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REVIEW ARTICLE

Effects of acid deposition control in China: a review based on responses of subtropical forests

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HIGHLIGHTS

- S and N leaching from forest soils declined due to recent decreases in anthropogenic S and N emissions in China.
- Streamwater chemistry recovery was delayed by at least 5 years after peak S and N deposition.
- N_2O–N emission are particularly high in (sub)tropical forests and may amount to 8% of total N deposition from the atmosphere.
- N_2O emissions from forest soils declined with reduction in N deposition.

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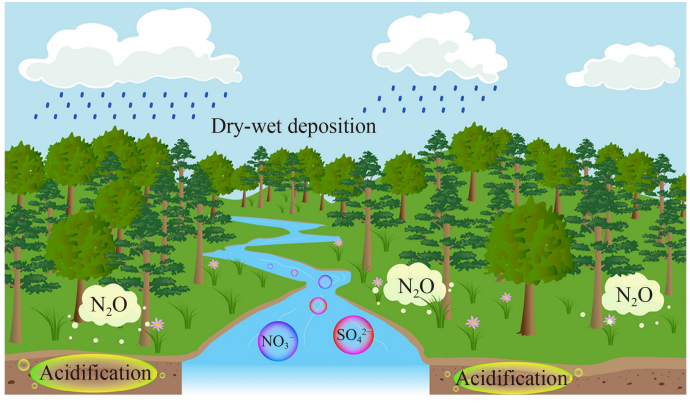
GRAPHIC ABSTRACT



ABSTRACT

For many decades, acid deposition used to pose a significant regional air pollution challenge in China. After substantial emission control of anthropogenically derived sulfur and nitrogen containing gasses, both sulfur and nitrogen deposition, as well as the acid rain-affected area, have significantly decreased compared to their peak levels. Forests, particularly in the humid subtropics, are sensitive to acid deposition, as evidenced by soil acidification, sulfate and nitrate leaching in stream water, and elevated soil nitrous oxide emission. Reduction in the total deposition of sulfur and nitrogen, caused a significant decline in sulfate and nitrate leaching from subtropical forest and subsequently in sulfate and nitrate concentrations in stream water, although there was about a 5-year delay. This delay may be attributed to the desorption of accumulated sulfate and continued elevated mineralization of accumulated nitrogen pools. Emissions of nitrous oxide, a potent greenhouse gas, also declined in nitrogen-saturated subtropical forest soils, as soil water nitrate concentration decreased. Therefore, subtropical forests in China suffering from elevated acid deposition have begun to recover. Yet, the current levels of sulfur and nitrogen deposition continue to exceed the critical loads, i.e., the assigned threshold levels in accordance with emission control policies, in more than 10% of the country's land area, respectively, indicating remaining risks of acidification and eutrophication. Thus, further emission reductions are urgently needed, also because they will help achieving goals related to air quality and nitrous oxide emissions.

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Special issue—Towards a pollution-free planet

1 Changes in sulfur and nitrogen emissions and their deposition in China over the past four decades

Atmospheric deposition of sulfur (S) and nitrogen (N), including dry and wet forms, onto the earth's surface remains a major environmental concern (Galloway et al., 1987). Wet deposition of sulfuric acid and nitric acid, generally called acid rain, refers to the precipitation with a pH of less than 5.6. The primary acidifying gasses responsible for atmospheric acidic pollutants are sulfur dioxide (SO_2), and nitrogen oxides (NO_x). Although ammonia (NH_3) neutralizes acidity in rainwater due to the formation of ammonium (NH_4^+), significant acidification occurs in the soil due to NH_4^+ assimilation and nitrification (Liu et al., 2019; van Breemen et al., 1983). Globally, Europe, North America, and subsequently East Asia (particularly southern China) were the three largest acid rain regions, of major environmental concern (Duan et al., 2016). Acid deposition has the potential to erode artifacts and building materials directly, as well as damage crops and trees. In terrestrial ecosystems, it can indirectly lead to acidification and eutrophication of soil and surface water, as well as to the release of nitrous oxide (N_2O) (Duan et al., 2016). N_2O is a potent greenhouse gas with a long residence time in the troposphere, while also contributing to the destruction of stratospheric ozone (Ravishankara et al., 2009). With the regulation of emissions of acidifying gasses, natural ecosystems in Europe and North America are showing recovery from high acid loads (Gilliam et al., 2019; Schmitz et al., 2019). In comparison, the control measures in China began approximately 20 years later than those in Europe and North America. Also in China significant ecological benefits have been achieved in recent years (Duan et al., 2016; Xie et al., 2021, 2024). Here, we review the estimated emissions and deposition of S and N in China during the last four decades, based on monitoring and modeling, and evaluate the effect of emission control based on the responses of forest soils and stream waters to acid deposition, supporting policymaking, targeting integrated prevention and control of atmospheric pollution and forest management.

China has conducted extensive research spanning nearly four decades investigating anthropogenic emissions and atmospheric deposition of S and N including monitoring distribution characteristics, formation mechanisms, ecological impacts, and control policies (Yu et al., 2021). From the early 1980s to about 2007, frequent periods of heavy pollution of acid rain were common. The national average pH of precipitation declined to 5.18 at its most severe, with localized areas of highly acidic rainfall were observed in south-central, central, and eastern China, and significant declines in pH were also recorded in northern China (CMA, 2023). After 2007, a significant increase in the national average pH of precipitation was observed, reaching a value of 5.91 in 2019 (CMA, 2023). Notably, the ongoing improvement is expected to persist as continued stringent control measures were implemented for SO_2 and NO_x emissions.

