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Particulate Materials: Threatening Products Resulting from Burned Fuels

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The fossil fuels, such as coal, oil derivatives and natural gas are nowadays extensively used by our society for electricity and heat generation, and also for a variety of private and mass transportation. Since the Industrial Revolution, thermal machines consume huge amounts of these fuels [1], providing a myriad of modern life industrial, professional, personal and leisure activities, which have grown continuously and explosively during the 20th century. But the beginning of the 21st century claims for quality, within the challenge of requiring each time more quantity; for efficiency, instead of nowadays wastefulness that is responsible for unallowable losses; and for low bio-environmental impact, instead of the potential dissemination of diseases and the destruction of terrestrial, fluvial, lacunar and oceanic ecosystems, as it has been observed.

Some science and engineering areas stand out, being instigated to offer innovative solutions, among which for biocompatible and biodegradable materials to improve quality and extend our life time and yet to guarantee adequate reinsertion into the environment by recycling. In addition to that, nanoscience and nanotechnology also impact on these same themes and still others, such as catalysts in an attempt of better cleaning harmful products created by the combustion of fossil fuels in thermal machines. Such combustion produces particulate materials, which come with a series of other liquid and gaseous products which are malefic by themselves, and might be transformed in other products that are even more deleterious. As an example, the reactive combination of products from the combustion of fossil fuels also generates ozone in our environment, which is a strong local contaminant and, alternatively, volatizes products that destroy the stratospheric ozone layer, which is important to protect us from the malefaction caused by ultraviolet solar irradiation.

Among the particulate materials generated in abundance in the important urban centers by the use of motor vehicles, by the abrasion and suspension of asphalt particles, as well as in commercial, service and industrial activities, more importance is given nowadays to those with sizes of up to 2.5 µm. These are easily inhaled, going through our whole respiratory system until the alveolus, being mainly responsible by the occurrence of respiratory and cardiac illnesses and eventually contributing to injure the human life. They are made of a micrometric solid carbon particle with condensed hydrocarbons on its surface, still bearing adhered particles of liquid hydrocarbons that are soluble in organic media, hydrated sulfates and, eventually, small particles of toxic heavy metals. In addition to that, they play the role of bacteria, viruses and toxic chemical products carriers and also pollute the water, the soil, plants and food, besides the air.

Approaching scientific themes from any area of knowledge associated to energetic and environmental subjects require clear prove for the anthropogenic responsibility in generating causes, so that the effects are well determined. For this reason, I've searched information with high statistic meaning, which had been obtained with well proven methodologies by trusted research groups, in urban centers that are representative of technology-based modern life, in order to quantify and characterize the pollution caused by particulate materials and their effects. I've found these characteristics in a project named Aphekom [2], developed in 25 European cities, through the years of 2004 to 2006, whose results were conveniently reported and analyzed [3]. I've manipulated the tables and the results published [3] to make Figure 1, which shows data relative to the quantitative average of the level of particulate materials with sizes up to 2.5 µm – PM2.5 – , expressed in µg/cm3, in suspension in air in each city studied, with indication of the maximum acceptable level proposed by the World Health Organization – WHO, equal to 10 µg/cm3, superposed to the data of human mortality by 100.000 inhabitants, relative only to respiratory and cardiac problems, which are supposed to be the most affected by this type of pollution. It may be verified that the majority of the cities studied presented air pollution levels superior to the maximum level established by the WHO and also that there is a good correlation

