

# [Sources of particulate matter: an overview](https://assignbuster.com/sources-of-particulate-matter-an-overview/)

A brief summary of the sources of particulate matter (PM) will be presented. The will be a brief overview of ‘ particulate matter’ in regard to sources, history and additionally there will informative discussion such as PM levels as set by authoritative regulations.

Discussion will include the different sources of particulate matter and with specific attention to emission vehicle fuel sources, since they are the largest contributors of PM in the environment (1, 2). Lastly, A brief discussion of the different metals found in ambient PM will be discussed and their health effects, these include copper, zinc and iron (4).

There are several sources from which particulate matter finds itself into the environment and ultimate humans, inhalation is the typical mechanism in which PM enters the body and is then absorbed during gas-exchange in the lungs (3). Therefore there will be a brief summary of the health effects of particulate matter (PM).

## Discussion – Overview and a brief history

Particulate matter (PM) is a world wide problem; one of the major sources of PM is vehicle traffic and as a result it has been the subject of various epidemiological studies (1). Studies on PM have shown that particle size plays a key role on the adverse effects cause by PM concentrations (1). For example, studies have shown that children living near higher have larger risk of developing asthma and allergies from dust (2). Studies have also shown that the density of vehicles traffic does not account for differences in PM toxicity between similar communities; it therefore indicates that particle chemistry also plays a role in health effects (1, 2).

Particulate matter is typically composed of organic and inorganic materials and source are both natural and anthropogenic (1). Thus particulate matter can be divided in to two groups, Primary PM and Secondary PM: Primary PM can be the direct result of fossil fuel combustion, natural wood combustion, volcanoes, soil dust, pollen, smelting, mining and milling process (3). Secondary PM are created by chemical reaction of primary PM such as SO2, nitrogen oxides (NOx) and Ammonia (NH3), for example the formation of ammonium nitrate (NH4NO3) (3). However, Volcanoes, wildfires and other can contribute to both primary and secondary PM (3). Other natural sources include volatile organic compounds (VOC) from trees, vegetation and emission of gases such as sulfur from wet lands (3, 8).

Particle size pertaining to both primary and secondary PM can be subdivided into size fractions: Large particles are > 30µm and smaller particles are divided into PM2. 5 (<2. 5 µm) and PM10 (<10 µm) and lastly there are ultrafine particles of (<100 µm) (1, 2). In the atmosphere, Total suspended particles (TSP) concentrations usually have higher concentrations of PM2. 5 and PM10 than larger particles (> 30µm) since these are only suspended for short periods of time (1) (see figure 1 (6. PM of sizes smaller then 1 µm are consider to cause the most adverse effect since these can penetrate the pulmonary alveoli (part of the respiratory system for gas-exchange in the lungs) (1). Although particle size is a factor in the penetration capabilities of PM into the alveoli, another factor is the chemical composition of the PM (1). Some of the pollutants that are part of PM composition include heavy metals, polycyclic aromatic hydrocarbons (PAHs), and acid aerosols among others (1).

PM is considered one of the 6 criteria pollutants by the Environmental Protection agency (7). Additionally, The U. S. Clean Air Act and set by the EPA has established that the primary standard for the protection of human heath is PM10 at 150µg/m3 (24 hrs) and PM2. 5 at 35µg/m3 (24 hrs) and 15µg/m3 (Annual) (7). The EPA recognizes that there is no threshold for the adverse health effects from long term exposure to PM10 therefore the annual PM10 standard has not been accepted (7).

In Canada, Air Quality objectives where first established in the 1970s and revised in 1980 under the knowledge that PM could cause adverse effect only in severe pollution loads (8, 9). However, it was not until the 1990s that serious health effects where identified for low levels of fine particles such as PM2. 5 and PM10 (8, 9). As result, PM10 and PM2. 5 where consider to be toxic and where included in the Canadian Environmental protection Act (CEPA, 1999), the Canada-Wide Standard (CWS) goal (set in 2000) for Canada ambient air quality are PM2. 5 < 30µg/m3 (24 hrs) by 2010 (9) (see figure 2 and table 1 for CWS across Canada). Additionally, in 2003 the secondary pollutants forms of PM2. 5 such as sodium oxides, nitrogen oxides and volatile organic compounds where consider to be toxic and added to CEPA (7). Lastly, Canada and the United States joined together to corporate in the reduction of PM under the Canada-United States Border Air Quality

Strategy (1991) (12).

As mention above, urban traffic is one of the major sources of PM; some studies in Copenhagen found that traffic accounts for about 13% for PM10 and 35% to 50% of PM2. 5 (1). Most of vehicles today run on combustion engines using fossil fuel such as gasoline and diesel (diesel engines are known to contribute significantly in greater quantities to PM concentrations then gasoline engines) (1). Other sources of PM from vehicle traffic include brake pad wear, tire wear, and by physical resuspension of dust (1).

