Trends and fluxes of soil solution chemistry focusing on nitrate leaching responses to air pollution in Italian forest soils.

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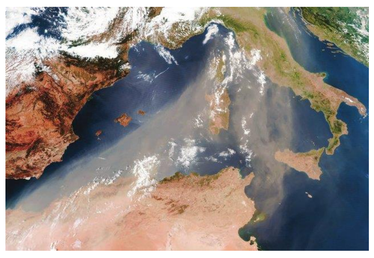
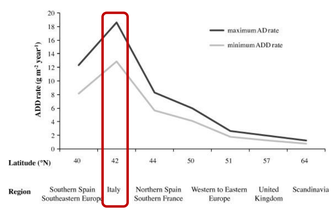
Background

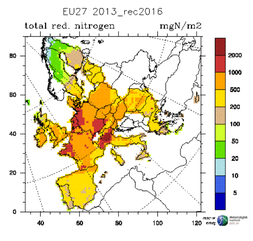
- The present **aeolian dust** deposition levels in in the Mediterranean Basin are among the **highest** throughout the late Quaternary

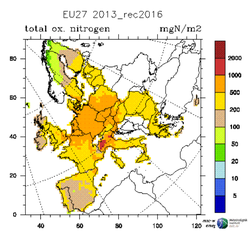




Base cation deposition in Italy are **high and stable**.

- Italy sees some of the **highest N deposition** loads, concentrated especially in the North.





Objectives

General aim: explore the specific impacts of peculiar atmospheric deposition on forest soil ecosystem in Italy as representative of Mediterranean region

Specific objectives

- to evaluate **the long term trends** in soil solution elemental concentrations in relation to deposition trends;
- to capture **nutrient fluxes** into and out of forest ecosystems;
- to estimate **mineral N soil fluxes** and compare them with N deposition and critical loads

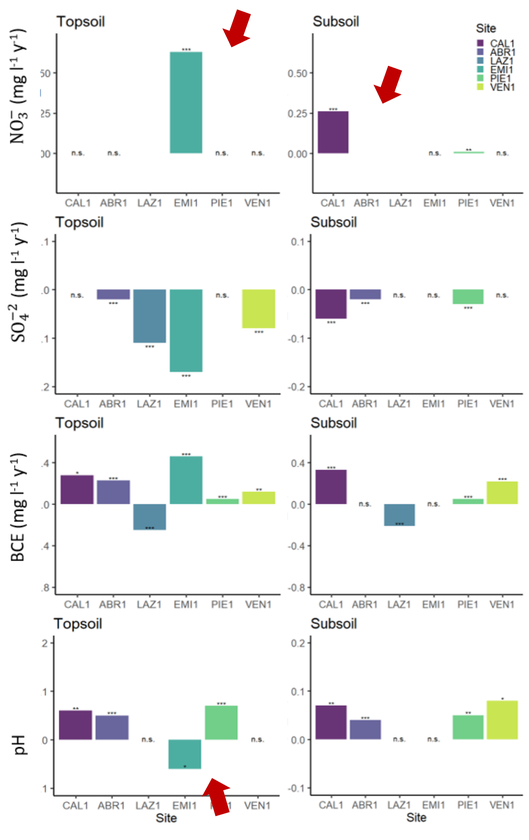
→ To individuate whether **soil acidification** is, or not, an active process

→ to identify sites where the **transfer of reactive N** from atmospheric N pollution to fresh- or ground-waters is a real concern.

Results

Temporal changes

Significant trends (Sen's slope) are expressed with (:p<0.05, **:p<0.01, *** p<0.001)*



No significant or **increasing** trends appear to prevail in NO_3-N. Strong increasing trends are notable in EMI1 a site with high-deposition loads.

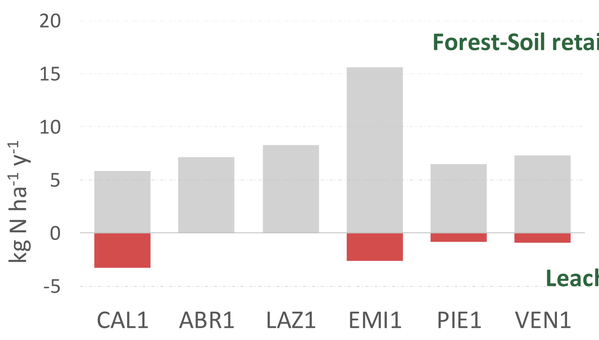
Significant **decreasing trends** in SO_4-S concentration in soil solutions are clear in most of the sites.

A dominance of significant **increasing trends** is clearly visible for **base cations**.

pH shows prevailing significant **increasing trends**, likely related to the general decreasing trend of acidifying sulphate deposition.

