Assignment 1: Indoor ultrafine particles from traffic

Ultrafine particles (UFP), or $PM_{0.1}$, are particles less than 0.1 μm in diameter. UFP's are formed by chemical reactions between gases (Jeong et al., 2019). UFP's from traffic are formed by condensed semi volatile organic compounds that come from vehicle emissions. The burning of fossil fuel in vehicles produces reactive oxygen molecules which bind to chemicals released from combustion and chemicals in the air to make UFP's more toxic (Kwon et al., 2020).

UFP's have a large surface area per unit of mass due to their small size. Their surface area enables them to have a higher reactivity and absorb chemicals for transport through the body (Kwon et al., 2020). Their size enables them to penetrate cells (Campagna et al., 2016) by moving across the cell's lipid bilayer (Schraufnagel, 2020). UFP's can travel through the respiratory system to alveoli, the circulatory system, (Kwon et al., 2020) and locate in multiple tissues and organs (Downward et al., 2018) including the GI tract (Schraufnagel, 2020). UFP's are also able to deposit onto other surfaces in the environment (Kwon et al., 2020).

UFP's disperse into the atmosphere when they are emitted by vehicles, and form clusters or "hot spots" in areas of high concentrations (Schraufnagel, 2020). Atmospheric and traffic conditions can increase the concentrations of UFP's present. Humidity increases, minimal air movement, seasons, vehicle speeds, and vehicle combustion sources such as diesel can increase the number of UFP's present (Schraufnagel, 2020; Tong et al., 2016). Nyarku et al. (2021) reiterated that wind and vehicle density affect UFP concentrations. Heavy traffic increases UFP concentrations since vehicles doing full stops then accelerating again emit more UFP's. Idling vehicles, especially diesel vehicles, also increase UFP concentrations (Schraufnagel, 2020).

In indoor settings, UFP's caused by traffic are found due to buildings not being airtight and natural ventilation systems such as open windows or doors (Miller et al., 2017). Window

size and location as well as wind speed play a role in how much UFP's can diffuse (Tong et al., 2016). A study in preschools found elevated levels of UFP's indoors in the mornings and late afternoons which was attributed to both traffic density outdoors and behaviors such as indoor cooking (Gaspar et al., 2018). Similarly, indoor UFP's were attributed to traffic emissions and outdoor burning in a community in Africa (Nyarku et al., 2021). Campagna et al. (2016) found that UFP's were found inside an airport since UFP's are produced by airplane emissions.

Multiple studies found that UFP concentrations were higher closer to the emission source for UFP's from airplane and vehicle traffic (Campagna et al., 2016; Jeong et al., 2019). Outdoor traffic UFP concentrations accounted for 34% of the concentrations found indoors (Jeong et al., 2019). A downtown area with higher vehicle traffic density had 15% more UFP concentrations indoors than areas that were farther from roads, had less roads, less vehicle traffic, and had shorter road lengths. Similarly, Tong et al. (2016) found higher UFP concentrations indoors in areas closer to freeways. Due to diffusion, UFP's were less likely to be found across buildings and in rooms that were farther from the emission source (Tong et al., 2016).

Health effects of UFP's include lung inflammation, allergies, asthma, neurodegeneration, and DNA degeneration (Jeong et al., 2019). They can lead to cardiovascular disease, oxidative stress, inflammation of organs, atherosclerosis, and chronic obstructive pulmonary disease (Downward et al., 2018). Lastly, they can increase risk of stroke, hypertension, diabetes, cancer, and low birthweight (Schraufnagel, 2020). Children are most susceptible to negative effects from UFP's (Campagna et al., 2016). UFP acute effects usually have delayed symptom onset ranging from 1-5 days (Schraufnagel, 2020). Not much is known of the role of lag times in long-term health effects (Schraufnagel, 2020). Further research is needed considering UFP's are thought to have a larger impact on coronary health risks than PM2.5 (Downward et al., 2018).

References

Campagna, Marcello, Andrea Frattolillo, Sergio Pili, Gabriele Marcias, Natalia Angius, Costantino Carlo Mastino, Pierluigi Cocco, and Giorgio Buonanno. "Environmental Exposure to Ultrafine Particles inside and Nearby a Military Airport." *Atmosphere* 7, no. 10 (2016): 138. http://dx.doi.org/10.3390/atmos7100138.

Downward, George S., Nunen Erik J. H. M. van, Jules Kerckhoffs, Paolo Vineis, Bert Brunekreef, Jolanda M. A. Boer, Kyle P. Messier, et al. "Long-Term Exposure to Ultrafine Particles and Incidence of Cardiovascular and Cerebrovascular Disease in a Prospective Study of a Dutch Cohort." *Environmental Health Perspectives* 126, no. 12 (n.d.): 127007. https://doi.org/10.1289/EHP3047.

Gaspar, F. W., R. Maddalena, J. Williams, R. Castorina, Z.-M. Wang, K. Kumagai, T. E. McKone, and A. Bradman. "Ultrafine, Fine, and Black Carbon Particle Concentrations in California Child-Care Facilities." *Indoor Air* 28, no. 1 (2018): 102–11. https://doi.org/10.1111/ina.12408.

Jeong, Cheol-Heon, Sepehr Salehi, Joyce Wu, Michelle L. North, Jong Sung Kim, Chung-Wai Chow, and Greg J. Evans. "Indoor Measurements of Air Pollutants in Residential Houses in Urban and Suburban Areas: Indoor versus Ambient Concentrations." *Science of The Total Environment* 693 (November 25, 2019): 133446. https://doi.org/10.1016/j.scitotenv.2019.07.252.

Kwon, Hyouk-Soo, Min Hyung Ryu, and Christopher Carlsten. "Ultrafine Particles: Unique Physicochemical Properties Relevant to Health and Disease." *Experimental & Molecular Medicine* 52, no. 3 (March 2020): 318–28. https://doi.org/10.1038/s12276-020-0405-1.

Miller, Shelly L., Nick A. Facciola, Darin Toohey, and John Zhai. “Ultrafine and Fine Particulate Matter Inside and Outside of Mechanically Ventilated Buildings.” *International Journal of Environmental Research and Public Health* 14, no. 2 (February 2017): 128. https://doi.org/10.3390/ijerph14020128.

Nyarku, Mawutorli, Giorgio Buonanno, Francis Ofosu, Rohan Jayaratne, Mandana Mazaheri, and Lidia Morawska. “Ultrafine Particles in Key Microenvironments in Rural and Urban Areas of Ghana.” *Atmospheric Pollution Research* 12, no. 11 (November 1, 2021): 101212. https://doi.org/10.1016/j.apr.2021.101212.

Schraufnagel, Dean E. “The Health Effects of Ultrafine Particles.” *Experimental & Molecular Medicine* 52, no. 3 (March 2020): 311–17. https://doi.org/10.1038/s12276-020-0403-3.

Tong, Zheming, Yujiao Chen, Ali Malkawi, Gary Adamkiewicz, and John D. Spengler. “Quantifying the Impact of Traffic-Related Air Pollution on the Indoor Air Quality of a Naturally Ventilated Building.” *Environment International* 89–90 (April 1, 2016): 138–46. https://doi.org/10.1016/j.envint.2016.01.016.