One of the challenges of studies on PM is to identify the source of the PM (1). Researches know that PAH and some of its derivatives are created via combustion of fossil fuel (1, 2). It is a selection of PAH derivates together with other organics chemicals such as hopanes and steranes (from lube oil) that are used in the identification of PM from traffic sources (1, 2). Dynamometer test which is used for the measurement of HP and torque of engines provide a good control environment to adequately measure PM from engines, since exhaust lines are attached to collection and detection instruments (2). The only difficulty or limitation in dynamometer test is that real life environment of urban traffic has other factors that contribute to the overall PM concentrations, these include the age of the vehicle, maintenance history, size of engines (expensive to test every size engine), atmospheric interactions/reactions with other chemicals and other dust contributors like brakes dust etc (2).

## Vehicle Emission a source of PM – Los Angeles, CA study

Because of the challenges presented for vehicle emissions there have been studies conduction in traffic tunnels, these present researchers with unique control environment (2). The only limitation of tunnel test is that it does not account for cold start emission since it only measures the vehicles through the driving conditions of the tunnel, secondly the tunnel may present different conditions than ambient conditions such as dilution with air, temperature and humidity (2).

Gas chromatography-mass spectrometry (GC-MS)) is the preferred method for the detection of atmospheric PM in the environment (2). The methods for identifying primary PM from gasoline and diesel engines has been to identify for example hapanes & steranes and tracing back of these chemicals using a chemical mass balance (CMB) (2). Other tracers include high molecular weight benzo perylene (BgP) for high powered gasoline vehicles and light molecular weight PAHs for diesel vehicles (2).

A study was conducted in two freeways: 1. the Interstate 710 (I-170) who’s traffic compositions is a mixture of gasoline power vehicles with a percentage of heavy-duty diesel vehicles. 2. The California freeway 110 (CA-110) in which traffic is normally composed of mainly gasoline power vehicles (2). During the study it was found that concentration level of hapanes, steranes, BgP and high molecular weight PAHs where similar comparable in both CA-110 and I-710 (2). However, there was higher level of elemental carbon (EC) and low molecular PAHs in I-710 as is expected due to the higher concentration of diesel vehicles (2). Measurements on site for CA-110 and I-710 locations where conducted using a custom built collection sampler able to measure 450 liter/minute (lpm) (2). The samples where then separated into:

Coarse-Dp <2. 5 µm, accumulations - 0. 18 µm Table 2, shows that organic levels where higher in both CA-110 and I-710 than in the background site but not by a significant amount, hence suggesting a significant impact on PM levels form vehicles emissions at the background site (2). Table 3 compares the results of highway CA-110 and I-710 into chemical species (2)

As mention above, studies have been done in tunnels since these present unique control environments in order to study emission factors (EF) and therefore appoint specific PMs to vehicle emissions (2). The study of the California freeways also compared the CA-110 & I-710 PM concentrations (hopanes, steranes, BgPs and high molecular weight PAHs) to those measured in the Caldecott tunnel, Berkley, CA. As a result of the study, PM such as: hopanes, steranes, BgPs and high molecular weight PAHs could be traced back to emission factors (EF), this was done by comparing the concentration these chemicals to the tunnel results (2).

Table 4 & 5 shows a comparison of the levels of hapanes, steranes, and PAH between CA-110, I-710 and Caldecott tunnel (See table 4 and table 5) (2). It is evident form these table that similar concentrations distribution between the freeways and tunnel (2)

## PM Health Effects

Particulate matter has been reported as causing respiratory and cardiovascular health effects (4). It has been found that metals from PM enter the cardiovascular system after it has passed thought the pulmonary system; these metals can thus have negative health effect in other organs that are part of the cardiovascular system such as the hearth (4). Particulate matter metals come from both natural and anthropogenic sources and can be found suspended in the atmosphere, dissolve in water and/or at ground level in the form of colloids (4). Ground level PM can be a health risk of infants since because of their close proximity to the ground, low body mass, rapid respiration and also can affect children with the eating disorder known as ‘ pica’ (disorder to eat non food items such as soil and paint flakes)

The most common metals found in PM are: iron, copper, zinc, nickel and vanadium (4). Brake pads wear from vehicles is a common source of copper and zinc is part of tire rubber vulcanization, hence both of these metals are commonly found on the atmosphere near highways (4). Vanadium and nickel are typically a common result of the smelting process and industrial oil combustion (4).

As mentioned above, pulmonary system is affected by PM exposure; these can lead to pulmonary inflammation and even death (4). Pulmonary inflammation can lead to health effects such as atherosclerosis (arteriosclerotic vascular disease) and can lead to blood cloths (thrombosis) by activating the coagulation process (4). Additionally, pulmonary inflammation can have a direct result in the cardiovascular system and nervous system thus causing irregular heart rate and ultimately can be the cause of death via cardiac dysrhythmia (4) (see figure 2 (12).

## Conclusion:

Particulate matter as source from natural and anthropogenic sources will continue to be the subject of many health impact studies. These studies include the allocation of PM point sources. These studies will aid in the understanding PM transport methods and will aid how to reduce PM levels. For example better materials for brake pads can be used, and/or catalytic converters with higher efficiency can be part of the exhaust systems of all transportation vehicles.

Air transportation is a major route for PM2. 5 and PM10, these light particulate matter are not detained by national border and therefore collaboration between nations such as the US and Canada are important agreements in order to joint together in the reduction of PM not just in North America but also world wide.