China's national S and N deposition trends align with those of emission of SO_2 and NO_x (Fig. 1). In China, SO_2 emissions increased from 1980 to 2005 (Fig. 1A), along with the increase in coal consumption (Zheng et al., 2018; Zhao et al., 2022). Meanwhile, NO_x emissions increased significantly from 1980 to 2011 (Fig. 1A), due to a rapid increase in energy consumption and vehicle ownership, while NH_3 emissions increased by 94% from 1980 to 2015 (Fig. 1A), due to the increase in fertilizer use and animal production (Zheng et al., 2018). Along with the rapid increase in SO_2 and NO_x emissions around the turn of the century, China became a global hot spot for both S and N deposition (Vet et al., 2014; Tan et al., 2018; Ackerman et al., 2019). Associated with increased S emissions, wet deposition increased significantly from 1992 to 2006 (Fig. 1B), while simulated total S deposition (mainly as sulfate, SO_4^{2-}; using the generalized additive model, GAM; Zhao et al., 2022) reached 9.09 Tg S in 2005 (Fig. 1D), with high S deposition observed in eastern and south-western China (Fig. 2). High N deposition was predominantly found in southern and eastern China, reaching a peak of 11.7 Tg N in 2010. Wet deposition of NH_4^+ increased slightly from 1990 to 2015, while that of nitrate (NO_3^-) peaked already in 2010 (Fig. 1B). However, the simulated exceedance of total NH_4^+ deposition over total NO_3^- was consistent (Fig. 2).

Since the implementation of new policies to curb emission of air pollutants (e.g. Total Emissions Control of Air Pollutants and later the Action Plan of Air Pollution Prevention and Control policies in China), SO_2 emissions decreased by 82% between 2005 and 2020. For NO_x, emissions declined by 40% from 2010 to 2020, and for NH_3 by 19% from 2015 to 2020 (Zhao et al., 2022). Subsequently, S and N deposition decreased, whereas a time delay existed as a consequence of increased precipitation levels (Zhao et al., 2022). National wet and total deposition of S had decreased significantly after 2006, with a total S deposition of 5.39 Tg S in 2018 (Fig. 2). Specifically, there was a notable decrease in S deposition in eastern China, whereas it remained elevated in south-western China. A significant decrease in total NO_3^- deposition was observed from 2010 to 2018 (3.50 Tg N in 2018). Meanwhile, total NH_4^+ deposition experienced only a slight decline from 2015 to 2018 (Fig. 2).

Forests, covering approximately 23% of the land area in China, are relatively sensitive to acidification (FAO, 2020; Huang et al., 2015). The elevated S and N deposition of forests in China was reported via long-term monitoring of bulk deposition (wet deposition plus a part of dry deposition) and throughfall (representing total deposition, including dry deposition and wet deposition)

