Biomonitoring of atmospheric CO_x and NO_x using carbon and nitrogen isotopes as proxy parameters. Part II: The Cologne Conurbation

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Introduction

Industry, power plants, domestic heating and vehicular traffic emit significant amounts of gaseous air pollutants, that may be taken up by vegetation.

Although climate, nutrition and physiology dominate the isotopic signature of needles, air pollution leaves a detectable trace in needle isotopes (Gebauer and Schulze, 1991, Gebauer et al., 1994, Jung et al., 1997, Ammann et al., 1999).

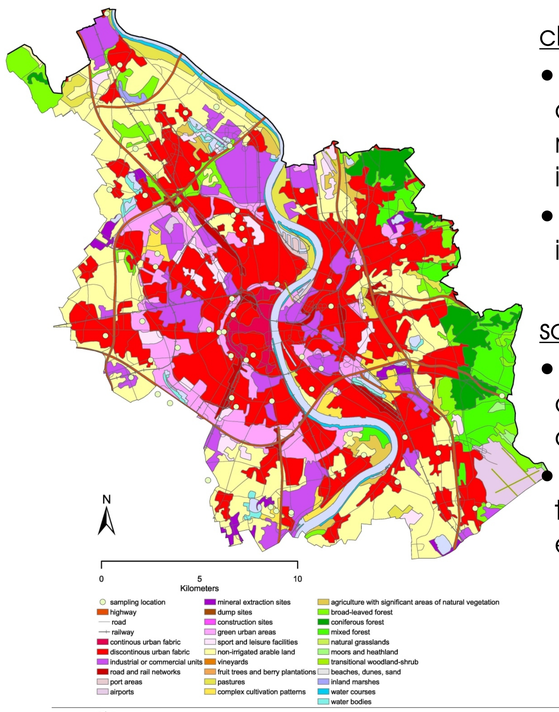
EU Daughter Directive (1999/30/EG) imposes the need on municipal governments to monitor and control air quality. Budget restrictions prevent installation of sufficient numbers of active monitoring stations. Passive biomonitoring allows acquisition of a time-integrated and spatially well resolved air quality dataset.

This biomonitoring study conducted in a heavily populated and industrialised region presents proxies for the following airborne pollutant loads: **PM ➪ magnetic susceptibility**; **NO_2 ➪ ^{15}N**; **CO_2 ➪ ^{13}C**.

Conclusion

- biomonitoring of atmospheric quality using proxy parameters in conurbations is feasible
- basic physiogeographic parameters (topography, climate, soil) do not control distribution of environmental proxies (^{15}N, ^{13}C)
- data accessibility is improved by storage in a GIS-database
- gaseous pollutant loads can be assessed by needle isotopic signature
- particulate pollutant load is reflected by magnetic parameters
- bulk isotopic and magnetic properties can be obtained at very high spatial (and temporal) resolution to serve as screening parameters for further investigations
- isotopic proxies for NO_x and CO_x loads preferentially reflect industrial emission, whereas reflects particulate traffic emissions

Cologne City - variability of atmospheric pollution proxies measured on pine needles (macro scale)

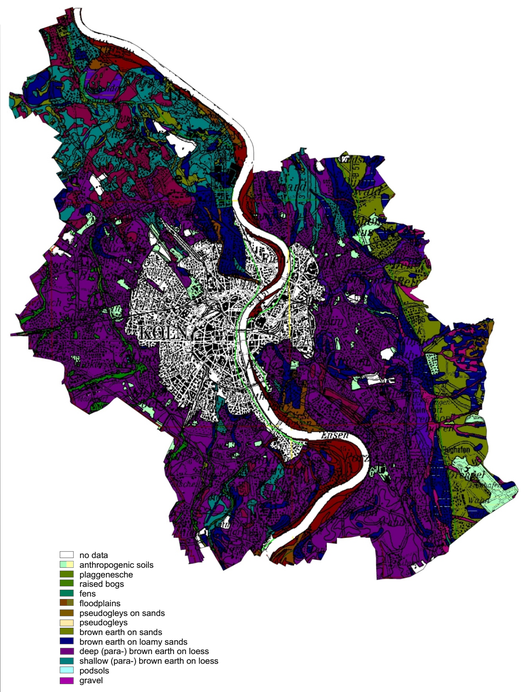


characteristic landuse:

- prominent (petro-) chemical and car manufacturing industry in the north
- high traffic volume in the inner city

sampling locations:

- 60 locations covering entire city area
- stations fully reflect the heterogenous emission background



geology / hydrology:

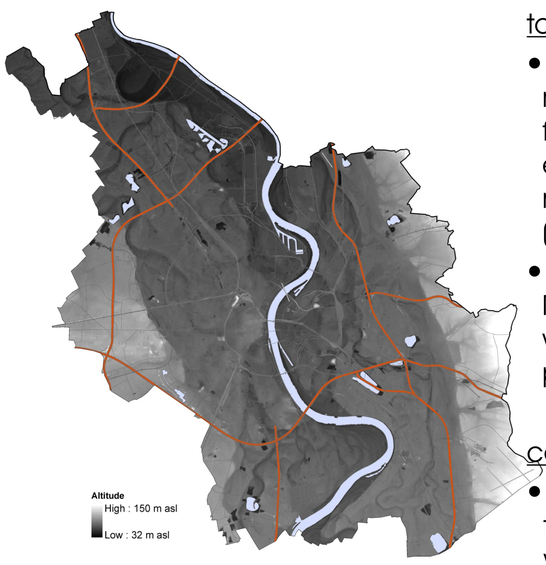
- Cologne is situated in the Rhine valley ➪ fluviatile deposits with high ground-water permeability

soil properties:

