A comparative study of exposure to crystalline silica in natural and artificial marble stone processing as a platform for designing exposure control measures.

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Crystalline silica is known to cause a chronic lung disease, silicosis. Recent data address the increase in incidence of silicosis in Israel. The majority of the cases come from SMEs and workshops where counter tops and sanitary fixtures made of artificial quartz are processed. This study focused on the effect of individual work processes on the dispersion of silica dust and their contributions to worker exposure. Understanding the characteristics of the individual processes may assist in ranking the health risk and in setting priorities for the introduction of control measures.

The study population consisted of small and medium workshops where artificial stone made of quartz surfaces as well as natural lime and granite stone were processed. Dispersion of silica dust and workers' exposure were assessed by air monitoring under various combinations of the type of material, type of process, application of wet and dry processing methods and size selective dust fractions. Airborne dust levels were determined using gravimetric methods and silica was determined by XRD analysis. Size distribution and electron microscopy were also carried out on the dust particles.

The average silica contents in the respirable fractions of artificial stone and natural stone were 41.5% and 16%, respectively, the difference being statistically significant. Geometric means of respirable airborne silica in personal samples taken over process duration were 0.158 mg/m^3 and 0.099 mg/m^3 in artificial and natural stone, respectively. The difference between these averages was not statistically significant although statistical significance ($p < 0.05$) was observed between the parallel averages in area samples. The increase in the silica level in the air during processing tombstones made of natural stone is mainly contributed by sand blasting.

The TWA exposures of workers assessed in the respiratory fraction of silica were 0.55 mg/m^3 and 0.038 mg/m^3 in dry and wet processing of artificial stone, respectively, the difference being statistically significant. The parallel exposures in processing natural stone were 0.07 and 0.087 in dry and wet processing, respectively, a difference not statistically significant. While dry processing of artificial stone exceeded the Israeli Threshold Limit Value (TLV) for respirable crystalline silica (0.1 mg/m^3), the average silica concentration in wet processes was below the TLV. Sixty percent of the measurements in dry processing of artificial stone and 4.5% in wet processing exceeded the TLV, while the respective values for dry and wet processing of natural stone were lower.

Among the dry processes for processing artificial stone, contour blades were found to produce the highest airborne levels of silica, followed by the cutting process using a manual disc cutter. Dry hand cutting using a saw was found to be the cause of the highest levels of silica in the air during natural stone processing.

Among the wet processes, contour blades were responsible for the highest air levels of silica in both types of stones. The lowest levels were achieved when processes were subject to CNC (computerized, mechanized processing), where the processes are contained and wet.

Particle size up to 10 µm (aerodynamic) comprises the dominant fraction in the size distribution; however, the largest mass fraction still resides in the larger particles. Irregular and angled particles were observed under the microscope.

The different proportion of silica content in artificial as compared to natural stone is the main reason for the difference in exposure levels. Granite is the dominant contributor to the level of silica in the air while processing natural stone. Wetting the process reduces the airborne concentration dramatically in comparison to dry processes, but does not prevent unacceptable exposures in some workers during processing either type of stone. Disposable masks do not reduce the actual exposure to acceptable range, as it was found that 33% of workers performing dry processing of artificial stone and 7% of workers

performing wet processing of artificial stone were exposed to unacceptably high levels of silica.

After characterizing the work processes and the examining the profile of the work carried out in the workshops, it was concluded that a weighted exposure measure calculated by workday could distort the degree of actual exposure due to the nature of the work and the very large variations in exposure during separate, brief processes. Hence it was deemed preferable to present the weighted exposure of workers over each specific type of processing rather than the weighted exposure over an eight-hour workday.

Because of a possible discrepancy between conclusions drawn from air monitoring of respirable versus total dust fractions, measurements of the respirable fraction of silica is the only strategy relevant to assessment of worker exposure, despite the existence of legal standards in Israel for silica as total dust.

CNC processing seems to be the most promising way to reduce dust dispersion and reach acceptable exposure levels. Where such a process is unavailable or technically impossible, a combination of a wet process and focal, forced ventilation (local or dilution) may reduce exposure to acceptable limits.