Diffuse Pollution Control and Water Soil Conservation in the Watershed of Miyun Reservoir, Beijing, China

—An Example of Shixia Catchment, Miyun County

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Abstract: Miyun Reservoir, the only one source of drinking surface water of Beijing, Capital of China, is situated at Miyun County where is within northern mountain area of Beijing. Nitrogen and phosphorus, coming mainly from diffuse pollution, are major nutrients to cause eutrophication to degrade water quality of Miyun Reservoir. Loss from chemical fertilizer, animal waste and soil erosion are the main patterns of diffuse pollution. It is estimated the percent diffuse pollutants as TN (75 %) and TP (94 %).

As a example of Shixia water soil conservation in Miyun County, the twenty experimental units and two monitoring channels, residential area and livestock units were used to monitor the flow, runoff and erosion, nitrogen and phosphorous content associated with various land uses in the meantime. Based on the relevant data which range from meteorological and hydrological data to land use, fertilizer and pesticide usage, and even livestock raising information, a total of four land use scenarios were modeled to evaluate various land management strategies on sediment and nutrient loading from catchment.

From the study, conclusions are summarized as follow: (1) Variations of TN, TP and COD in continuous rainfall processes are almost accordant with rate of flow. At the beginning of runoff, concentrations of suspended matter, TN, TP and COD are higher. (2) The pollutant content of residential area and livestock units are nearly 10—20 times of that of other land use areas. These areas should be treated as critical areas of diffuse pollution. (3) Different land use influences intensively the loss of pollutants, especially slope tilling in agricultural land. The amount of nutrient loss from the agricultural land per unit is the highest, that from forestry is the secondary and that from grassland is the lowest. (4) Nutrient is enriched in sediment. Phosphorus is migrated with sediment, while the dissoluble form in runoff is very little. Being carrier of loss nutrients, the fine particles are thought to be the controlling focus.

Based on the distribution of pollutants and ecological characteristics, we divide the Control zones of diffuse pollution in Miyun Reservoir as following: (1) Water source Forest remedial zone in the northeast and west mountain area with greater density of soil erosion. (2) Eco-agricultural manage zone in the northern rim around reservoir with agricultural land use and villages. (3) Water soil erosion control zone in northern hilly areas.
Keywords: Miyun reservoir, diffuse pollution, soil conservation, watershed, shixia catchment

1 Introduction

Miyun Reservoir is the most important source of drinking water supply in Beijing. It is situated at Miyun County, which is within northern mountain area of Beijing. The water surface area is 188km^2. The entire Miyun Reservoir watershed (approximately 14,000 km^2) drains to Miyun Reservoir on the Chao River and Bai River. Due to strictly control of point source pollution by forbidding the existence of any kind plant in the second-class protecting areas, nitrogen and phosphorus are mainly from non-point sources and eutrophication trend has become an important factor to degrade the water quality of Miyun Reservoir. The water quality of Miyun Reservoir is at the primary mesotrophic stage.

Many researches have focused on the water body of Miyun Reservoir (Song *et al*., 1986; Wang, 1997; Cheng *et al*., 1998). Yu (1985) was the pioneer in this field and she pointed out that non-point sources contributed significant percentages of such pollutants as TN (26%) and TP (53%) in Miyun Reservoir by using USLE Equation. Song *et al*. (1995) have estimated the relations of soil type, land use, slope and erosion, pollutant loss of little area in Miyun County with modified CREAMS Model. Bao *et al*. (1997) estimated the percentages of non-point source pollutants as TN (66%) and TP (86%) on the basis of hydrological data. So it is necessary to assess the origin and distribution of the non-point source pollutant loading in the upper reach watershed.

Shixia Experimental District is situated at northeastern of Miyun Reservoir(Fig.1). It is a hilly area on the lower reach of Chao River. The range of elevator is about 150m—390 m. Density of ravine is 0.2 km/km^2. The slope is about 20º. The main rock type is granite and soil series is eluviated drab soil. Agriculture, forest and grass are the three major land use types in the watershed, accounting for 55.84%, 20.58% and 15.04 % of the total land area, respectively. The region has a typical continental climate. An average annual precipitation amount is 660 mm, of this amount, 76.5% usually falls from July through September. (Water Soil Protecting Station of Miyun County, 1993).

