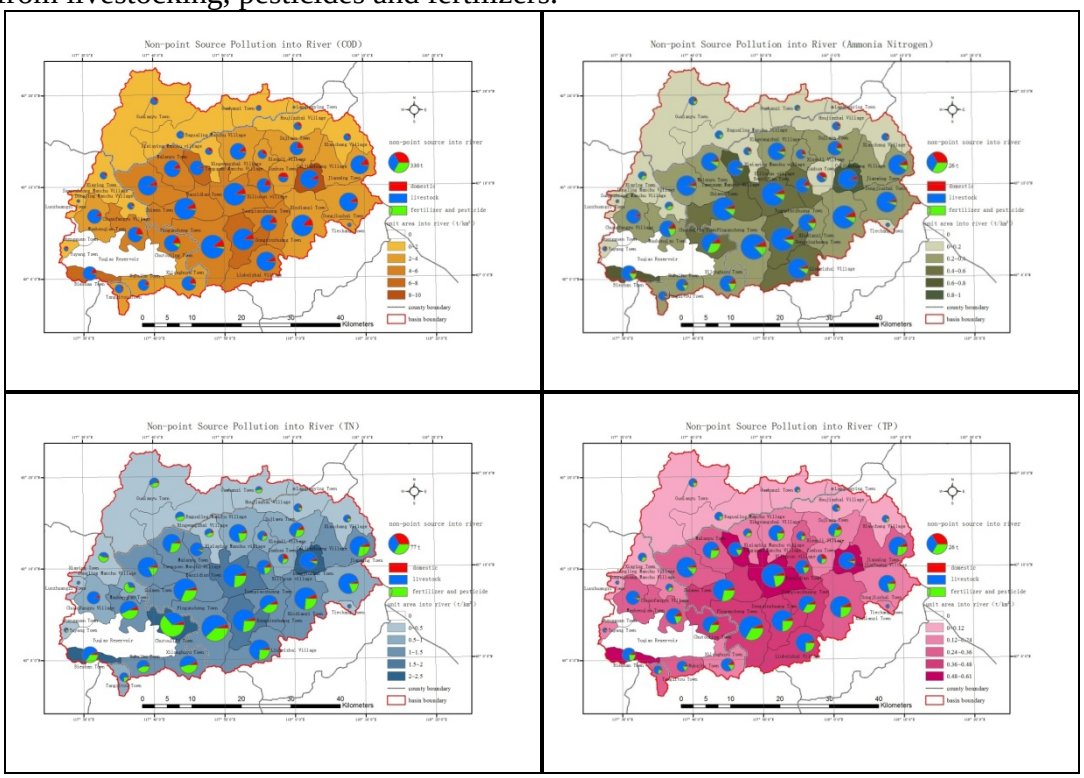

Fig.1 Discharged into Rivers of the Main Pollutants

The evaluation by empirical coefficient merely considers the social and economic data including the rural population, the number of livestock and poultry and the application of pesticides and fertilizers and the inflow coefficients of the pollutants from various pollution sources. It ignores the influence of rainfall and vegetation cover on surface and ground water. In the process of calculation, the same inflow coefficient is applied to TP and TN. However, the pollutants containing phosphorus can seep into the soil more easily than that containing nitrogen in fact. Further research needs to be conducted to figure out the inflow coefficient of TP. The empirical coefficient simplifies the calculation process. In addition, it can be used to analyze the main sources of pollutants in all towns and townships.

4. Conclusions

The methods for non-point pollution load calculation of the process of yielding, losing and running into rivers are described in this paper.

The pollution sources involve domestic life, livestocking, fertilizer and pesticide. The pollution loads of Zhouhe River Basin were calculated and analyzed. In the process of pollution yielding, the COD and NH_3-N are mainly from livestocking, TN and TP are mainly from pesticides and fertilizers. In the process of pollution losing and running into rivers, all the four pollutants are mainly from livestocking.

A total of 5887.3 ton COD, 526.5 ton NH_3-N, 1665.8 ton TN and 463.1 ton TP is discharged into rivers in the river basin.

To reduce the pollution loads running into Yuqiao Reservoir, the best method is to control the livestocking waste. However, although other non-point pollution sources make less pollution to the rivers, the groundwater may be contaminated by the sources. So, it's better to avoid the pollutants discharge to environment before treatment.

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