

Minireview

THE IMPACT OF AIR POLLUTION ON HUMAN HEALTH

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Abstract

Based on the definition of the National Institute of Environmental Health Sciences (<https://www.niehs.nih.gov/>), "air pollution" is a mixture of natural and man-made substances in the air we breathe. It is usually divided in two different classes: outdoor and indoor. The outdoor air pollution refers to the presence of contaminants out of the home environment, while the indoor one indicate the pollutants usually present within home [1]. The outdoor air pollutants include substances as sulfur dioxide, nitrogen oxides, carbon monoxide, fine particles and several molecules produced by the burning of fossil fuels and by the car exhaust gases. However, another contaminant highly represented in industrialized area is the ozone that seems to have severe irritant effects on epithelial tissues [2]. Indoor air pollutants, instead, comprise chlorinated volatile molecules and formaldehyde, usually contained in shampoos [3].

The presence of excessive levels of pollutants in specific geographic areas highlighted the need to

continuously monitor the air and to regulate the emissions. This monitoring activity led to identify very large contaminated areas that are now called "Siti di Interesse Nazionale" (SIN) and that are subject to remediation intervention (<http://www.isprambiente.gov.it/it/temi/siti-contaminati/siti-di-interesse-nazionale-sin>). Sicily counts more territories classified as SIN and, among these, the most important are Gela (CL), Priolo (SR), Biancavilla (CT), Milazzo (ME) and Termini Imerese (PA). Epidemiological studies showed as in these areas there is a higher incidence of specific diseases, if compared with other regions [4]. In particular, several cases of lung and pancreatic cancer as well as neuroinflammatory and neurodegenerative diseases were diagnosed. Moreover, a higher rate of infertility and of congenital malformations were reported.

The mechanisms by which VOC and particulate matter cause this severe damage are partly known. In particular they act by two different ways. About the DNA, they can induce permanent DNA damage or can modify the

normal gene expression. However, often pathological conditions result from continuous inflammatory stimuli that these molecules trigger on the respiratory epithelial cells, when they are inhaled.

Development of chronic inflammatory diseases after VOC exposure

Most conditions related to air pollution affect the airway tract leading to chronic respiratory diseases. In particular, bronchial asthma is the most common and its worldwide incidence is estimated to increase. PM2.5 was shown to enhance the recruitment of inflammatory cells in bronchoalveolar lavage fluid and to reduce the expression of antioxidant enzymes as SOD1 and GSH leading to an increase of ROS level [5]. Together with oxidative stress, also nitrosative one increases resulting in an induction of apoptosis and decreased autophagy. All these mechanisms become chronic causing the idiopathic pulmonary fibrosis, a fatal interstitial lung disease associated with disruption of alveolar epithelial cell layer [6]. ROS can also cross-link with phospholipids of endothelial cells plasmatic membrane leading to an increase of endothelial permeability and augmented pulmonary endothelial barrier dysfunction [7]. Moreover, a study conducted in China on a cohort of non-smoker patients [8] showed that exposure to PM2.5 can cause the loss of function of the human nasal epithelium barrier by the impairment of the tight junctions present among cells. All these biological responses result in continuous inflammatory stimuli that become chronic after long-term exposure [9].

Air pollutants and cancer

One of the most deleterious effects of air pollutants on human health is related to the increased risk to develop cancer [10]. In particular, lung cancer can originate as consequence of chronic inflammation [11]. The evidence of the correlation between air contaminants and lung cancer is well evident due to the higher number of non-smoker patients

affected by mesothelioma and living in polluted areas compared to number of cases in free countries [12]. Although lung cancer can obviously linked to air pollutant exposure, also other neoplasms seem to be related to the same factors. In particular, the bladder, the kidney, the colon and the pancreas are the other more often affected organs [13].

Infertility and congenital malformations

Exposure to pollutants can cause a particular kind of DNA modification, known as epigenetic modification. This phenomenon leads to the alteration of the normal gene expression in the cells resulting in the development of cardiovascular diseases and metabolic disorders [14]. However, an even more drastic effect of these modification regards the reproductive function. In industrialized areas, indeed, the number of patients affected by idiopathic infertility cases is largely growing due to the defective gametogenesis, in particular in men [15]. Moreover, together with the infertility cases, also the increase of malformed fetuses was reported in these areas [16]. An important study showed an increase of mitochondrial DNA (mtDNA) copy number in placenta of women exposed to air pollutants. The mtDNA is essential for the foetus development and its perturbation can lead to birth defects [17]. Moreover, placental methylation of genes involved in Circadian pathway was also reported and these genes are essential for the correct foetal development [18].

General remarks

Several pathological conditions are related to the bad air quality. Although this issue was neglected for several decades, now this is a very highlighted problem not only for the public opinion. The alarm linked to the high health risk is global. Therefore, many awareness campaigns are started also from Institutions. Air quality monitoring services of the SIN and prevention actions are executed as well as epidemiological studies. One of these is the "SENTIERI - Studio Epidemiologico Nazionale dei Territori e degli

Insedimenti Esposti a Rischio da Inquinamento” project that aims to monitor the mortality rate of citizens living in SIN and to program and prioritize the remediation programs of the same areas (<http://www.epiprev.it/sentieri/home>).

In conclusion, the cooperation between Government in to regulatory emissions and industries in to monitor the quality of the waste substances probably will help to improve the environment and to limit a further worsening of the quality of life.

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