Fig.1 The watershed map of Miyun Reservoir

2 Method

Shixia Experimental District is laid based on the achievements of water soil conservation in Miyun County, There are 2 catchments and 20 experimental units used to monitor the precipitation, runoff; loss of sediment and TN and TP in runoff and in sediment are analyzed in the meantime. A GIS based model is developed to calculate total annual non point nutrients and total solid loads from the watershed. The watershed is subdivided and loads are estimated for all land uses. The results of this study provide a better understanding of non point source pollution.

The detail description of Shixia Experimental District is shown in Table 1.

Table 1 Characteristic of selected units in Shixia experimental district

Unit	Slope	Direction	Length(m)	Land use	Practice of water soil conservation
01	16° 47′	Positive	10	Corn	Reclaim wasteland
02	16° 47′	Positive	10	Chestnut	Horizontal strip, width 2m
03	16° 47′	Positive	10	Chestnut, Cowslip in the ridge of field	Horizontal strip, width 2m
04	14° 38′	Half positive	10	Leisure, No shrub and grass	Standard unit
05	14° 38′	Half positive	10	Nature	
06	11° 40′	Half positive	10	Apple tree and haw tree	Horizontal strip, width 2m
09	27° 02′	Negative	10	Grass	Horizontal strip, width 0.3m
17	3° 50′	Positive	10	Corn，Cowslip in the ridge of field	Terrace，width 4m
18	3° 50′	Positive	10	Sloping tillable field，corn	Sloping tillable field
20	6° 3′	Half positive	10	Bean	No tillage

3 Results and discussion

3.1 The variations of pollutants in the units

We collected the soil and runoff samples before and after rainfall, and then we analyzed the grain composition of sediment and chemical component of TN and TP. The results are shown in Fig. 2.

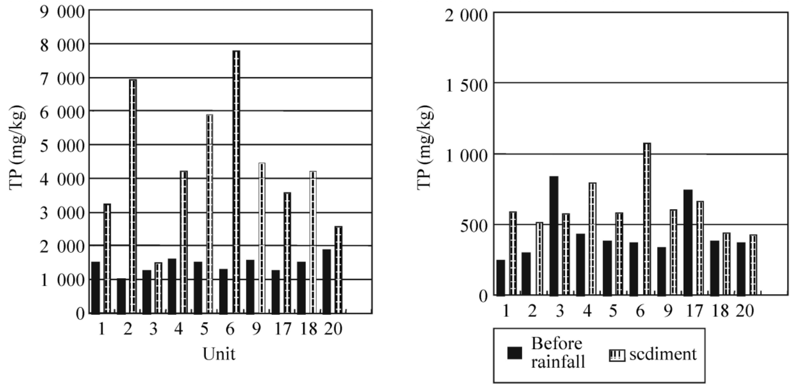

Fig. 2 Variation of TN and TP in sediment and soil before and after rainfall

It could be seen that concentrations of TN and TP in sediment were higher than that in soil before rainfall, which indicates the enrichment of nutrient in flush sediment. The value of PH and organic matter have a slightly drop in most soil after rainfall. The content of TN and TP in sediment of bare field are highest, then is wood land and grassland, the agricultural land is lowest; The sequence of ratio of TN and TP is cultivating on slope field > No tillage > contour tillage; PH and organic matter of eroded soil is low. Nutrient is enriched in sediment. As to soil grain size composition, grain whose size at 0.05mm—0.01mm and <0.001mm decrease after rainfall, it imply that clay material is main carrier which absorb nutrient to lass.

