Science of the Total Environment 553 (2016) 607–616

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Combined impacts of precipitation and temperature on diffuse phosphorus pollution loading and critical source area identification in a freeze-thaw area

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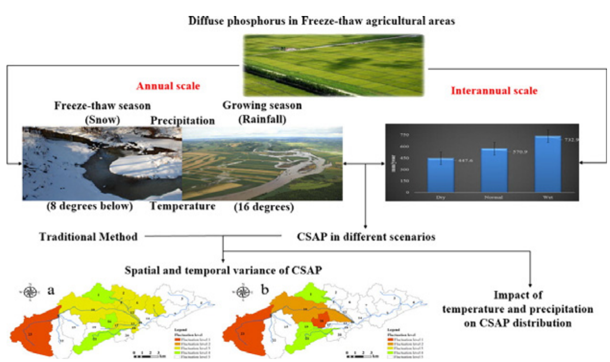
HIGHLIGHTS

- Features of phosphorus (P) loss and critical source areas of P (CSAP) were assessed.
- A modified method of CSAP identification in the freeze-thaw area was introduced.
- Spatial-temporal variances of CSAP in the freeze-thaw area were highlighted.
- Impacts of temperature and precipitation on CSAP distributions were elaborated.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 23 December 2015
Received in revised form 18 February 2016
Accepted 19 February 2016
Available online 22 March 2016

Editor: D. Barcelo

Keywords:
Freeze-thaw area
Diffuse phosphorus pollution
Critical source area
Temperature
Precipitation

ABSTRACT

The loss of diffuse phosphorus (P) presented different characteristics in the freeze-thaw area due to the combined impacts of precipitation and temperature, which caused spatiotemporal variations of the critical source area of diffuse P (CSAP). The temperature and precipitation classification (TPC) method was proposed to identify the spatiotemporal characteristics of the CSAP in the cold area, and each year was divided into a freeze-thaw season and a growing season according to the average monthly temperature. The Soil and Water Assessment Tool (SWAT) provided the spatiotemporal patterns of the diffuse P loads. The years were also reclassified into dry, normal and wet years according to the annual precipitation levels. The CSAP with the 1st cumulative load level shared 9.68% of the same area between the two seasons, which had dry land as the dominant land use with direct P fertilization. The spatial distributions of the potential areas and the CSAP with the 2nd cumulative load level were more sensitive to the variation in temperature, which had 30.8%–46.1% of unvaried area between seasons. The cumulative load level analysis indicated that 14 subbasins in the freeze-thaw season and 7 subbasins in the growing season, which covered 61.2% and 48.6% of the total basin area, respectively, changed with the traditional CSAP identification among dry, normal and wet years. The fluctuation level analysis was carried out to compare the distributional difference of the CSAP and the potential areas between the TPC method and the traditional method, which highlighted the advantages of the TPC method. The results would be useful in identifying the distribution of the CSAP in cold areas, which improved the efficiency of diffuse pollution control.

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http://dx.doi.org/10.1016/j.scitotenv.2016.02.138
0048-9697/

