Atmospheric nitrogen deposition in a highly human impacted area in northern Italy

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ABSTRACT

Nitrogen can enter the water cycle through atmospheric depositions on ground and water surfaces, leakages from point and diffuse sources (i.e., sewage treatment plants or sewage systems, fertilizer and manure applications), and erosion processes affecting nitrogen rich soils (EEA, 2005). However, integrating all nitrogen forms, processes and scales is still a major challenge for the understanding and the management of the nitrogen cycle.

Keywords: air pollution, ammonium, nitrate, precipitation

METHODS

A monitoring experiment was set up to collect wet atmospheric depositions in a human impacted area with multiple land uses, representing different emission sources (i.e., extended urban areas with residential buildings and industrial activities, high traffic roads and agricultural activities).

Wet deposition is measured at 17 sites, homogeneously distributed in the western sector of Lombardy Region (northern Italy), in the surroundings of Milan. Rainwater collection was executed almost at each single rainfall event at all the sites, starting from February 2017 to February 2019. In summary, 16 precipitation events were monitored and 155 rainwater samples were collected, involving, on average, 10 sites each time. After collection, samples were analysed for pH, electric conductivity, ammonium, nitrate, nitrite, major cations (calcium, magnesium, sodium, potassium), and major anions (sulphate, chloride, fluoride). The physico-chemical parameters were analysed according to their spatial distribution and temporal variation to identify similarities or differences among samples according to the location of the monitoring sites and the season when rainwater samples have been collected. Moreover, rainwater chemistry was compared to atmospheric pollution, derived from air quality data from ground-based stations and pollutant emissions data provided by the Regional Environmental Agency (ARPA Lombardia), to identify a quantitative correlation between emissions and depositions.

Maps of deposition of nitrate and ammonium were obtained by multiplying precipitation maps with concentration maps (Rogora et al., 2016). These maps have been transformed into nitrogen deposition maps ($N\text{-}NO_3^-$ and $N\text{-}NH_4^+$), in order to obtain a map of total nitrogen depositions.

RESULTS

Results show a direct relationship between high levels of air pollutants (e.g., NO_2, SO_2, NH_3) and relatively high contaminant concentrations (e.g., NO_3^-, SO_4^{2-}, NH_4^+) in rainwater samples. Consequently, rainfalls sampled in autumn-winter or during the fertilisation period (April-July) show higher contaminant concentrations respect to those sampled in spring-summer or before the fertilisation period. In addition, the chemical composition of rainwaters reflects local meteorological conditions and local emission sources.

In fact, samples collected in urban or agricultural areas show higher concentrations of specific chemical species (e.g., Ca^{2+}, NO_3^-, NH_4^+) in comparison to those collected in rural areas or close to natural environments (i.e., Alps and Como Lake).

Such results allowed estimating wet nitrogen depositions, as nitrate and ammonia, in the study area. The average concentrations of nitrate and ammonia in precipitation during the monitoring period were 5 mg L^{-1} and 2.5 mg L^{-1}, respectively (Fig. 1).

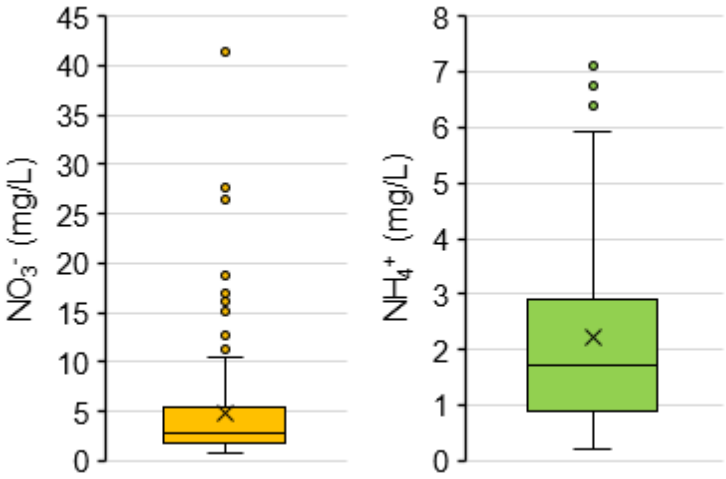

Fig. 4 – Nitrate (left) and ammonium (right) concentrations in rainwater samples.

Consequently, given an average annual precipitation of about 800 mm for the period 2016-2018, a wet deposition of inorganic nitrogen equal to 9 kg (NO_3^--N) ha^{-1} yr^{-1} and 15.5 kg (NH_4^+-N) ha^{-1} yr^{-1} was estimated. Considering both the variability of the spatial or temporal distributions of precipitations and the variability of concentrations of nitrogen compounds in rainwaters, the total amount of nitrogen depositions can range between 20 and 30 kg ha^{-1} yr^{-1}.

CONCLUSIONS

As leaching of nitrogen compounds from soils generally increases at nitrogen deposition rates higher than 10 kg ha^{-1} yr^{-1} (Butterbach-Bahl et al., 2011), this study suggests that the nitrogen atmospheric input to soils should not be neglected when evaluating the impacts of nitrogen sources to terrestrial and aquatic ecosystems, as well as to groundwater resources.

References

Butterbach-Bahl K., Gundersen P., et al., 2011. Nitrogen processes in terrestrial ecosystems. In: Sutton M.A., Howard C.M., Erisman J.W., et al. Eds, The European Nitrogen Assessment: sources, effects and policy perspectives. Cambridge University Press, Cambridge