Mixed dust exposure and health risk assessment in the ceramics industry

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Health risk assessment in the ceramics industry traditionally rests upon crystalline silica toxicity and exposure levels (*e.g.*, NIOSH, 2002). Notwithstanding, workers in the ceramics factories may be exposed to a number of potential toxicants, including iron (Fubini and Fenoglio, 2007). Iron, which is a major element in the pastes of clay brick and pottery productions, has been shown to modulate quartz toxicity through enhancing or inhibitory effects depending on surface concentrations (Ghiazza *et al*, 2011). In this paper the nature and properties of quartz and Fe-bearing minerals in clay brick and pottery productions and the possible mutual interactions between them, have been evaluated by means of integrated individual particle characterisation-bulk chemical analyses of both the raw materials and the airborne dust particles.

Aerosol dust samples have been collected from different working stations in different clay brick and pottery factories in Umbria (Central Italy). Individual particle characterization has been performed by means of scanning electron microscopy (SEM) coupled with image analysis and EDS microanalysis (Moroni *et al* 2013). The bulk mineralogical composition has been determined by means of X-ray diffraction (XRD), while the concentration and the solubility degree of Fe in the bulk samples at both neutral (7.2) and acid pH (4.6) have been determined by inductively coupled plasma atomic emission spectrometry (ICP-AES). Distinctive technological features of toxicological interest have been also investigated by means of experimental firing tests on the pastes performed at 950°C (clay brick) and 1050°C (pottery) peak temperature.

Quartz morphology revealed similar grain size and surface morphology in both sectors, and lower values of the shape factor in the clay brick production. Mean values of the exposure doses for quartz in the clay brick and the pottery working environments were evaluated based on the grain size, leading to 84 and 93 $\mu g\ cm^{-2}$, respectively. These values greatly exceed the minimum dose (40 $\mu g\ cm^{-2}$) able to induce significant cytotoxic and inflammogenic effects on cell cultures (Ghiazza *et al.* 2011) although the particle mass concentrations in the factories be lower than the threshold limit value (0.025 $mg\ m^{-3}$). This fact suggests the necessity of employing surface area instead of gravimetric measurements when evaluating quartz occupational exposure.

The mineralogical composition of pastes is similar before firing, with just some more variability in the clay brick, and changes after firing in the pottery for remarkably higher amounts of the amorphous phase. The clay brick pastes, on turn, show lower total iron, and higher soluble iron contents in respect to the pottery pastes. The total iron amounts are mostly related to variable amounts of Fe-bearing clay minerals (mostly chlorite) and ores in the clay brick pastes. The soluble iron contents, on turn, depend on the amounts of the amorphous phase, as the thermal decomposition of Fe-rich silicates such as chlorite produces an amorphous phase which can retain iron and prevent hematite crystallization (Nodari *et al*, 2007). These facts point to the possible role of bioavailable soluble iron in modulating quartz toxicity in the airborne dust as a function of the composition of raw materials and the mineralogical-chemical evolution in the firing process.

Mean values of the Fe/Qz ratio have been estimated based on the values of iron and quartz concentrations in the samples, leading to the following results: $Fe/Qz_{clay\ brick}<0.03$; $Fe/Qz_{pottery} \sim 0.004$
The values obtained for clay brick are in the range of possible adverse health effect (Ghiazza *et al* 2011), while the values for pottery are too low to attain reliable interaction. Results support the evidence of higher incidence of silicosis in the clay brick division (Verdel *et al* 2006), although it should be better to consider the occurrence of mixed dust fibrogenetic processes rather than simple silicosis in this case (Mossman and Churg 1998). In the light of all these points, significant reduction of the health risk may be attained only after a deep examination of the properties and the exposure conditions of the whole materials even in the same working environment. Also, generalization of the results should be kept with caution and the situation be analysed case by case.

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