Characteristics of Non-Point Source Pollution in the Watershed of Miyun Reservoir, Beijing, China *

WANG XIAOYAN (王晓燕)1), WANG YIXUN (王一峋)1), LI TINGFANG (李庭芳)1), HE WEI (贺 伟)2), HU QIUJU (胡秋菊)3), AND ZHANG HONGFEN (张弘芬)1)
1) (Department of Geography, Capital Normal University, Beijing 100037, China)
2) (Water/ Soil Protecting Station of Miyun County, Beijing 100037, China)
3) (Department of Chemistry, Capital Normal University, Beijing 100037, China)

Abstract: Nitrogen and phosphorus are the major nutrients to cause eutrophication to degrade water quality of the Miyun Reservoir, a very important drinking water source of Beijing, China, and they are mainly from non-point sources. The watershed in Miyun County was selected as the study region with a total area of 1400 km². Four typical monitoring catchments and two experimental units were used to monitor the precipitation, runoff, sediment yield and pollutant loading related to various land uses in the meantime. The results show that the total nutrient loss amounts of TN and TP are 898.07 t/a, and 40.70 t/a, respectively, in which nutrients N and P carried by runoff are 91.3 % and 77.3 96, respectively. There is relatively heavier soil erosion in the northern mountain area whereas the main nutrient loss occurs near the northeast edge of the reservoir. Different land uses would influence the loss amounts of non-point source pollutants. The amount of nutrient loss from the agricultural land per unit is highest, that from forestry comes next and that from grassland is lowest. However, due to the variability of land use areas, agricultural land contributes a lot to TP and forestry lands to TN.

Key words: Miyun Reservoir; non-point source pollution; watershed

Introduction

Non-point source (NPS) pollution commonly exists in the world. With the enhancement of point source pollution control, the detrimental effects of non-point source pollution have become prominent. NPS of sediments and nutrients, primarily in agricultural runoff, have been identified as the major cause of surface water quality degradation. NPS discharge from agricultural lands in the United States contribute about 46 % of the sediment, 47 % of the total phosphorous (TP) and 52 % of the total nitrogen (TN) to surface water (EPA, 1983). Many models based on the Geographic Information System (GIS) have been proposed (Gilliland et al., 1987; Young et al., 1989, Tim et al., 1992; He et al., 1993).

China’s agriculture is conducted at a high fertilizer application rate in order to support its large population. Large amounts of fertilizer enter into the runoff, especially in summer times with heavy rainfalls. In addition, water/soil erosion and the application of pesticides also make the NPS pollution become more and more serious. The Miyun Reservoir is the most important

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source of drinking water in Beijing. It is situated at Miyun County, within the northern mountain area of Beijing. The water surface area is 188 km². Its upper-reach watershed, covered by two main rivers (the Chaohe River and the Baihe River) and five seasonal rivers, winds through nine counties of Beijing and Hebei Province. The total area of the watershed is 14871 km² (The area of watershed in Miyun County is 1400 km²). Due to the strict control over point source pollution by forbidding the existence of any kind of plants in the second-order protecting areas, nitrogen and phosphorus are mainly derived from non-point sources and eutrophication trend has become an important factor affecting the water quality of the Miyun Reservoir. The water quality of the Miyun Reservoir is at the primary mesotrophic stage. Many studies have focused on the water body of the Miyun Reservoir (Song Fu et al., 1986; Wang Xiaoyan, 1997, 1999; Cheng et al., 1998). Yu (1985) was the pioneerer in this field and she pointed out that non-point sources contributed significant percentages of such pollutants as TN (26%) and TP (53%) to the Miyun Reservoir by using USLE Equation. Song Fu et al. (1995) have estimated the relations among soil type, land use, slope and erosion, and pollutant loss of a few areas in Miyun County with the modified CREAMS Model. Bao Quansheng et al. (1997) estimated the percentages of non-point source pollutants such as TN (66%) and TP (86%) on the basis of the hydrological data. So it is necessary to assess the origin and distribution of the non-point source pollutant loading in the upper-reach watershed.

The watershed in Miyun County as the study area is divided into 73 catchments with a total area of 1400 km² (see Fig. 1). The hilly area (elevations are from 150 m to 400 m) is up to nearly 74.8% and the mountain area (elevations are from 400 m to 800 m) is about 4.9%. Agriculture, forest and grass are the three major land-use types in the watershed, accounting for 20.4%, 39.2% and 33.0% of the total land area, respectively. The region has a typical continental climate. An average annual precipitation amounts to 660 mm, with 76.5% usually falling from July through September. Major soil series on the watershed are brown earth and umber (Water Soil Protecting Station of Miyun County, 1993).

Based on our investigations, it is suggested that non-point source pollution is caused by the following factors: (1) loss of nutrients from chemical fertilizers. As viewed from statistics on fertilizer usage in different counties and the loss ratio of fertilizers, it is assumed that the loss of nitrogen is 442.5 t/a and phosphorus 10.46 t/a (Oyang et al., 1996); (2) pollutants of animal wastes. Based on the monitoring results of Environmental Protecting and Monitoring Center of Beijing, of them, BOD 12447 t/a, COD 15106 t/a, TN 2065 t/a and TP 820 t/a; and (3) soil erosion. The area of soil erosion comes up to 57.3% of the total area. The annual amount of soil erosion is 1940967 t. It is the general picture of non-point source pollution (Water Soil Protecting Station of Miyun County, 1993).

**Methods**

Based on the achievements in water/soil conservation in Miyun County, 4 catchments and 26 experimental units were used to monitor the precipitation, runoff, loss of sediment and pollutant content associated with various land uses. TN and TP in runoff and sediment were analyzed. Pollutant loading in runoff and sediment is worked out from equation groups (1) and (2), respectively.

(1) \( Q_i = R_i \times S_i \times 10^{-4} \), \( T_{sij} = 0.01 \times Q_i \times C_j \), \( T_{sj} = \Sigma T_{sij} \)

- \( Q_i \): Surface runoff amount on the type i land-use areas (\( \times 10^3 \) m³);
- \( R_i \): Average runoff depth (m);