Ten-year measurements of Radon's decay products to study the role of atmospheric dispersion on PM levels

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Keywords: radon decay products, dispersion, PM

The measurement of the concentration and temporal behaviour of radioactive aerosol in atmosphere can provide information on atmospheric thermodynamic conditions as well as on atmospheric processes that involve aerosols such as transport, dispersion, removal rates and residence time.

Since 1997 our group has been measured the concentration of Radon's short-lived decay products routinely and continuously in Milan (Italy) with hourly resolution (Marcazzan et al., 1995; Sesana et al., 2003; Vecchi et al., 2004).

Radon activity concentration outdoor is detected through the collection of its short-lived decay products attached to aerosol particles and the spectroscopic evaluation of their alpha activity by a home-made instrument with high sensitivity (detection limit = 0.2 Bq m^{-3}).

Long-term Radon measurements (Kataoka et al., 1998; Perrino et al., 2001; Sesana et al., 2003) show that the temporal variation of its concentration can give immediate information on the evolution of the stability conditions in the boundary layer. The stability conditions of the lower atmospheric layers, on a local scale, are very important as influence pollutants concentration on different time scales. Indeed, the dilution of pollutants in the mixing layer must be ascribed to thermal and dynamic turbulence, whilst the horizontal transport of pollutants is due to the wind field. In the Milan area and in the whole Po valley ventilation is scarce (despite sporadic advection episodes, typically Föhn events) and vertical dispersion plays the main role.

From long-term measurements performed in Milan by our group a typical daily pattern in Radon concentrations can be singled out: it is generally characterised by a minimum in late afternoon and a maximum in the early morning. This pattern is observed on sunny days with clear sky (both during day and night) and low ventilation rate and it occurs very frequently in Milan during both winter and summer months. The nocturnal accumulation of Radon is due to the low mixing layer generally caused by a low-height or ground-based temperature inversion of radiative origin. The variation of Radon concentration observed between the minimum in the afternoon and the maximum in the following day is a good indicator of the nocturnal mixing layer depth. When the sun rises in the morning and heats the ground the inversion is destroyed so that the re-mixing of Radon takes place in layers of increasing heights causing a decrease of its concentration levels. The minimum concentration is registered during the afternoon when the mixing layer reaches its maximum depth. The variation between maximum and minimum Radon concentration in the same day is an index of the maximum height of the mixing layer, which has been evaluated by means of a box model suitably set up (Pacifico, 2005).

The analyses performed on our long-term dataset have been singled out a significant correlation between PM10 and ^{222}Rn daytime concentrations evidencing the dominant role of atmospheric dispersion in determining the temporal variation of PM10 levels. Whenever ^{222}Rn concentrations accumulate during the night (indicating the formation of a nocturnal atmospheric stability), PM10 concentrations show higher values than those registered during the daytime before, despite a nocturnal decrease in emissions from active sources. On the contrary, when ^{222}Rn concentrations do not accumulate during night hours, PM10 levels are lower than those measured the daytime before. It is worth noting that in both cases the aerosols residence time plays a role and has to be taken into account.

Moreover, an analysis of the relationship between PM and atmospheric dispersion over the ten-year data set will be presented.

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