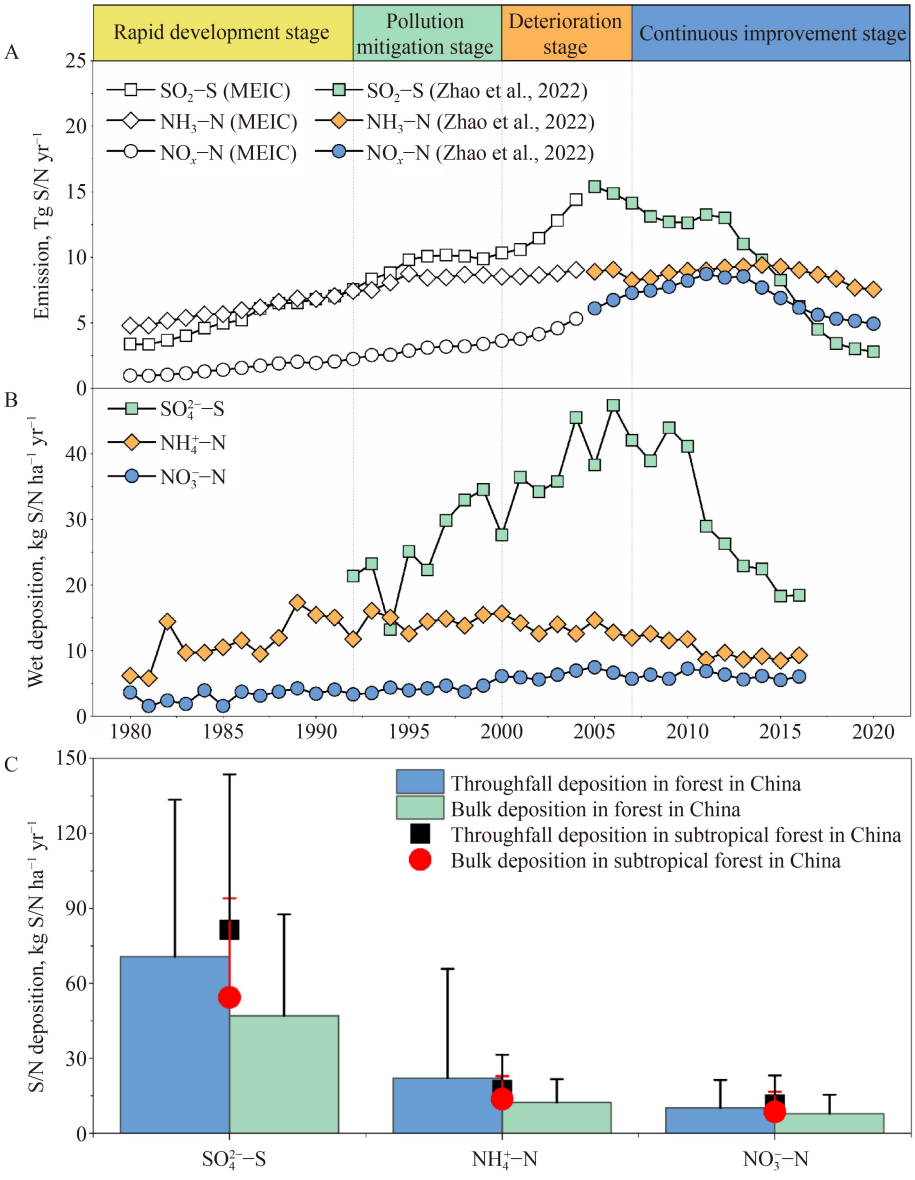

Fig. 1 Average annual emissions of SO_2–S, NO_x–N, and NH_3–N (A), average annual wet deposition fluxes of SO_4^{2-}–S, NO_3^-–N, and NH_4^+–N in China wet deposition (B), and bulk and throughfall deposition fluxes in forests in China, both at the national scale and in the sub-tropics (C). Emission data from 1980 to 2004 are from MEIC (Zheng et al., 2018), and it from 2005 to 2020 are from Zhao et al. (2022). Wet deposition of SO_4^{2-}–S is from Acid Rain Monitoring Network of China Meteorological Administration (CMA, 2023), and wet deposition of NO_3^-–N and NH_4^+–N are from the Nationwide Nitrogen Deposition Monitoring Network (Li et al., 2019; Wen et al., 2020). Bulk and throughfall deposition fluxes in forests in China are from Du (2018).

at 56 forested sites (Fig. 1C). Both bulk and throughfall S and N deposition in subtropical forests in southern China exhibited higher levels compared to the average deposition in forests across China (Fig. 1C). The average fluxes of SO_4^{2-}, NH_4^+, and NO_3^- in bulk deposition in subtropical forests were 54.4 kg S ha^{-1} yr^{-1}, 13.7 kg N ha^{-1} yr^{-1}, and 8.59 kg N ha^{-1} yr^{-1}, respectively, while in throughfall these values were 81.4 kg S ha^{-1} yr^{-1}, 17.4 kg N ha^{-1} yr^{-1}, and 11.5 kg N ha^{-1} yr^{-1}, respectively (Du, 2018). Notably, the S and N deposition in forests exceed that in open fields due to enhancement of dry deposition in tree canopies. Because some of the deposited N may have been assimilated in the canopy, these fluxes may have not been underestimated so far (Kang et al., 2023).

2 Soil acidification and leaching of SO_4^{2-} and NO_3^- to surface waters are mitigated due to the reduction in acid deposition

Soil acidification is a natural process characterized by the leaching of base cations (such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), and sodium (Na^+)) and the subsequent increase in soil H^+ concentrations,

