A METHODOLOGICAL APPROACH TO THE DEVELOPMENT OF CHARACTERIZATION FACTORS FOR CALCULATING THE TOXIC ENVIRONMENTAL IMPACT OF MINERAL PARTICLES IN THE CONTEXT OF LIFE CYCLE ANALYSIS

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1. INTRODUCTION: LCA AND CURRENT PARTICLE CHARACTERIZATION FACTORS

Within the scientific community one of the most widely accepted tools for the evaluation of environmental impact is Life Cycle Analysis (LCA), which analyses the environmental aspects and potential impact of a product or an activity throughout its life cycle. The composition and quantities of the pollutants which are produced and the resources that are consumed can be calculated in terms of environmental loads by means of this method. These loads are subsequently classified to obtain environmental indicators. In order to do this, characterization or equivalence factors, which enable different environmental loads from the same impact category to be measured uniformly, are employed, so that a desired environmental profile can eventually be obtained and classified within different impact categories, such as global warming, the depletion of the ozone layer, acidification and eutrophication, amongst others.

In most cases gases and their effects, which are associated with different impact categories, and their corresponding characterization factors, have been widely studied, while, on the other hand, particles or particulate matter (PM) have not. There are currently many ways of classifying the particle types which exist and they are highly diverse. As far as the effects associated with them and how they are related to LCA are concerned, particles are only contemplated in the human toxicity category in the CML 2 baseline evaluation methodology and in the winter smog category in the Eco-indicator 95 methodology. Furthermore, they are grouped together under the same name as "particulates" with the same characterization factor, irrespective of the composition, type and size of the particles (PM_{10}, $PM_{2.5}$) they contain.

2. GUIDELINES FOR THE METHODOLOGICAL DEVELOPMENT OF PARTICLE CHARACTERIZATION FACTORS

Given that this research is currently in process, the chief aim of this study is the presentation of guidelines for obtaining characterization factors for the human toxicity impact category, in accordance with the size and composition of the particulate material concerned, and the evaluation of effects linked to exposure. The development of these factors will necessarily rely on two key procedures: the classification of each particle, depending on its size and composition, and the determination of any exposure-related effects.

Atmospheric particulate material can be classified into various groups, depending on the criteria we apply. Whether we use granulometry, the length of time particles persist in the atmosphere, the mechanism underlying their formation, their origin or chemical composition to classify them, a wide range of particles can be found.

The effects which may be associated with PM chiefly affect human health and ecosystems. In order to apply the human toxicity category the effects on human health which are potentially caused by particles need to be classified. Numerous epidemiological studies confirm that there is a significant correlation between exposure to atmospheric particulate material and a range of adverse health effects. The effects that the inhalation of particulate material can have on human health depend on various factors, the most important of which are the size of particles, their chemical composition and the length of exposure to an atmosphere with high levels of particulate material.

The size of particles is directly related to their potential ability to cause health problems. $PM_{2.5}$ particles pose a greater risk to our health. These fine particles can penetrate the lungs and even enter the bloodstream. Exposure to these particles can cause damage to the lungs and heart. However, large particles (PM_{10}-$PM_{2.5}$) are of less importance, although they can irritate the eyes, nose and throat.

Length of exposure influences the severity of any health-related injuries. Long-term exposure, such as that experienced by people who have lived for many years in areas with high levels of particles, has been linked to problems such as decreased lung function, the development of chronic bronchitis and even premature death. Short-term exposure to particles (hours or days) can exacerbate lung disease, causing bouts of asthma and acute bronchitis, and can also increase susceptibility to respiratory infections. In people with heart disease short-term exposure has been linked to heart attacks and arrhythmia.

3. CONCLUSIONS AND FUTURE RESEARCH

The development and/or improvement of impact categories to ensure greater accuracy and a more thorough understanding of the global impact of ceramic materials in the context of LCA is needed, for example in the case of characterization factors for the category corresponding to human toxicity as a result of the emission of clay-like particles. The most important part of this research must focus on the effects of this particulate material on human health.

Given that it is intended that the final research will be conducted in the province of Castellón, in future studies standardization factors will be developed so that this effect on health can be compared with effects in other LCA impact categories, such as acidification. Some particles, such as sulphur dioxide, are formed during the combustion of fossil fuels, which are rich in sulphur. Consequently, we are dealing with two primary pollutants with a strong presence in urban areas, which are potentially more damaging to our health when they are combined. The irritant capacity of sulphur dioxide is known to multiply in the presence of particles, which could be due to their ability to transport the compound deep into the lungs.