Scan and read the full paper

Mean annual N fluxes

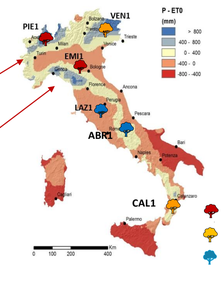


Soil solution fluxes reveal risks of nitrate leaching

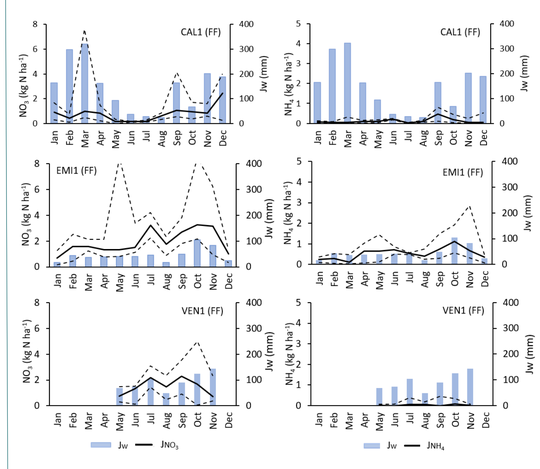
Simple deposition data do not fully predict **soil response to nitrogen deposition**.
It was found that the standard European method of Critical Load (CL) estimation, taking into account forest growth, is a better predictor of the **risk of nitrogen export** to water bodies.

Exceedance of CL in the monitoring sites has demonstrated to be an efficient predictor of N export from soils. All sites with significant CL exceedance show N leaching.

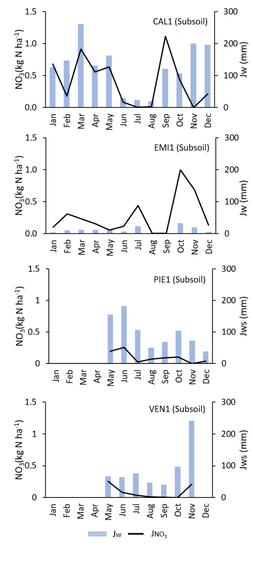
Site	Critical load	N deposition	N soil solution flux
	Kg ha^{-1} y^{-1}	Kg ha^{-1} y^{-1}	
ABR1	15.0	10.2	No flux
CAL1	11.4	9.1	Irregular N flux
EMI1	11.4	18.9	Regular flux
LAZ1	12.4	8.3	No flux
PIE1	10.9	15.9	Regular flux
VEN1	14.1	13.4	Irregular N flux



Monthly water and N fluxes (Forest Floor)



Monthly water and N fluxes (Subsoil)



Drivers other than pollution should also be considered: N can follow different pathways at different time scales, influencing N leaching independently from the amount of deposition.

Methods

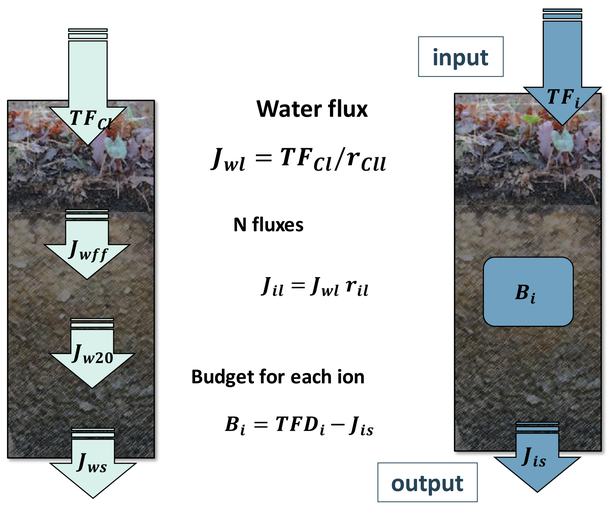
- **Temporal changes** of deposition and soil solution were assesed using the **non-parametric Seasonal Mann Kendall** (SMK) test for monthly concentrations in R statistical environment using "*rkt*" package.

- **Input-output budget**

Mineral nitrogen **TF deposition** was adopted as a input.

To estimate **water flow** through the soil, we used the chloride tracer approach.

Where J_{wl} is the water flux at layer *l*; TF_{Cl} is Cl^- TF deposition and r_{Cll} is the median Cl^- soil solution concentration at *l*. **The flux of each ion**, J_{il}, was calculated by multiplying the relevant J_{wl} value for the median soil solution concentration, r_{il}, for the same layer and period. **The overall budget** for each ion (B_i) was then calculated: *s* is the subsoil layer of the deepest samplers.



Water flux

$$J_{wl} = TF_{Cl}/r_{Cll}$$

N fluxes

$$J_{il} = J_{wl}\, r_{il}$$

Budget for each ion

$$B_i = TFD_i - J_{is}$$

Synthesis and Outlook

- Soil acidification appears to be prevented in central-southern Italy, and markedly mitigated in northern Italy by high base cation deposition, with aeolian dust from Sahara and aerosol likely being the main BCE sources.
- Sign of increasing acidification are visible in EMI1, a site located in the Po valley one of the most urbanised and industrialised areas of Europe. **High anthropogenic nitrogen deposition play a major role, with consequently high and increasing concentration of nitrate in soil solution.**

These results outlines the **importance of integrated monitoring** of different parameters, in order to obtain accurate assessments of **pollution risks**.

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Cecchini, G., Andreetta, A., Marchetto, A., Carnicelli, S. Soil solution fluxes and composition trends reveal risks of nitrate leaching from forest soils of Italy (2021) Catena, 200, art. no. 105175, .