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Genotoxic and cytotoxic properties of PM2.5 collected over the year in Wrocław (Poland)

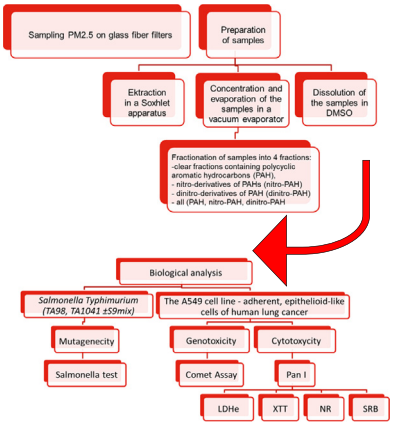
M.K. Bełcik [a,*], A. Trusz-Zdybek [a], E. Zaczyńska [a], A. Czarny [b], K. Piekarska [a]

[a] Faculty of Environmental Engineering, Wrocław University of Science and Technology, Wybrzeże S. Wyspiańskiego 27, 50-370 Wrocław, Poland
[b] Institute of Immunology and Experimental Therapy, Polish Academy of Science, ul. Rudolfa Weigla 12, 53-114 Wrocław, Poland

HIGHLIGHTS

- Wrocław is an agglomeration which is one of the most polluted cities in Poland.
- The obtained results show the genotoxic and cytotoxic effects of the total dust collected over the year in Wroclaw.
- The tests were performed on 4 fractions of PM2.5: mixture of all absorbed pollutants, PAH fraction and its nitro and dinitro derivatives.
- During the research were performed *Salmonella* assay to evaluate mutagenicity, comet assay to evaluate genotoxicity and PAN-I assay to evaluate cytotoxicity.
- Results show differences in properties depending on fraction of particulate matter and time of collection.

GRAPHICAL ABSTRACT



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ABSTRACT

In the ambient is >2000 chemical substances, some of them are absorbed on the surface of the particulate matter and may causes many health problems. Air pollution is responsible for >3.2 million premature deaths which classifies it as a second place environmental risk factor. Especially dangerous for health are polycyclic aromatic hydrocarbons and their derivatives which shows mutagenic and carcinogenic properties. Air pollutions were also classified by International Agency for Research on Cancer to group which carcinogenic properties on human were proved by available knowledge.

Air pollutions, are one of the biggest problem in Polish cities. The article presents results of mutagenicity, genotoxicity and cytotoxicity researches conducted on a particulate matter fraction 2.5 μm collected during all year long in Wroclaw agglomeration (Poland). The material was collected on filters using high-flow air aspirator and extracted using dichloromethane. Additionally it was fractionated into 4 parts containing: all pollutants, only polycyclic aromatic hydrocarbons, nitro derivatives of PAHs and dinitro derivatives of PAHS. Dry residue of this fraction was dissolving in DMSO and tested using biological methods. Biological methods include mutagenicity properties which are investigated by *Salmonella* assay (Ames assay). Other biological method was comet assay and 4 parameter cytotoxicity test PAN-I assay.

Results of the conducted experiments show differences in mutagenic, genotoxic and cytotoxic properties between seasons of collection and between volumes of dust pollutions fractions. The worst properties shows particles collected in autumn and winter season Results showed also some correlations in results obtained during different methods and properties. Due to the limited possibilities of testing all chemical compounds present in

* Corresponding author.
E-mail addresses: maciej.belcik@pwr.edu.pl, agnieszka.trusz-zdybek@pwr.edu.pl (M.K. Bełcik).

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the PM2.5 fraction, it is recommended to carry out tests based on a set of genotoxic and cytotoxic tests, which is confirmed by the conducted research.

1. Introduction

More than 2000 chemical substances occur in the environment. Some of them are adsorbed on the surface of particulate matter. Substances present in the air form a complex mixture of unknown properties. Substances adsorbed on the surface of particulate matter include metals, polycyclic aromatic hydrocarbons (PAHs), aromatic hydrocarbons, phenols, organic compounds containing chlorine, and many more (Alves et al., 2015; Bełcik et al., 2017; Borgie et al., 2015; Cachon et al., 2014; Callén et al., 2013; Claxton et al., 2004; Lepers et al., 2014; Vinitketkumnuen et al., 2006).

Dust pollution causes many health problems and even premature death, particularly due to cardiovascular and respiratory reasons. Research by Burns and Lim (2014) showed that air pollution is responsible for >3.2 million premature deaths. This classifies it on the second place among environmental, and ninth among global risk factors. Air pollutants, including particulate matter, can also cause airway diseases such as asthma, pneumonia, and disorders of lung function and cardiovascular system which may lead to heart attacks. Such diseases caused by particulate pollution of the air are observed not only among groups exposed to environmental risks such as children and elderly people, but also in the potentially healthy part of the population (Burns et al., 2014; Lim et al., 2014; Loomis et al., 2013; Pope III and Dockery, 2006; Rückerl et al., 2011; Stieb et al., 2002).

Polycyclic aromatic hydrocarbons (PAH) and their nitro- and amino derivatives (Purohit and Basu, 2000; Brunekreef and Holgate, 2002; Cohen, 2000; Lewtas, 2007; Ohura et al., 2013; Risom et al., 2005) are particularly dangerous for health, showing mutagenic and carcinogenic properties. A lot of such pollutants adsorb on suspended dust particles of various sizes. Their harmfulness for organisms depends on the diameter of dust particles. The finest dust fraction, with particle diameters below 2.5 μm, also called PM2.5 fraction, is the most dangerous for human and animal health. Particles of this fraction penetrate farthest deep down into the respiratory tract, and deposit in the alveoli (Araujo and Nel, 2009; Künzli et al., 2000; Loomis et al., 2013; Novák et al., 2014; Park et al., 2011; Steiner et al., 2013).

Based on available knowledge and evidence reported on studies on air pollution, in October 2013, 24 experts from 11 member countries of the International Agency for Research on Cancer (IARC) classified particulate matter in group 1 of genotoxic substances. The classification groups chemical substances into 4 groups identifying their harmful genotoxic properties.

In May 2016, WHO published a report presenting cities around the world with exceeding levels of air pollution involving particulate matter fraction 10 μm (PM10) and 2.5 μm (PM2.5). The report presents many Polish cities as the most polluted regions in the European Union. One of the cities with a high level of particulate matter air pollution mentioned in the report is Wrocław, with annual mean of PM10 amounting to 36 $\mu g/m^3$ and 29 $\mu g/m^3$ for PM2.5. The presented data are from 2013. They were provided by the European Environment Agency (WHO, 2016).

The assessment of the degree of air pollution is made by determining the concentration of suspended particulates and PAHs included in the United State Environment Protection Agency (USEPA) list, and then comparing their value with the permissible values determined by law. Detection and identification of many pollutants based on chemical analysis is expensive and requires the use of modern analytical techniques. Chemical methods examine the concentrations of specific compounds or their groups. The research based on the use of living organisms characterized by special sensitivity to toxic and genotoxic substances

Fig. 1. The map of Wrocław with a marked location where dust samples PM were taken.