A case study of aerosol trace element deposition to Moroccan coastal waters

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Aerosol deposition is an important source of trace elements (TEs) to the surface ocean. Due to the proximity to the Sahara Desert/Sahel, the North Atlantic receives some of the highest inputs of mineral dust globally (100-220 Tg yr^{-1}; Prospero *et al*, 1996; Kaufman *et al*, 2005). In terms of biological production, this significant input of TEs contributes to the greater efficiency of the Canary Current Upwelling System (CCUS) relative to its Pacific counterpart (Carr *et al*, 2003); both of which support socio-economically important fisheries. However, mineral dust is just one component of atmospheric aerosols. Human activities (*e.g.* vehicle emissions, fossil fuel burning, agricultural practices) also contribute to the atmospheric load, resulting in changes in the elemental ratios with respect to crustal composition.

In order to investigate the TE composition of aerosols and quantify atmospheric deposition fluxes to the CCUS, aerosol and bulk deposition samples were collected from three coastal locations in Morocco (Agadir, Laayoune and Dakhla) as part of the EPURE project (http://www-iuem.univ-brest.fr/epure), over an annual cycle (March 2015-2016). Here, we present TE composition and flux estimates, with a focus on Cd.

Aluminium (Al) is frequently used as a tracer of mineral dust inputs. Whereas cadmium (Cd) is an element of concern for human health, and is toxic to phytoplankton above a certain threshold, despite being essential for carbon uptake in some genera (Brand *et al*., 1986). A poor correlation between aerosol Al and Cd (r^2 = 0.31, P = 0.091) suggests that mineral dust was not the dominant source of Cd during this study. However, coincident peaks of Al and Cd did occasionally occur (*e.g.* early August, Fig. 1), suggesting that during dust events mineral dust could be an important source of Cd.

Despite the presence of phosphate mining activities to the south of the Laayoune, we did not observe significantly different ratios of Cd/Al relative to the other two stations. Indeed, the elemental ratio of Cd/Al (by mass) at all three stations (Agadir = $2.1x10^{-5}$ - $2.3x10^{-4}$,Laayoune = $1.1x10^{-5}$ – $1.8x10^{-4}$, Dakhla= $2.1x10^{-5}$ - $2.3x10^{-4}$) fall within the range observed at nearby locations (e.g., Cap Spartel=$4.6x10^{-5}$ - $2.3x10^{-4}$ (Guieu et al., 2010) and Gran Canarian = $4.6x10^{-5}$ – $1.84x10^{-4}$ (Gelado-Callero et al., 2012)). Similarly, the Cd /Pb ratios (Pb is derived from industrial activities) for Agadir = 0.0032-0.070, Laayoune = 0.0035- 0.11, Dakhla = 0.0044-0.045), Cap Spartel (0.0088-0.056) and Gran Canaria (0.031-0.079), all show a similar range in the Cd/Pb ratio, which suggests that the same sources dominate aerosol composition throughout the region. With the exception of Ni, the primarily anthropogenic elements were most enriched in the Agadir samples, suggesting that industrial activities in and around Agadir have a larger impact on aerosol composition that the local effect from the phosphate mining industry near Laayoune.

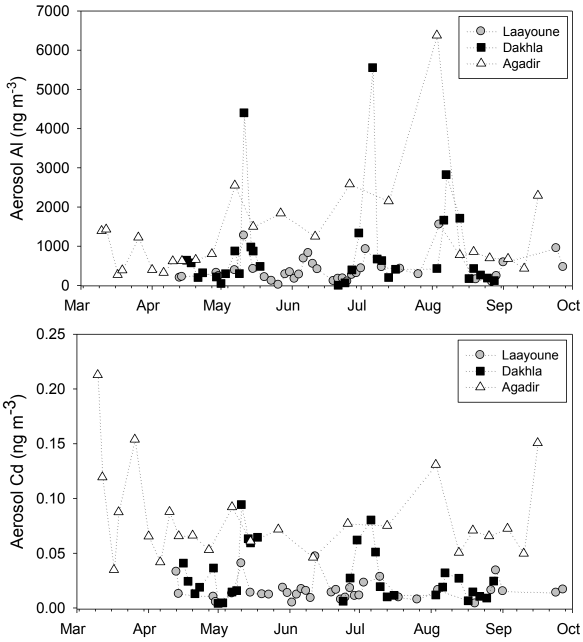

Figure 1. Aerosol Al (top) and Cd (bottom) from the first six months of the field campaign.

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