3.2 Variations of TN and TP in runoff

Table 2 Variations of TN and TP in runoff

No. Unit	Vegetation (%)	Runoff (m^3)	Sediment (kg)	TN (g/L)	TP (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)
1	85	0.475	0.475	6.10	<0.02	1.21	3.39	0.089
2	10	0.147	0.294	6.91	—	0.59	2.38	0.973
3	10	0.141	0.282	5.24	—	0.86	2.38	0.814
4	0	0.543	0.543	2.99	—	0.74	1.06	0.056
5	95	0.147	0.147	5.53	—	0.89	2.48	1.072
6	5	0.137	0.137	5.72	—	0.77	2.58	1.047
9	100	0.192	0.192	5.26	—	0.45	2.78	0.817
17	20	0.26	0.52	3.04	—	0.49	1.47	0.384
18	50	0.113	0.113	4.89	—	0.38	2.48	0.903
20	90	0.203	0.406	3.24	—	0.70	1.26	0.025

Runoff and sediment in unit 1 and unit 4 are higher. It suggested that it is easy to cause runoff in the reclaimed wasteland and bare land. As to similar slope, Runoff in unit 3 is significantly lower than that in unit 2 (reduction of 35.48%) just because of the ridge of field, which can control water soil erosion effectively. No dissoluble P is detected in the runoff, which implies that phosphorus is migrated with sediment. In addition, Because of the first rainfall in this summer, water flow didn't rush the texture of soil completely, so it affected the absorbed P in the soil entering the runoff. Being carrier of loss nutrients, the fine particles are thought to be the controlling focus. Due to the migrated sediment mainly coming from cultivated layer of soil and in the fine-grained. Therefore, the content of N and P in erode sediment are higher than that in the surface layer of soil, even in the runoff. Phosphorus content of sediment in agricultural land is higher than that in the forestland and grassland. However, as for nitrogen, the content in the forestland and grassland is higher than that in the agricultural land. That may be relevant with the capability of plant to absorb N and P the absorbed in the soil. The pollutant content in the sloping tillable field is the lowest for the cause of severe water soil erosion.

Pollutant concentrations of surface runoff coming from different land use area are discrepancy, which is similar to the variation of runoff. The content of TN and TP in runoff of agricultural field are highest, then is forestland and grassland. In agricultural land, different farming practices lead to the diversity of pollutant concentration in runoff. The sequence of TN and TP is cultivating on slope field > No tillage > contour tillage.

3.3 The variations of pollutants in the catchments

The detail description of two catchments is shown in Table 3.

Table 3 The land use type of the two investigated catchments (km^2)

Name	Total area	Agricultural land	Forest land	Grass land	Residential area	Others
East Chapeng bridge	2.29	1.30	0.38	0.43	0.05	0.13
Yaoting bridge	4.82	0.44	3.51	0.05	0.11	0.71

We made continuous monitoring on two catchments for several rainfalls in 1996. The variations of TN, TP and COD in continuous rainfall processes are showed in Fig. 3. We can see that variations of TP and COD in continuous rainfall processes are almost accordant with rate of flow where that of TN and other forms of N in continuous rainfall processes has little relevant with rate of flow and the variation of sediment.

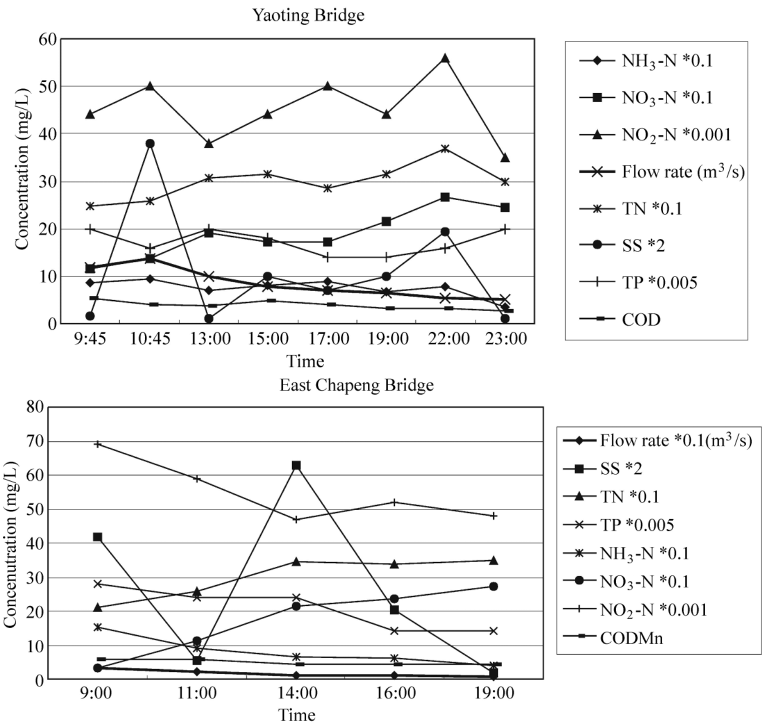

Fig. 3 The variations of TN, TP and COD in continuous rainfall processes in catchments

