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Nitrogen budgets of agricultural fields of the Changjiang River basin from 1980 to 1990

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Abstract

To assess the fate of the large amounts of nitrogen (N) brought into the agricultural environment by human activities in the Changjiang River basin, we used [China's county level agricultural database of 1980 and 1990. National Resources and Environmental Data Center, China] and published conversion data to set up a complete N budget for the Changjiang River basin. Sources considered include imported N such as atmospheric deposition, inorganic fertilizer, biological fixation and manure. Dominant losses considered include crop harvests, denitrification of soil nitrate and NH_3 volatilization, and the budget was estimated from the difference between all inputs and all outputs. Therefore, the geographic distribution of excess N, considered as lost, by N storage in farmland and N transported to water bodies in Changjiang River basin was analyzed.

In the Changjiang River basin, the anthropogenic reactive N has far exceeded the terrestrial bio-fixed N in nature, and human activities have significantly altered the N cycle in this region. The total inputs of N in 1980 and 1990 were 8.0 and 12.9 Tg N, respectively. The total N outputs are 4.41 Tg N in 1980 and 6.85 Tg N in 1990. Thus, the excess N that was stored in farmland was 1.51 Tg N at 1980 and 2.67 Tg N at 1990, respectively, and losses through transportation to water bodies in 1980 was 2.08 and 3.38 Tg N in 1990, respectively. Our research shows that from 1980 to 1990, cultivated land increased 5.9%, grain production increased 30% and N fertilizer-use increased 106%, but the N fertilizer-use efficiency decreased 36%, and the variations in the distribution of N fertilizer-use efficiency, N budgets and N transport to water bodies tended to coincide with each other geographically.

Keywords: Nitrogen; Inputs; Outputs; Budgets; Agricultural field; Changjiang River basin

1. Introduction

Nitrogen (N) is a key element in intensive agricultural systems that rely on high inputs of N fertilizers to

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achieve sufficient yields (Høyås et al., 1997). In the agricultural N cycle, there is often a substantial discrepancy between input and output of N. Surplus N is deposited in the agricultural soil or transferred to water bodies through runoff and leaching, and induces considerable changes in the ecosystem of the aquatic and coastal environment such as enhanced eutrophication and frequent harmful algal blooms (Zhang et al., 1999). In addition, modern agricultural activities have a large impact on global atmospheric environmental pollution. About 85% of ammonia (NH_3), 81% of N_2O and 35% of $NO+NO_2$ originate from agricultural activities (Krafenbauer and Wriessning, 1995). The research of Xing (1998) also suggested the added N from agricultural activities will contribute to increased nitrous oxide emissions from land, rice paddies and rivers.

Agricultural contributions to N loads in watersheds are of interest because of local contamination of water for drinking, aquatic ecosystems and regional effects of N loads on nutrient balances in the marine and estuary systems into which these streams flow. Eradication of N contamination of local and regional aquatic systems by agriculture will require a comprehensive understanding of how N is processed in agricultural systems.

The Changjiang River is ranked third in length and is the largest river in terms of water discharge over the Euro-Asian continent. The drainage basin of the Changjiang supplies 5–10% of the total world population with water resources and nutrition and irrigates 40% of China's national crop production (Zhang et al., 2003). Moreover, the materials carried by the Changjiang River have a significant influence on the coastal environment. Especially with the rapid development of the economy and increases in population, the Changjiang River basin has been and continues to be significantly affected by human activities. As a result, the aquatic ecosystems in this area and in the East China Sea will be seriously affected.

It is crucial to understand the mechanisms controlling the watershed-scale N budget. For this purpose, we used county-level agricultural statistical data to estimate N input, output and budgets in China's Changjiang River basin for 1980 and 1990 to provide geographical distribution maps of the items mentioned above.

Several studies have addressed different aspects of nutrient pollution in the Changjiang River basin. Zhang et al. (1999) and Liu et al. (2003) analyzed the nutrient conditions in the main stream of the Changjiang and its 15 largest tributaries based on field expedition data of N and phosphorus (P). Xing and Zhu (2002) estimated the N inputs and outputs for China as a whole and its 3 main river valleys, including the Changjiang River basin using statistical data. Yan and Zhang (2003) analyzed the relationship between N inputs, river nitrate concentration and N output at the outlet of the Changjiang for 1968–1997. Shen et al. (2003) estimated the various sources of N and its transport to the mouth of the Changjiang River basin based on field investigations, rain sampling, historical and literary data of this area. However, none of these studies has involved, or they have only involved slightly, aspects of agricultural N budgets and its geographical distribution. This kind of research is very important to the Changjiang River basin, mainly because management of excess N requires knowledge of the structure and geographic distribution of N sources, losses and budgets. The study described in this paper differs from previous studies. The purpose of this paper is to provide an analysis of changes and the geographic distribution of N budgets, N fertilizer-use efficiency and N transport to water bodies covering all the agricultural fields of the Changjiang River basin based on county-level data. Non-agricultural sources, municipal and industrial, were not included, mainly due to the lack of systematic data in the 1980s.

2. Study area

The Changjiang River (Fig. 1) is the largest outflowing river in China. It embraces an area of 1.81×10^6 km^2 (Table 1), with its main stream being 6.38×10^3 km long. The river runs through 18 provinces. Its middle and lower reaches stretch from east to west through the subtropics in the central and northern parts, where the annual precipitation averages 1.05×10^3 mm. The average annual runoff of the Changjiang River into the East China Sea is about 9.79×10^{11} m^3. The human population in 1990 was approximately 3.78×10^8, of which 3.18×10^8 was rural; the rural population accounted for 84% of the total population of 1990. Approximately 12.6% of the basin land was arable in 1990. The Changjiang River basin is one of the most densely populated and