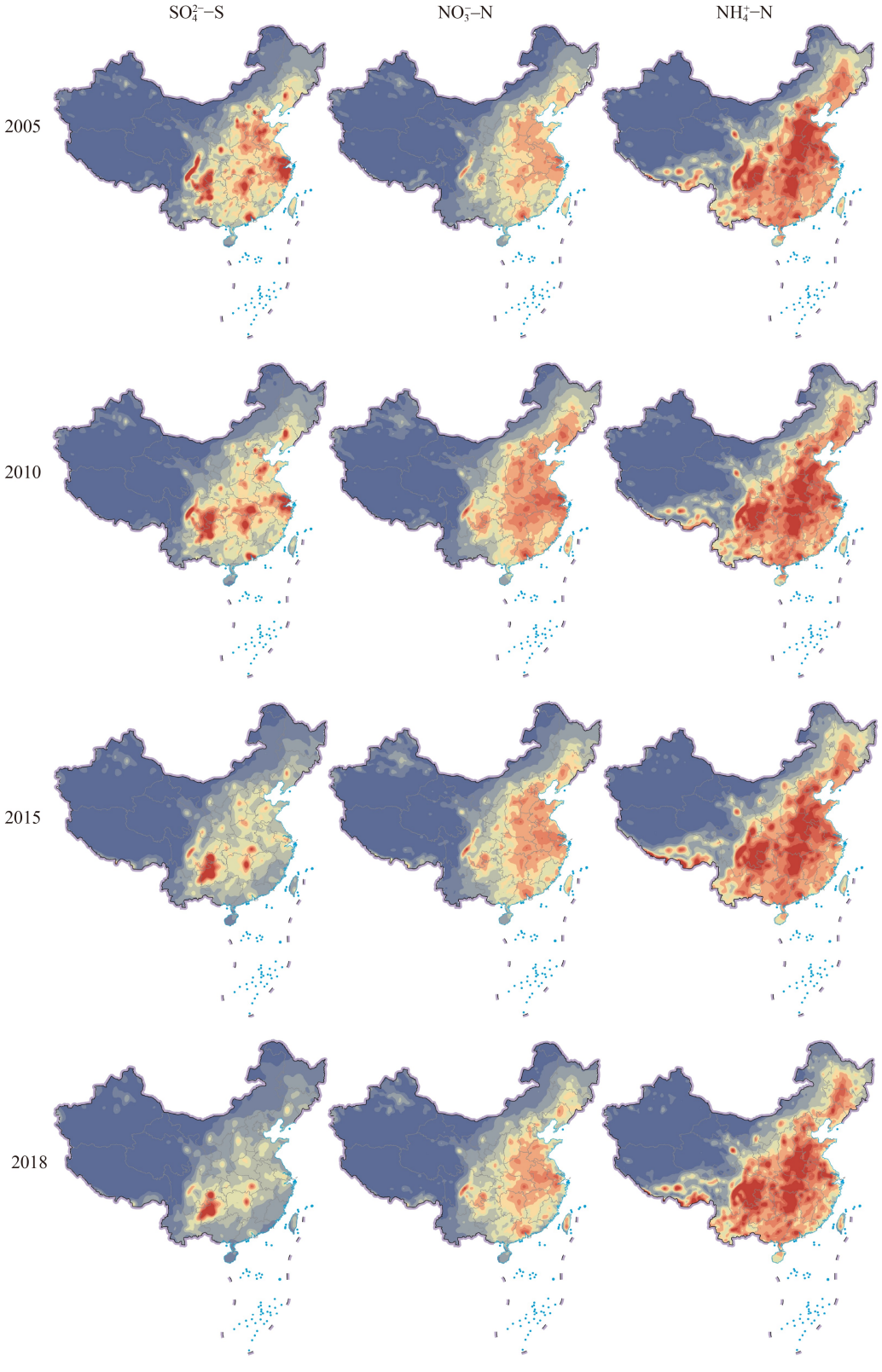

Fig. 2 Simulated total deposition of SO_4^{2-}–S, NO_3^-–N, and NH_4^+–N in China. Data are from Zhao et al. (2022).

leading to elevated soil acidity. At soil pH < 5, common after centuries long natural acidification of non-calcareous soils, the input of H^+ causes increasing dissolution and leaching of potentially toxic aluminum (Al) (Mulder et al., 1989; Mulder and Stein, 1994). Soil acidification typically occurs in regions with high precipitation compared to evapotranspiration and thus net leaching (van Breemen et al., 1983). Leaching of base cations gradually reduces the soil's pH and acid buffering capacity (Driscoll et al., 2006). Forests on non-calcareous soils are generally sensitive to acidification, primarily due to the low rates of mineral weathering which provide essential cations such as Ca^{2+} and Mg^{2+} (Greaver et al., 2012). Subtropical forests in China typically occur on highly weathered, acidic soils (such as Acrisols) (Seip et al., 1999). Elevated SO_4^{2-} and NO_3^- leaching promote the loss of base cations from such soil, ultimately resulting in relatively low soil pH and increased concentrations of dissolved Al (Larssen et al., 2011; Huang et al., 2015; Xie et al., 2018a). N transformation in soil, especially nitrification of NH_4^+ from atmospheric deposition, causes soil acidification, often even contributing more acidity than the actual H^+ deposited to the soil. In the Tieshanping subtropical forest, outside Chongqing city in southern China, these values were 2.03 keq ha^{-1} yr^{-1} and 0.76 keq ha^{-1} yr^{-1}, respectively, during the period 2001–2020 (Xie et al., 2021).

Soils characterized by elevated cation exchange capacity and base saturation have a greater capacity to buffer acid inputs at relatively high pH values (van Breemen et al., 1983). Soils with high mineral weathering rates are characterized by a high base saturation and are generally found in a pH buffering range well above 5 (Ulrich, 1983). However, in many sub-tropical forests of China, besides mineral weathering, also base cation deposition serves as a significant mechanism to neutralize acidic precipitation and strengthen the resilience of soil and surface water against acidification. A recent study showed that more than half of the acid inputs in four subtropical forests in southern China were neutralized by alkalinity associated with atmogenic Ca deposition, which effectively enhanced the soil's base saturation (Larssen et al., 2011). Elevated atmospheric Ca inputs, often derived from particle emissions from e.g., power plants, cement industry, and soil dust, are quantitatively less important in temperate forests in Europe and North America (de Vries et al., 2003; Watmough et al., 2014).

The deposited S and N undergo transformations and retention in the soil, thus providing a significant buffering mechanism against soil and surface water acidification in subtropical China. Specifically, adsorption and reduction of soil SO_4^{2-} as well as N immobilization in soil organic matter and denitrification of NO_3^- in deeper soil layers and in wet soils of groundwater discharge zones in near-stream environments are primary mechanisms of S and N transformation and retention in subtropical China (Huang et al., 2015; Yu et al., 2016; Yu et al., 2023). Fe- and Al-oxides, prominently present in well-drained, subtropical forests soils of southern China, are important sorbents for SO_4^{2-} (Yu et al., 2021). Besides SO_4^{2-} sorption, also reduction of SO_4^{2-} to sulfides (e.g., FeS, FeS_2) may provide a stable S sink. In the Tieshanping catchment SO_4^{2-} reduction was the found to be the main soil S sink, especially in wet soils of the groundwater discharge zone at the foot of well drained hill slopes (Yu et al., 2023). Sinks of S and N in subtropical southern China played a significant role and amounted to 77% and 92% of the atmospheric inputs, respectively (Yu et al., 2021). In contrast, net retention of S and N was less pronounced in temperate regions of Europe and North America, where nearly all deposited S is leached as SO_4^{2-} (Yu et al., 2021).