At the beginning of runoff, concentrations of suspended matter, TN, TP and COD are higher, and then these contents tend to steady. In addition, the content of NH_3-N has decreasing trend whereas that of NO_3-N has fluctuant rise, which reflects that the transform from NH_3-N to NO_3-N in the runoff. The pattern of pollutant variation is two peaks like "M". When the flow begins, there is a small peak. With the flow increase and sediment addition, it appears a large peak. The first peak represents the flush of flow to cumulate pollutant at the primary stage of stream. As the water erosion heavily, the texture of soil was destroyed, so material absorbed on the surface of soil was carried into runoff, and the second peak appears.

3.4 The variations of pollutants in the residential area

We selected a typical residential area which total area is 65m^2. There are 4 persons in the family, which is also raising livestock such as horse, hen, pig and cow. The result is showed in Table 4 and Fig. 4.

Table 4 Pollutant variation in continuous rainfall processes a typical residential area

Pollutant (mg/L)	1	2	3	4	5
COD	96.4	95.3	70.6	75.4	63.6
Dissoluble P	0.272	0.276	0.31	0.327	0.336
TP	2.085	2.991	2.701	2.594	1.294
Dissoluble N	42.7	33	18.8	19.4	23.2
TN	43.58	35.76	29.16	25.24	26.12

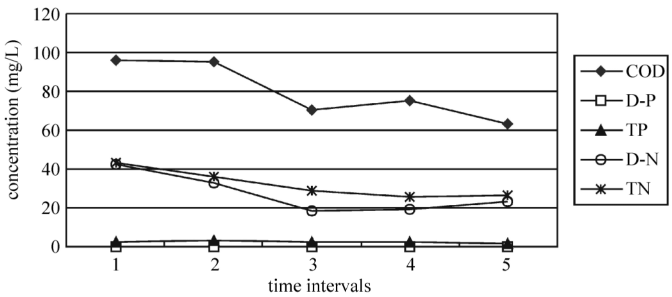

Fig. 4 Pollutant variation in continuous rainfall processes a typical residential area

Runoff in such kind area has a higher COD, which represents severe organic pollution. The pollutant content are nearly 10 times of that of other land use areas, even P can up to 100 times. These areas should be treated as critical areas of non-point source pollution, which have the largest pollutant load per unit.

N is mainly at the dissoluble form, which is up to 70%—90% of TN whereas dissoluble P is just 10% of TP. During the stream period, pollutant content became lower.

4 Conclusions

From the study, conclusions are summarized as follow:

(1) Variations of TN, TP and COD in continuous rainfall processes are almost accordant with rate of flow. At the beginning of runoff, concentrations of suspended matter, TN, TP and COD are higher, and then these contents tend to steady. In addition, the content of NH_3-N has decreasing trend whereas that of NO_3-N has fluctuant rise.

(2) The pollutant content of residential area and livestock units are nearly 10—20 times of that of other land use areas. These areas should be treated as critical areas of non-point source pollution.

(3) The content of TN and TP in sediment of bare field are highest, then is wood land and grassland, the agricultural land is lowest; The sequence of ratio of TN and TP is cultivating on slope field > No tillage > contour tillage; PH and organic matter of eroded soil is low.

(4) Nutrient is enriched in sediment. Phosphorus is migrated with sediment, while the dissoluble form in runoff is very little. Being carrier of loss nutrients, the fine particles are thought to be the controlling focus. (5) Due to scatter fertilizer grains without overlay in rain season, it is very easy to make nutrient lose. To reduce non-point source pollutant loading, fertilizer applying should be improved.

Acknowledgments

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