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Nitrogen and phosphorus losses from agricultural systems in China: A meta-analysis

Di Cao, Wenzhi Cao *, Jing Fang, Longyan Cai

State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiang'an District, Xiamen, Fujian 361102, China

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ABSTRACT

Studies worldwide have indicated that agricultural pollution is the main source of nitrogen and phosphorus (N and P) in surface waters. A systematic understanding of N and P sources and sinks in agricultural systems is important for selecting the appropriate remedial strategies to control nutrient losses and water pollution. Based on nationwide data and a long-term monitoring program in Southeast China, the nationwide spatial and temporal patterns of N and P losses and the relationships between such losses and N and P inputs and rainfall were analyzed. The results showed that the annual nutrient losses from agricultural systems in China strongly varied, and the N/P values ranged from 0.01 to 51.0, with a majority at approximately 0–20, and an arithmetic mean of 9.73; these values mostly overlap the suitable range of N/P (6–15) for red bloom algae.

1. Introduction

In recent decades, human activities have increased the availability of nutrients such as nitrogen (N) and phosphorus (P) in ecosystems Sundareshwar et al., 2003. Undoubtedly, a relationship exists between algal blooms and the N and P load of freshwater and coastal waters. There has been mounting evidence from around the world to suggest that coastal marine phytoplankton blooms have increased in frequency, intensity and geographic distribution (Hodgkiss and Ho, 1997). In China, the excessive use of commercial inorganic fertilizer to increase crop yield and meet the demand of a growing population has resulted in increased N and P additions (China Statistical Yearbook, 2008) and subsequent losses (Xing and Zhu, 2000), accelerated freshwater and coastal water eutrophication and has led to chronic hypoxia, reductions in species diversity and stressed fisheries resources. More than 50% of the N and P from agricultural diffuse pollutions contributes to surface water pollution in the Netherlands, Denmark and the USA (Kronvang et al., 1996; Boers, 1996; USEPA, 1995). Such pollution accounts for the majority of contributions to the total N and total P from agricultural diffuse pollution to the five largest freshwater lakes in China (Zhang et al., 2004). Thus, surplus nutrient loading is a challenge both for ecosystems and humans, with anthropogenic activities changing nutrient cycles and the atomic ratios among the major limiting nutrients (e.g., Si:N:P) Justić et al., 1995; Shen, 2001.

Nationwide data on agricultural nutrient losses caused by surface runoff and long-term monitoring in an agricultural system in Southeast China are collected. Our objectives were to (1) identify certain key factors that influence N and P losses from agricultural systems at a state scale; (2) characterize nutrient losses and their dynamics from agricultural systems at a state scale; and (3) build a baseline of information on N and P losses for use in areas without monitoring and data.

2. Materials and methods

The spatial and temporal patterns of N and P losses and the relationships between these losses and environmental factors were analyzed based on nationwide data on agricultural nutrient losses from 300 formally published papers (from 1993 to 2013) along with long-term monitoring conducted for this study in an agricultural system in Southeast China. All of the collected nutrient losses were caused by surface runoff rather than subsurface runoff or leaching into the groundwater. Surface runoff and drainage are major exports from agriculture systems to surface water, especially in rice field wetland systems, which comprise the main land use type in the high-product agricultural watershed in China (Sun et al., 1999). Paddy fields, vegetable fields and mixed land uses are included in our database; however, the available data for these land use types are insufficient. Nationwide spatial and temporal patterns of N and P losses and the relationships between these losses and N and P inputs and rainfall were analyzed. In the preprocessing phase, all of the TN and TP values were measured as the atomic mass of N and P, respectively, in standardized units of

* Corresponding author. Tel.: +86 5922185877.
E-mail addresses: caodi@stu.xmu.edu.cn (D. Cao), wzcao@xmu.edu.cn (W. Cao).

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kg ha^{-1} yr^{-1}. The geographical distribution of the data set covers most of the primary farming areas of China (102.41–127.50°E; 19.50–48.67°N). The data were statistically treated with a normal distribution test (for example, the Kolmogorov–Smirnov test), ANOVA and a correlation test using SPSS software. Subsequently, the frequency charts of each trait were constructed.