- low variation in soil type and soil humidity

consequences:

- no influence of subsurface on isotopic composition of pine needles

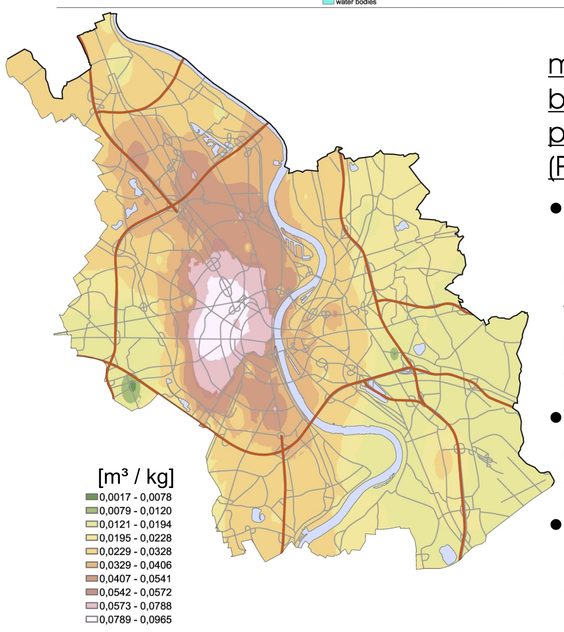


topography:

- the dominant morphological feature is the elevation gain of the middle Rhine terrace (30 m step)
- the NNW strike of the Rhine Valley controls wind direction and pollutant transport

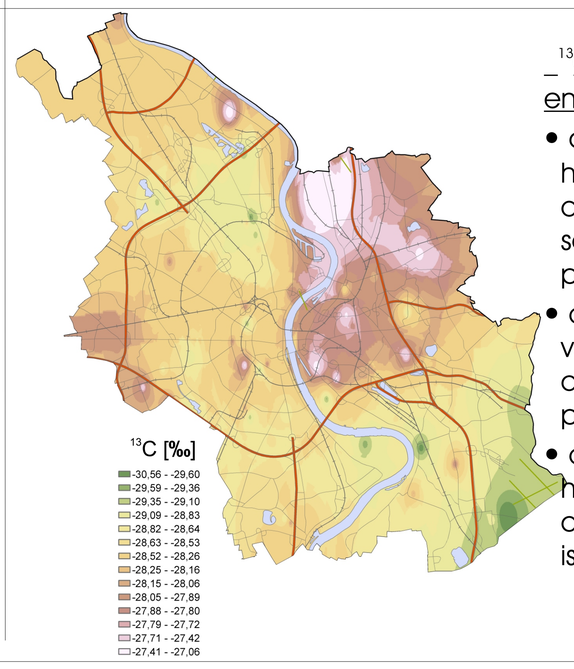
consequences:

- no influence of topography and wind regime on isotopic composition of pine needles



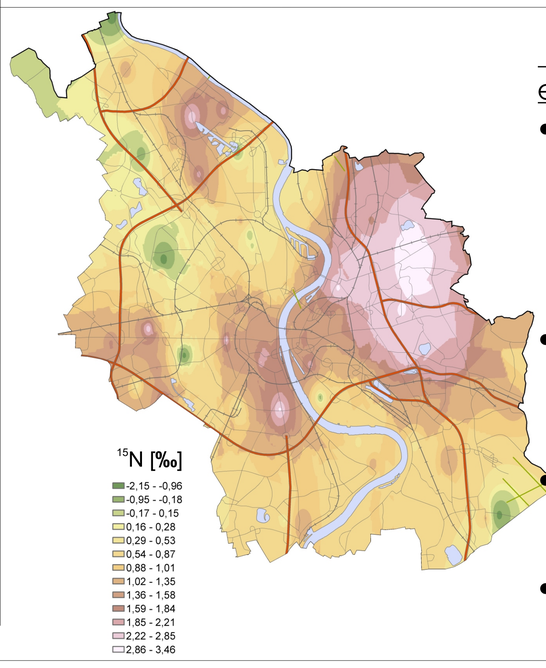
magnetic susceptibility (- a proxy for particle pollution (PM_{10}):

- significantly higher of needles in the inner city ➪ high traffic volume (combustion of fossil fuels and abrasion)
- no dependence on industrial emission
- no influence of physiogeographic properties on



^{13}C - a proxy for CO_x emissions:

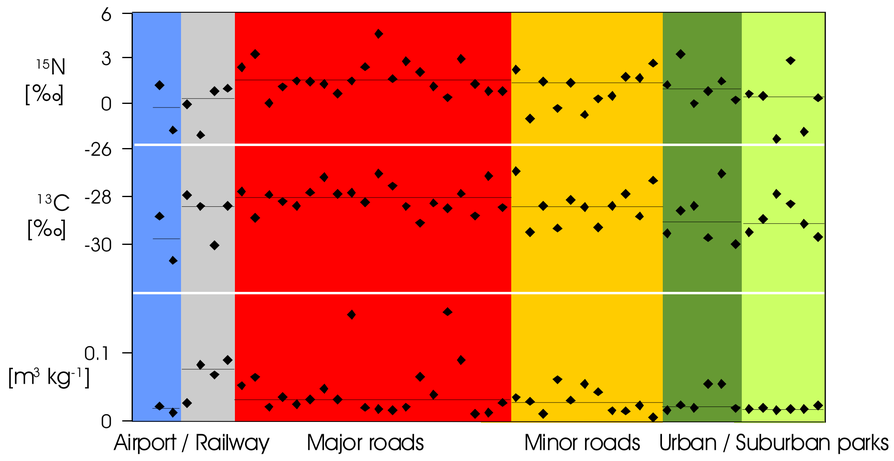
- a hotspot with heavy ^{13}C-values occurs in the NE-sector ➪ industrial pollution
- on a macroscale, vehicular traffic has a minor influence on pine needle isotopy
- on a microscale, high traffic volume affects pine needle isotopy, see below



^{15}N - a proxy for NO_x emissions:

- a hotspot with heavy ^{15}N-values occurs in the E-sector, partially overlapping with the ^{13}C maximum ➪ industrial pollution
- a subordinate maximum occurs in the inner city region ➪ traffic pollution
- agricultural influence on ^{15}N-values is not detectable
- microscale variability, see below

Proxy variability (micro scale)

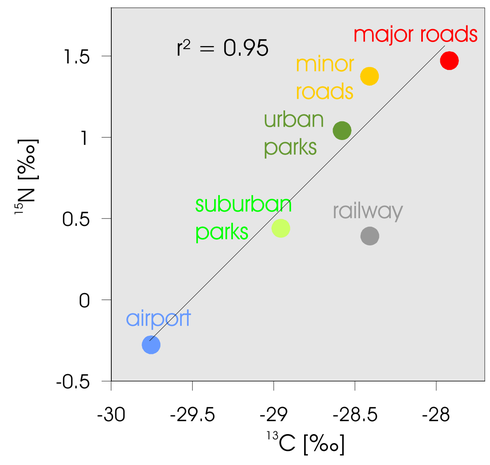


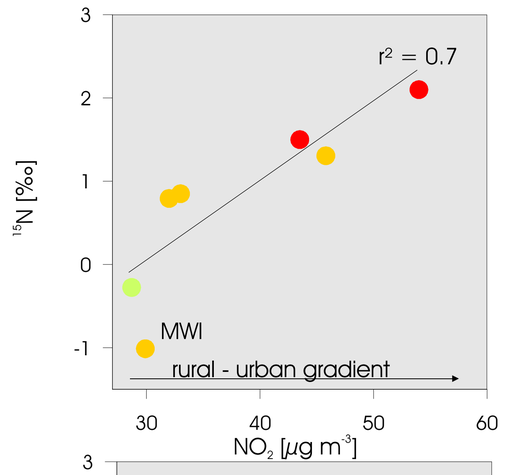
Differentiation according to land use and traffic volume for gaseous pollutants (^{13}C, ^{15}N) and fine magnetic particles ( ) indicates **higher particle emissions along railways and roads**. The latter show a high variability with peak values due to local exposure.

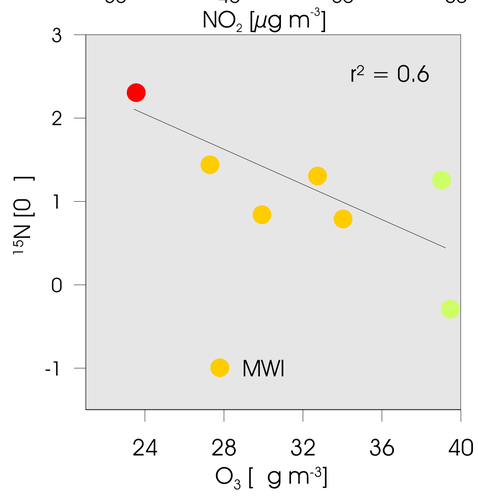
Susceptibility / particle load in parks, near railway and the airport indicate low deviation from median values (black bars) due to **increased distances to point emissions and high degree of air mixing**.

The trend to generally lighter ^{13}C and ^{15}N values in suburbs and parks reflects a **urban-rural gradient** due to the urban dome effect.

Isotopic proxies for nearground CO_2, NO_2 and O_3







Covariance of averaged needle isotope values indicate a trend to **^{15}N and ^{13}C enrichment with increasing environmental stress**.

The ^{15}N values may serve as proxy for NO_2 as shown by the good correlation with atmospheric NO_2-concentrations, determined by the City of Cologne.

Lighter ^{15}N-values are associated with lower NO_2 but higher nearground ozone-concentrations.

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