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Seasonal comparison of moss bag technique against vertical snow samples for monitoring atmospheric pollution

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ABSTRACT

This is the first study seasonally applying *Sphagnum papillosum* moss bags and vertical snow samples for monitoring atmospheric pollution. Moss bags, exposed in January, were collected together with snow samples by early March 2012 near the Harjavalta Industrial Park in southwest Finland. Magnetic, chemical, scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDX), K-means clustering, and Tomlinson pollution load index (PLI) data showed parallel spatial trends of pollution dispersal for both materials. Results strengthen previous findings that concentrate and slag handling activities were important (dust) emission sources while the impact from Cu–Ni smelter's pipe remained secondary at closer distances. Statistically significant correlations existed between the variables of snow and moss bags. As a summary, both methods work well for sampling and are efficient pollutant accumulators. Moss bags can be used also in winter conditions and they provide more homogeneous and better controlled sampling method than snow samples.

Introduction

World Health Organization (WHO) considers air quality as a major environmental risk to health where individuals have little control for the exposure. Industrial and transport activities are identified as the main air quality threats by 71% and 63% of the Europeans, and 58% and 34% of the Finnish in 2012 Eurobarometer (TNS Political and Social, 2013). Industrial point-like sources usually stand out in the environment and thus draw more attention than traffic pollution. Furthermore, emerging demands for even tighter emission or discharge limits for industry emphasize the needs of spatially accurate data. Automated monitoring stations alone can't respond to this due to their limited number and typically high costs.

Atmospheric particulate matter (PM) can absorb and transfer various pollutants such as heavy metals (Petrovský et al., 2000). Chemical assays are a conventional way to study air pollution but nowadays they are increasingly supported by magnetic and scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDX) methods, which can help identify the pollution source. Magnetic susceptibility, one of the most used magnetic proxy parameters, and heavy metal concentrations show significant correlations in several studies (Schmidt et al., 2005; Salo et al., 2012).

Snow surveying can be used for efficient and economic monitoring of air pollution loads in cold climatic regions, such as Nordic countries or mountain areas. Heavy metals, salt, and organic substances are the most common pollutants in snow

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(Viklander, 1996). The deposition time of precipitated snow, which can stay on the ground for several months, is definable from meteorological data (Hautala et al., 1995). When snow is not at all or insufficiently available, biomonitoring could be applied instead. Active biomonitoring with moss bags allows flexible sampling networks to be established and accumulated pollution concentrations to be closely determined since the initial concentrations are known. It is a very useful tool in highly polluted areas missing native (moss) species and/or around point-like emission sources. The significant disadvantage of this technique is the wide variety of application methods existing due to the lacking international standard (for review see Ares et al., 2012). In Finland, moss bag studies follow the national standard SFS 5794 (Finnish Standards Association, 1994) but differences *e.g.* in sampling location, weather and wind conditions or exposure time may influence the accumulation and weaken the study comparability.

Very few comparisons have been made between snow and moss surveys (Čeburnis et al., 2002). Moreover, even though moss bags are adjustable, only Viskari et al. (1997) have applied snow and moss bag samples in the same traffic pollution study, but in different seasons. In this article, we focused on mapping the spatial distribution of air pollutants close to the Harjavalta Industrial Park by comparing the methods of vertical snow sampling and moss bags. The possible problems related to winter conditions, such as freezing of the moss bags and snow accumulation, might cause restrictions in sampling applications. Our hypothesis was that both monitoring methods would show similar spatial trends in pollution dispersal and that the moss bags could be used in winter time in highly polluted industrial area. To our knowledge, this is the first study for seasonal comparison of these methods.

1. Material and methods

1.1. Study area

Harjavalta (61°19′N, 22°19′E) is located in southwest (SW) Finland (Fig. 1a). It has an area of 128 km^2 and a population of about 7500. The town is situated on an esker running in a northwest–southwest (NW–SE) direction, as well as the Kokemäenjoki River, the Pori-Helsinki highway and the adjacent railroad. The main source of local air pollution, and also one of the largest point sources in Finland, is the cluster of heavy metal and chemical industries in Harjavalta Industrial Park (Salemaa et al., 2001). The primary products include copper, gold, silver, sulfuric acid, nickel and special chemicals, and fertilizers. Thus, common pollutants are sulfur dioxides, dust, and heavy metals such as Cu, Ni, Zn, Pb, As, Cd, and Hg.

The air quality of Harjavalta is monitored constantly with two monitoring stations (PM_{10} and SO_2 level) representing town center and residential area within 1 km to the southeast (SE) and 2 km to the northeast (NE), respectively, from the Industrial Park. The heaviest anthropogenic air pollution load is settled within 2 km from the Industrial Park (Salo and Mäkinen, 2014). Moreover, the pollution is dispersed to further distances in SE and NW along the prevailing wind directions and Kokemäenjoki River valley. During the study period the prevailing wind directions were from east (E), NE, and SE (Fig. 1b).

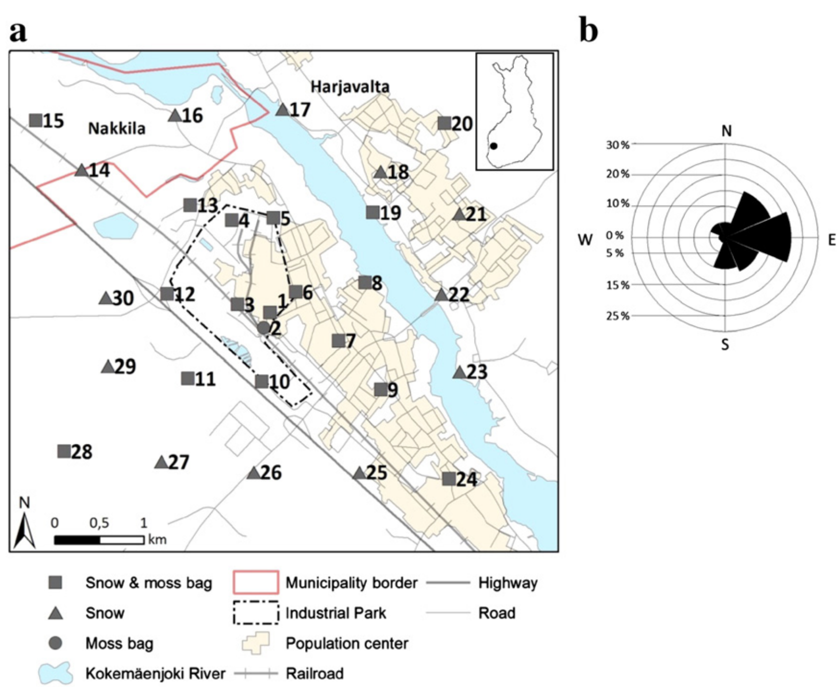

Fig. 1 – (a) Sampling sites (Nos. 1–28; two background sites located outside the view of the map) in the study area of Harjavalta (National Land Survey of Finland, 2010), southwest (SW) Finland (index map), and (b) wind rose from Vaisala weather station within Harjavalta Industrial Park from the time period of 1 January and 2 March, 2012.