WET ATMOSPHERIC DEPOSITION OF DISSOLVED NUTRIENTS (N, P, SI) IN NORTH AFRICA COASTAL SITE (ANNABA, ALGERIA) FROM LONG-TERM SURVEY

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Abstract
Wet atmospheric deposition of dissolved inorganic nitrogen (DIN), phosphate (PO_4) and silicates ($Si(OH_4)$) was studied in 271 samples collected at a fixed coastal site (Annaba, Algeria), during October 2011-February 2016. The DIN WAD was three-fold low when compared to Mediterranean values. In contrast, PO_4 wet atmospheric deposition may be considered as the highest value in the Mediterranean area. Annual $Si(OH)_4$ fluxes were also elevated and followed the same seasonal pattern of PO_4.

Keywords: Nutrients, Atmospheric input, South-Western Mediterranean

Wet atmospheric deposition (WAD) has been reported as the main source of dissolved nutrients to the western Mediterranean [1]. The WAD of dissolved inorganic nitrogen (DIN) has been recognized as significant in the Mediterranean region, contributing in the same magnitude of the riverine input [1]. Because of its proximity to Algerian desert, Annaba region is directly submitted to African high dust loads [2], which transport during rain events bioavailable phosphorus (phosphate: PO_4) and silicon (silicates: $Si(OH)_4$). However, data on wet atmospheric deposition of nutrients are missing in almost North African countries, and practically lacking in Algeria. The objective was to estimate the WAD of dissolved inorganic nutrients (N, P, Si) and to assess how much this input influenced the enrichment of Annaba Bay coast waters.

Wet atmospheric deposition of dissolved inorganic nitrogen DIN (NH_4^+ + NO_3^- + NO_2^-), PO_4 and $Si(OH)_4$ was studied from 271 samples collected at a fixed coastal location around Annaba city, Algeria, during October 2011-February 2016. The rain gauge used for rainfall sampling was placed in a cleared and fenced area of Badji Mokhtar University (4 km from Annaba coast, 30 m above the sea level). All samples were collected on an event basis. Data of daily precipitation in the Annaba region were obtained from Annaba meteorological station and completed from http://fr.tutiempo.net/climat/ws-603600.html. In the laboratory, all nutrient concentrations (µmol l^{-1}) were determined following the methods described in Parsons et al. (1989). The instantaneous flux of nutrients were assessed by multiplying the nutrient level (µmol l^{-1}) by the amount of the precipitation (liter/m²) for each rain event, and expressed in µmol/m².

Seasonal average levels of PO_4 and SiO_4 ranged from 1-1.60 µmol l^{-1} and 8-17 µmol l^{-1}, respectively, with maximum values encountered during spring and autumn when Saharan and tropical (El Niño Southern Oscillation: ENSO) influences dominated the area. At the opposite, levels of these nutrients dropped to their minimum under winter North Atlantic Oscillation (NOA) effects. PO_4 wet atmospheric loads varied with seasons (17-320 µmol m^{-2} yr^{-1}) and years (650-940 µmol m^{-2} yr^{-1}). These amounts may be considered as the highest values in the Mediterranean area. PO_4 inputs increased during winter rainy period (340 µmol m^{-2} yr^{-1}), and during autumn coinciding with large scale meteorological event impacts, in particular ENSO warm events which may increase autumn rainfall. Annual SiO_4 fluxes ranged from 6,740 to 8,960 µmol m^{-2} yr^{-1}, and followed the same seasonal pattern of PO_4. The rainfall over Annaba coastal area is heavily loaded with PO_4 and SiO_4 in particular during autumn and spring when ENSO event prevails in the region. Due to direct Saharan dust transport (and local human activities), levels of PO_4 and SiO_4 over Annaba coastal zone are the highest in the Mediterranean region. In winter, when the North Atlantic Oscillation (NOA) dominated, the levels of these nutrients decreased but their loads increased with the increasing of the precipitation events and amounts.

The DIN average levels (25 µmol l^{-1}) were three-fold low when compared to Mediterranean values. Ammonium (NH_4^+) and nitrate (NO_3^-) had comparable levels (11-13 µmol l^{-1}) with a maximum during autumn and summer for NO_3, and can be considered among the lowest known values in the Mediterranean Sea. The DIN wet atmospheric deposition fluxes were in the order 1,800 µmol m^{-2} yr^{-1}. Inputs were elevated during winter, autumn and in a lesser degree during spring. The local atmosphere in Annaba area seems to be weakly impacted by the low anthropogenic activities (transport, agriculture, industry emissions), as the WAD of dissolved nitrogen, was the lowest in the Mediterranean region. Also, large scale (NOA) transport (of nitrogen gaseous forms) may be limited. Similar fluxes were reported [1] in a contiguous coastal city (Mahdia, Tunisia), where human activities and climate are very comparables.

References
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