between mortality peaks and greater levels of air pollution with particulate materials with sizes up to 2.5 µm. In addition to that, the economic/financial impacts of these results on the ensemble of 39 million inhabitants living in the European cities cited were computed. This has led to the conclusion that if pollution with particulate material with sizes up to 2.5 µm were kept below the maximum level established by the WHO it would represent an annual economy with health and related expenses of the order of € 31.5 billion. Considering that the average contamination in the city of Rio de Janeiro during 2011 with PM2.5 was equal to 15.44 µg/cm3 [4] and, by hypothesis, that the mortality by 100.000 inhabitants was comparable to the European one for this level of contamination, by applying methodology analogous to the Aphekom project [2, 3] for computing the life statistical value, it is concluded that if contamination with PM2.5 in Rio de Janeiro were kept below the maximum level established by the WHO it would represent an annual economy with health and related expenses of the order of R$ 662 million. A drastic economic motivation, more than a confirmed human calamity, may represent political will to change urban habits, which would include eliminating the use of the most contaminant fuel, the diesel, to progressively substitute individual transport, such as in personal automobiles, by public non-pollutant transports, to use vehicles with electric power trains, to boost the use of bicycles and walking, in addition to envisage a more efficient use of energy, better exploitation of natural resources, among others. The use of electric hybrid-hydrogen power train is a viable and satisfactory option for vehicles equipped with fuel cells. The latter are supposed to gain in the 21st century the same level of importance attained by the computers during the 20th century. These adjustments will require the development of new materials for energetic use [5], and represent a great challenge for materials science and engineering on themes strongly encouraged for publication in new articles of the Materia Journal.

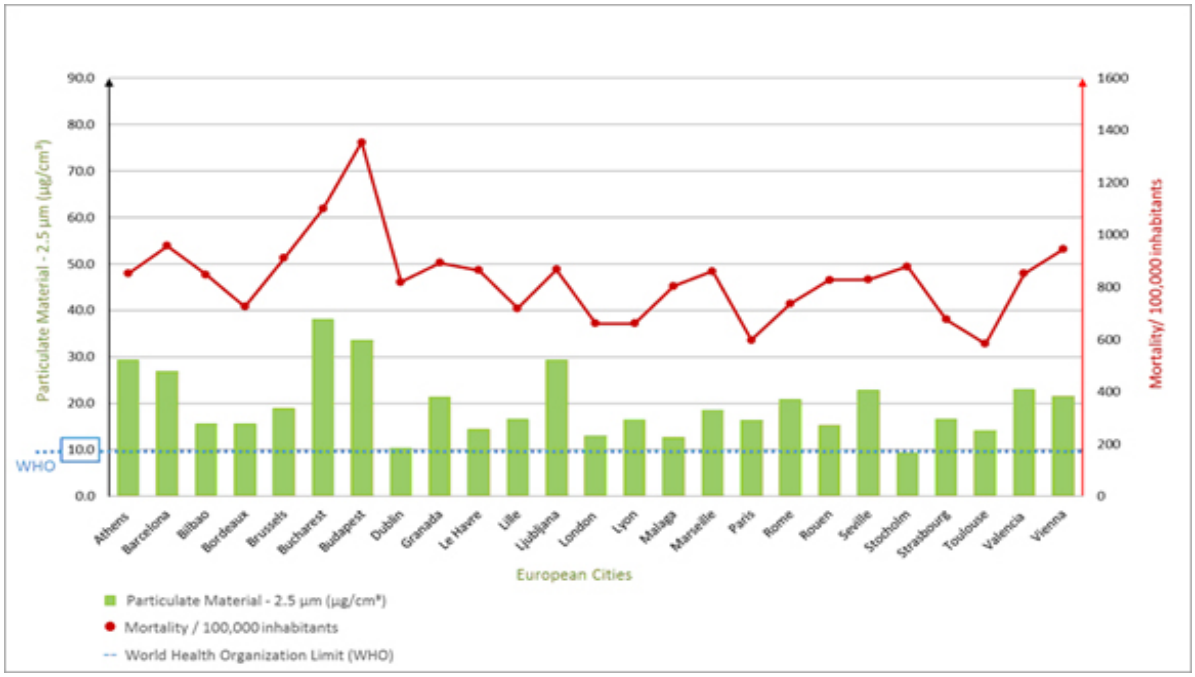

Figure 1: Average level of environmental contamination with particulate material in air suspension with sizes up to 2.5 µm and mortality per 100.000 inhabitants data due to respiratory and cardiac problems in the European cities indicated during years 2004 to 2006. Adapted from [3].

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