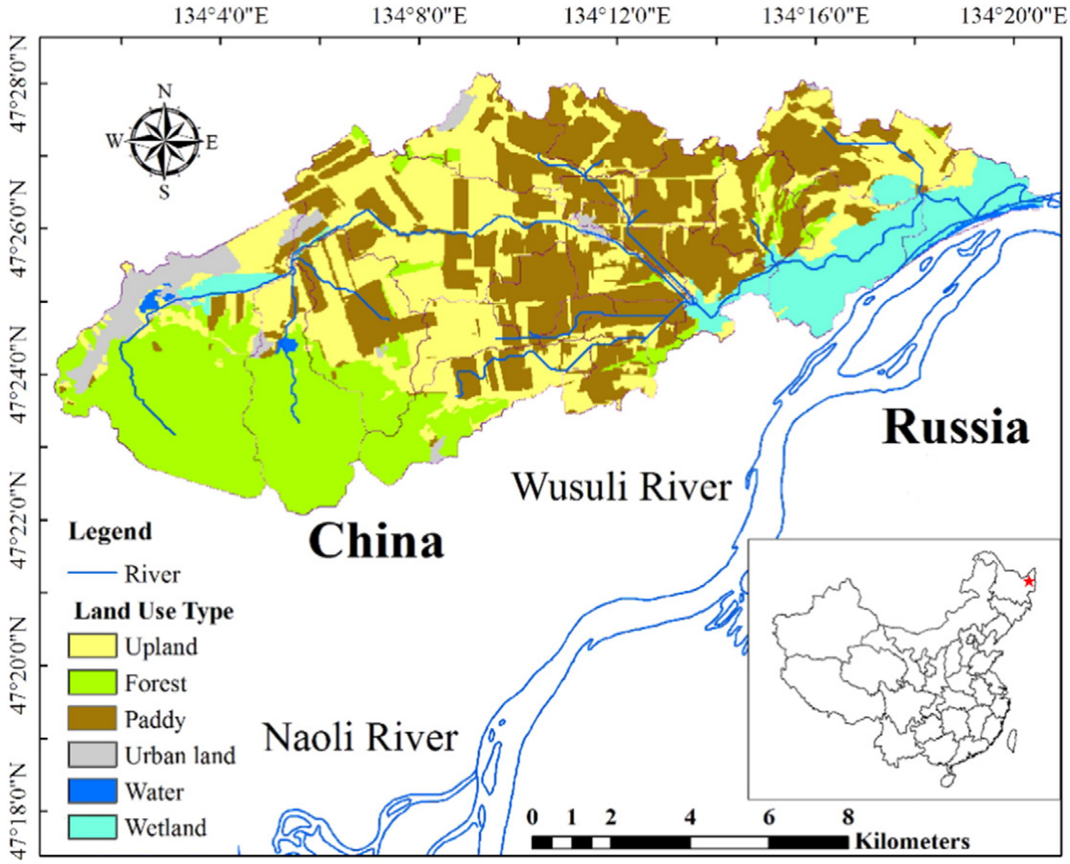

Fig. 1. Location of the study area in northeastern China.

1. Introduction

Hydrological processes are the driving force for the formation and transformation of diffuse agricultural pollutants (Mishra and Kar, 2012), which are critical factors in aquatic environment quality. In freeze-thaw areas, hydrological processes have different patterns with seasonal variations of temperature and precipitation on both spatial and temporal scales (Cheng et al., 2014). These complicated hydrological processes are not only increase the uncertainty of diffuse pollution discharge into water bodies, but also challenge the identification of

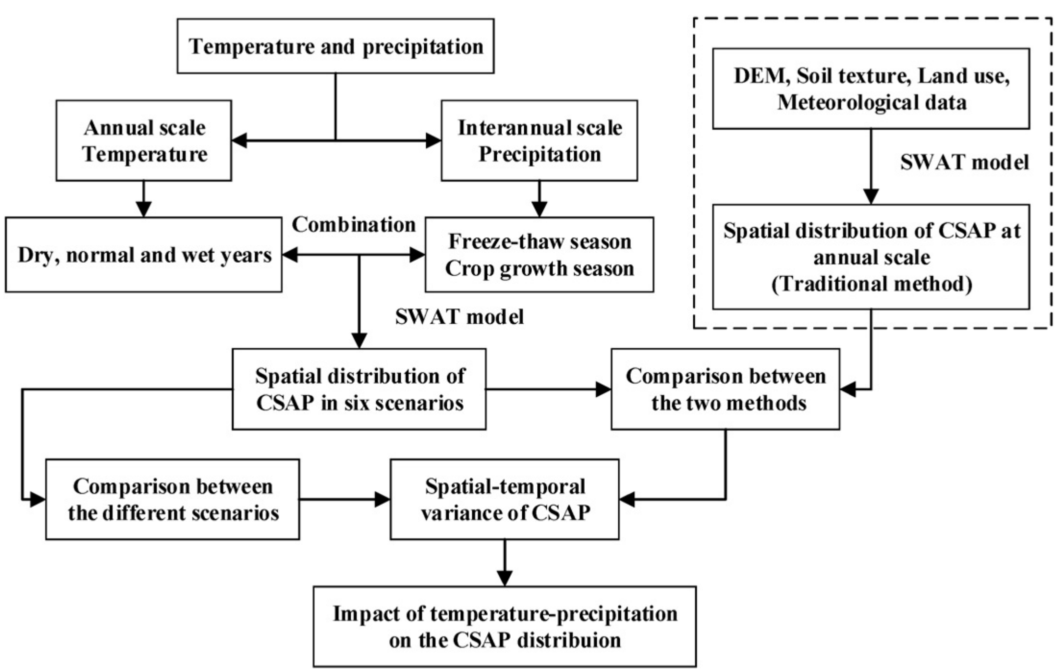

Fig. 2. The framework of the TPC method for evaluating the CSAP in the freeze-thaw area.