Leaching of SO_4^{2-} and NO_3^- in soils of subtropical forests in China rapidly decreased in response to the reduction in S and N deposition. Soil water SO_4^{2-} concentration showed a significant decreasing trend after the decline in S deposition at the Tieshanping catchment (Xie et al., 2018a). Similarly, the reduction in N deposition resulted in a rapid decline in soil water NO_3^- concentration. In a 10-year manipulation experiment adding NH_4NO_3 in a masson pine forested catchment at Tieshanping, less NO_3^- leached from the soil after cessation of the NH_4NO_3 addition (Xie et al., 2018a). At the long-term monioring plots at Tieshanping, a notable 66.8% decrease in the H^+ production, resulting from decreasing nitrification rates of atmospherically deposited NH_4^+, was observed following the reduction in N deposition after 2010. As atmospheric S deposition declined, soil SO_4^{2-} desorption occurred in the Tieshanping catchment, resulting in an average release of 2.20 keq ha^{-1} yr^{-1} of SO_4^{2-} to stream water during 2015–2020, significantly delaying the decrease in soil acidification rates (Xie et al., 2024).

Critical loads (CL), serving as the threshold of acid deposition, play a vital role in acid deposition control. CL is defined as a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge (Nilsson and Grennfelt, 1988). CL for soil and surface waters were mapped and updated in recent decades (Duan 2000a; 2000b; Lv et al., 2023; Ge et al., 2023), and applied in emission control policy in China (Yu et al., 2024). From the perspective of CL, the acid deposition control policies in China during 2005–2015 did not achieve as significant results as in Europe and North America (Yu et al., 2024). Although atmospheric inputs of acidity exceeding CL decreased from 157.8 Geq in 2005 to 117.4 Geq in 2015, the area of land exceeding CL actually increased from 15.9% to 16.3% (Fig. 3). In addition, both the area and total N deposition exceeding CL for eutrophication

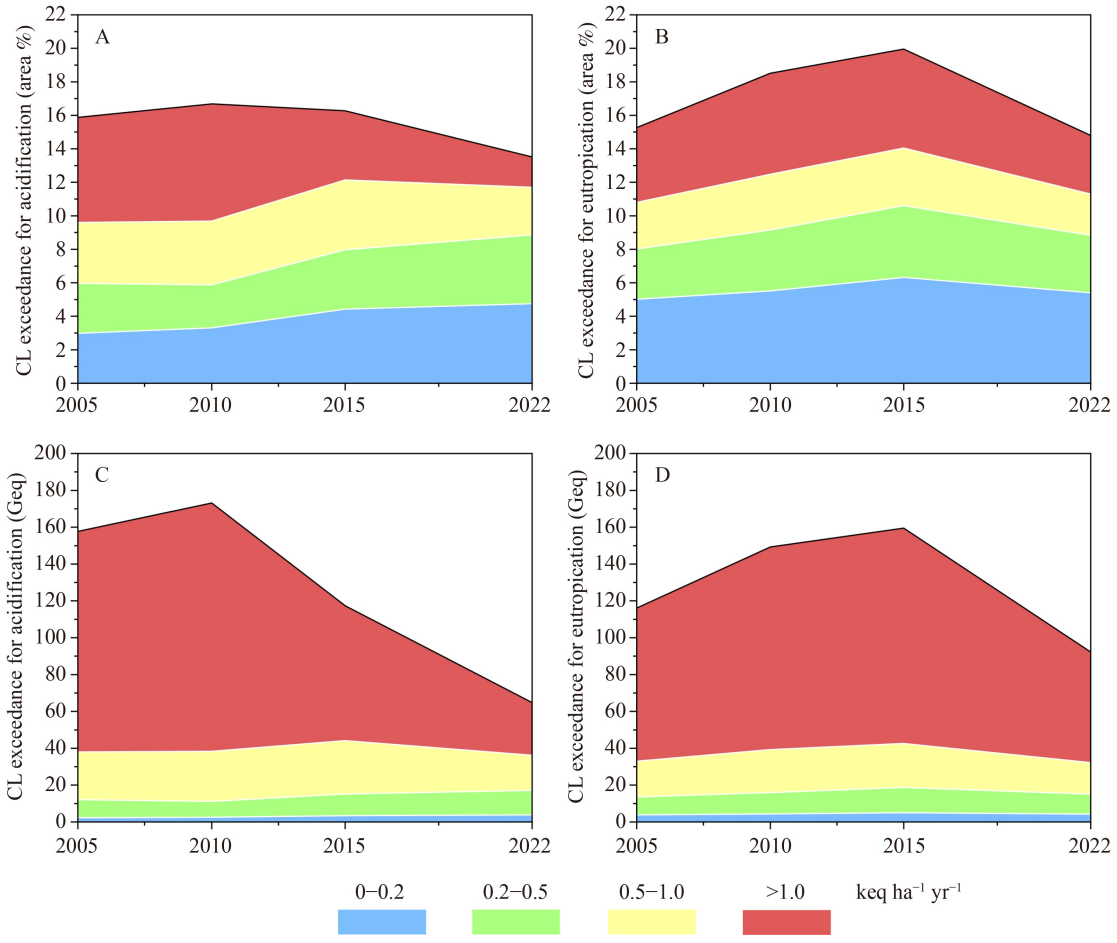

Fig. 3 Critical loads (CL) exceedance for soil acidification and ecosystem eutrophication with the changes in acid deposition in China from 2005 to 2022. Data are from Yu et al. (2024).