Generally, the event mean concentrations (EMCs) are the flow-weighted average concentrations of a contaminant over the duration of a single storm event, which is the standard parameter for quantifying the net effect of events (Huang et al., 2006). The site mean concentration (SMC) value is representative of the distribution of the EMCs encountered during a given period of time (Mourad et al., 2005). More than twenty storm events were collected to estimate the EMCs and SMC values (unit, mg/L) in areas of typical land use (rice paddy field, vegetable and dry land and mixed land use).

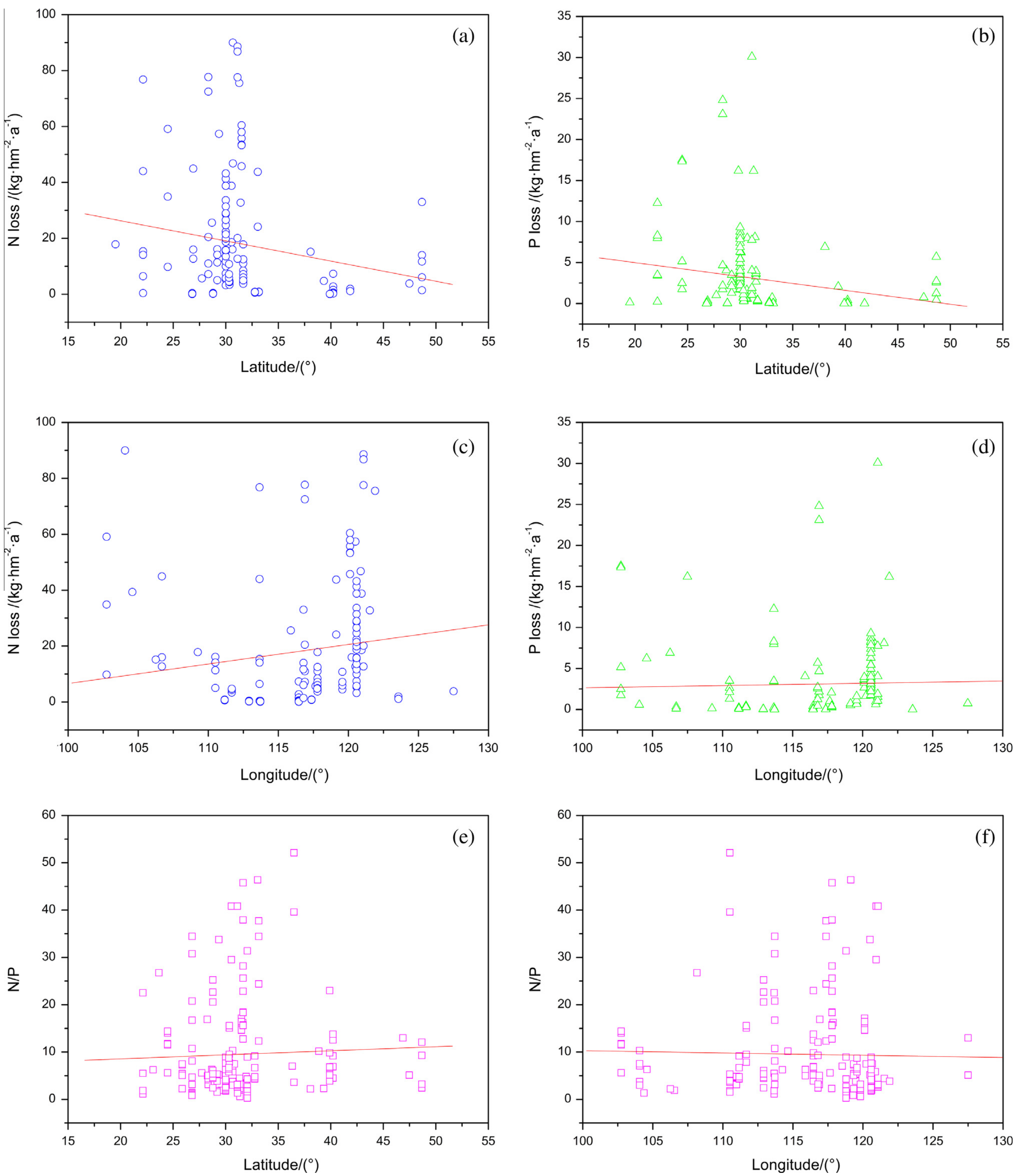

Fig. 1. Relationships between N and P losses and N/P values and latitude or longitude.