significantly increased, primarily due to the still ongoing rise in N deposition. However, from 2015 to 2022, when China implemented further emission reduction for both S and N also to meet air quality targets, both the area and the total rates of exceedance of CL, decreased significantly. At the national scale, exceedances for acidification and eutrophication decreased by 45% and 42%, respectively, in 2020 as compared to 2015. Despite this progress, 13.5% and 14.8% of the country's land area still experienced exceedance of CL of acidification and eutrophication, respectively (Fig. 3; Yu et al., 2024).

Surface water acidification was recognized as a major threat in Europe and North America (Stoddard et al., 1999). Its adverse impacts, including fish mortality, the inhibition of microbial activity (Xu et al., 2022), disruption of organic matter decomposition, and perturbations of the acid-base balance of phytoplankton (Cornut et al., 2012; Flynn et al., 2012), have attracted public and political attention. In contrast to Europe and North America, no surface water acidification damage was reported under continuous heavy acid deposition in China (Yu et al., 2017a). Large rivers and lakes did not exhibit a clear trend of decreasing pH probably because most surface waters have had longer residence times in soils, enabling enhanced acid neutralization (Hao et al., 2001; Ye et al., 2002; Duan et al., 2011). With shorter residence times and increased contributions of surficial, acidic runoff, small streams are more susceptible to acidification compared to large rivers (Lv et al., 2022). Especially after very high acid deposition around the turn of the century, a recent study showed that CL for acidification remain exceeded in approximately half of the monitored small streams (Fig. 4A) in subtropical China (Lv et al., 2022). This was found despite a significant buffering effect in the watersheds of the region involving elevated Ca deposition, SO_4^{2-} adsorption and denitrification (Yu et al., 2017a).

SO_4^{2-} and NO_3^- concentrations in surface water in south-western China decreased significantly by comparing it with historical levels (Figs. 4B and 4C). However, surface water concentrations of SO_4^{2-} showed a delayed response to declining atmospheric S deposition both in subtropical forested region in China (Xie et al., 2024). Similar observations were reoprted for temperate forested regions of Europe and North America (Stoddard et al., 1999; Rice et al., 2014; Vuorenmaa et al., 2018; Stelzer

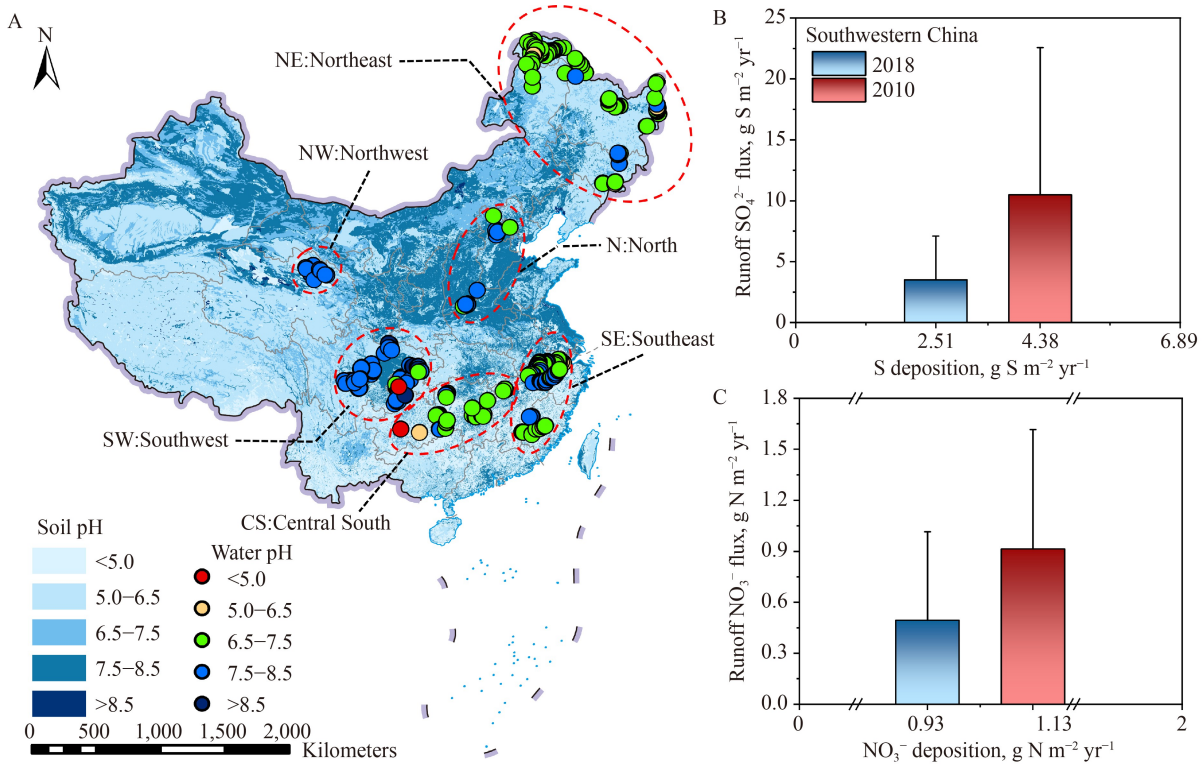

Fig. 4 Monitoring sites of stream water chemistry in China (A), The relationship between runoff SO_4^{2-} flux and S deposition (B), and the relationship between runoff NO_3^- flux and N deposition (C). The sampling sites of headwater streams are from Lv et al. (2023b); The 24 sites in North-west China are from alpine meadow, while the remaining 325 sites were from forest. The comparison of runoff flux is from stream water in south-western China (Xie et al., 2024).

et al., 2020). In China, the decline in surface water SO_4^{2-} concentration was delayed by approximately 5 years following the decline in S deposition, due to net soil SO_4^{2-} desorption (Xie et al., 2024). However, net SO_4^{2-} desorption gradually declined alongside the decline in S deposition eventually approaching zero (Xie et al., 2024), indicating attenuation of the effects of soil SO_4^{2-} desorption on surface water chemistry.

Also, NO_3^- concentration in surface waters of subtropical forested regions exhibited a 5-year delay in response to the reduction in N deposition (Xie et al., 2024). N immobilization declined rapidly after N deposition decreased, while elevated N mineralization persists for a period of time (Xie et al., 2021). Consequently, a constant high level of soil NO_3^- leaching was observed, indicating a delayed response to recovery of surface waters. However, in regions where N deposition exceeded the CL threshold, surface water NO_3^- declined rapidly with decreasing N deposition. Conversely, in regions where N deposition was below or close to the CL threshold, surface water NO_3^- concentrations remained low and showed an insignificant reduction (Xie et al., 2024). This phenomenon has also been reported in temperate forested regions of Europe and North America (Bernal et al., 2012; Eshleman et al., 2013; Vuorenmaa et al., 2017; Ryan and Lawrence, 2024).

3 Nitrogen deposition significantly impacted soil N_2O emissions in forest in China

N_2O is a long-lived greenhouse gas with an atmospheric lifetime of 130 to 170 years (IPCC, 2013). Furthermore, N_2O is a significant pollutant contributing to stratospheric ozone depletion (IPCC, 2013, 2014). Over the past 30 years, tropospheric N_2O concentrations steadily increased at a rate of 0.73 ± 0.03 ppb yr^{-1} (IPCC, 2014). Significant quantities of N_2O are generated through soil processes (D'Amelio et al., 2009), contributing 70% of the total global emissions (Mosier, 1998). Soil N_2O emissions from agricultural land, and tropical and subtropical forests account for approximately 60%, 24%, and 14% of the global surface emissions, respectively (IPCC, 2021). It should be noted that the N_2O emissions from subtropical forest soils have received relatively little attention and collected data are primarily based on discontinuous, intermittent sampling methods. Consequently, the N_2O fluxes from subtropical forest soils are poorly constrained.

The increase in N deposition in forest ecosystems until about 2010, both as NH_4^+ and NO_3^-, may have caused a rise in soil N_2O emissions due to nitrification and denitrification (Firestone and Davidson, 1989; Kool et al.,

2011; He et al., 2020). Over the past four decades, several long-term monitoring studies and N manipulation experiments were conducted in forests of southern China (Fig. 5A), to quantify soil N_2O emissions and investigate influencing factors. Specifically, elevated soil N_2O emissions were observed in the N-saturated Tieshanping subtropical forest catchment, primarily during periods of elevated soil moisture and high soil temperatures. For instance, warmer temperature accelerates N mineralization and nitrification, while increased precipitation enhances soil moisture, with both factors promoting soil N_2O emissions (Zhuang et al., 2012; Zhu et al., 2013; Li et al., 2020a, b). In the Tieshanping forest in SW China, the N_2O emissions were significantly higher in years with wet summers (5.4 kg N ha^{-1} yr^{-1}) compared to years with drier summers (4.3 kg N ha^{-1} yr^{-1}) (Zhu et al., 2013). Peak N_2O emissions (up to 1800 ug N m^{-2} hr^{-1}) occurred shortly after rainstorms during the monsoonal summer, coinciding with the highest water-filled pore space (Zhu et al., 2013). Soil N_2O emissions increased with both increasing N input (Fig. 5C) and increasing NO_3^- concentration in soil water (Zhu et al., 2013; Xie et al., 2018b). In N addition manipulation experiments in the Tieshanping catchment, the N_2O fluxes in control plots were about half of those for the plots where N inputs were doubled either through the addition of NH_4NO_3 or of $NaNO_3$ (Liu et al., 2017; Xie et al., 2018b). In addition, pH also plays a crucial role in regulating soil N_2O emissions, as lower soil pH is associated with a higher product ratio of N_2O:N_2(Zhu et al., 2013; Buchwald et al., 2016; Liu et al., 2010, 2017; Wang et al., 2018). Further, a ^{15}N labeling experiment in the subtropical Tieshanping forest indicated that most the N_2O derives from denitrification rather than nitrification (Yu et al., 2017b). The ratio of soil N_2O–N emissions to N deposition (emission factor) in subtropical forests in China was found to range from 8% to 10% (Zhu et al., 2013), which is significantly higher than the value of 1% which is commonly used to estimate N_2O emissions (IPCC, 2021). Soil N_2O emissions in tropical forests under atmospheric N deposition in China reached the highest level at 1.81 kg N ha^{-1} yr^{-1} (average value from tropical forests in Fig. 5A), followed by subtropical forests with an average of 1.60 kg N ha^{-1} yr^{-1}, and finally temperate forests (average of 1.23 kg N ha^{-1} yr^{-1}). The ratios of soil N_2O emissions to N deposition for different forest types showed the same order as the absolute emission (Fig. 5B).

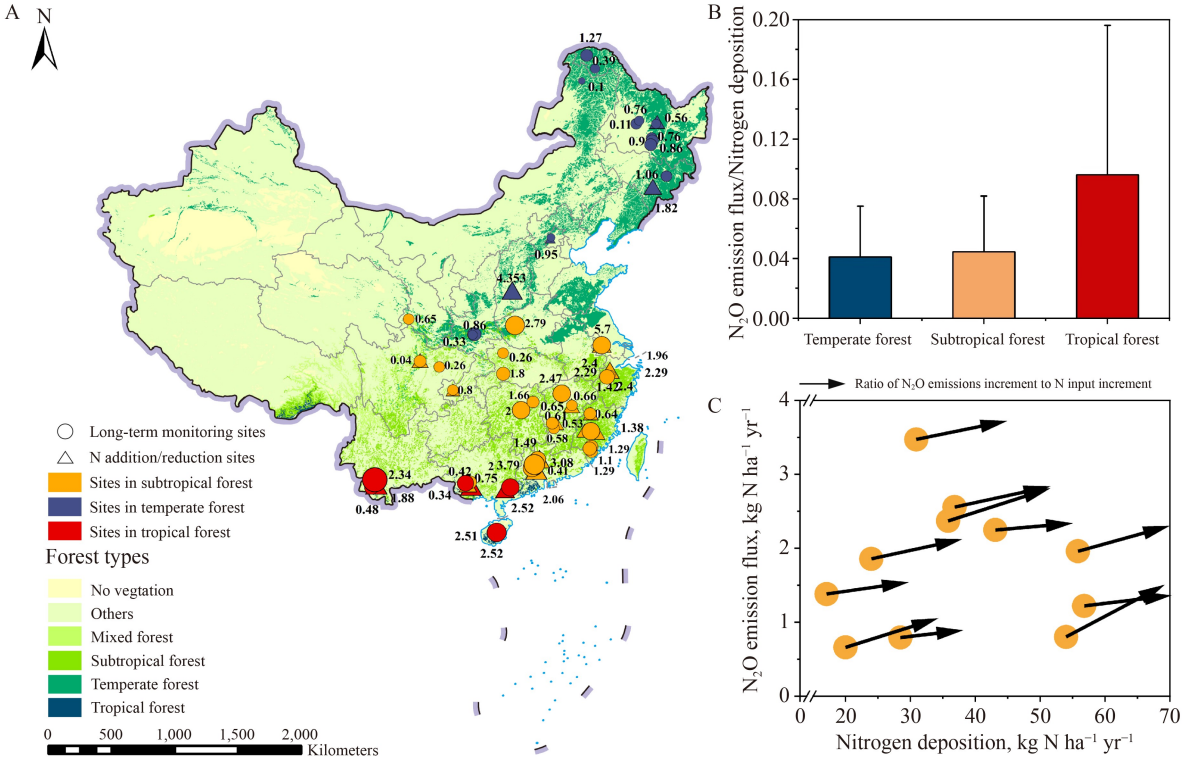

Fig. 5 Long-term monitoring and N addition manipulation experiments (A), Ratio of N_2O emission to total N deposition in forests in China (B), as well as the relationship between N_2O emissions and N input in subtropical forest sites (C). The number in A near each circle or triangle represent the soil N_2O emissions (unit: kg N ha^{-1} yr^{-1}) recorded from monitoring sites or control plots in the N manipulation experiment sites. A positive slope of the arrow in C indicates that N_2O emissions increase with increasing N input, while a negative slope indicates that N_2O emissions decrease with increasing N input. Data are from Du et al. (2024) and Li et al. (2020a).

N_2O emissions from forest soils is expected to decline as N deposition decreases. The response of soil N_2O emissions, following a decline in N deposition has been little studied in temperate forests in Europe and North America, possibly due to their comparatively lower soil N_2O emissions (Eickenscheidt et al., 2011). A previous study conducted in an N-saturated subtropical forest in south-western China showed that soil water NO_3^- concentrations declined rapidly due to decreasing N deposition, and soil N_2O emission decreased subsequently (Xie et al., 2018b).

4 Conclusions and outlook

With the recent significant decrease of SO_4^{2-} and NO_3^- deposition across China, leaching of SO_4^{2-} and NO_3^-, and emissions of N_2O in subtropical forests of China showed a declining trend. By contrast to a decrease in NO_x emissions, the emission of NH_3 and consequently the atmospheric deposition of NH_4^+ has not change significantly during the last decade. Despite the decline in acid inputs, the CL for acidification of forest soils continues to be exceeded in significant parts of southern China. Similarly, despite a significant decrease in NO_x emissions, the total N deposition remains high in significant portions of China's forests, resulting in exceedance of CL for eutrophication. Therefore, continued stringent control of S and N emissions, particularly of NH_3, continues to be important not only with respect to forest health and biodiversity, but also for soil and water quality and greenhouse gas emissions.

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Conflict of Interests Jan Mulder is an editorial board member of *Frontiers of Environmental Science & Engineering*. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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