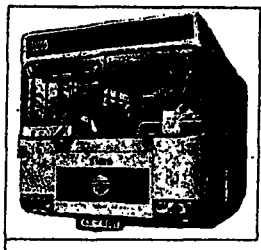


MOTORIZATION & AIRBORNE PARTICULATES AND OUR HEALTH

Clean air, an essential component of a healthy environment, is a mixture of many gases. Predominantly two gases: Nitrogen, which makes up 78 percent of the volume of clean dry air and Oxygen, which is 21 percent. An inert element Argon, and the remainder includes very small or trace concentrations of Carbon dioxide, Methane, Hydrogen, Helium, Ozone and other gases.

Air quality of the Colombo Metropolitan area has been declining over the past decade due to the reasons associated with rapid urbanization and motorization. Attention of the general public and the law enforcing officers are presently focused to the visible smoke emissions and not to the colorless and odorless toxic gases. Studies carried out by the various institutions have highlighted that the air quality has deteriorated to health hazardous limits and continue to do so. It is reported that, respiratory system diseases among the children are on the increase during the past couple of years and lead contents in the blood samples obtained from the traffic police officers who frequently exposed to automobile emissions have reached threshold level.

Combustion byproducts emitted by combustion of fossil fuels (automobiles, power generation, heating, factory use etc.), indiscriminate open burning of refuse & factory emissions considered as the main source of air pollution in the Colombo City;

Out of the described sources of pollution, automobile emissions are in the great magnitude and the emissions contain following health hazardous elements: Carbon Monoxide (CO), Nitrogen Oxides (NOx), Lead (Pb), Sulphur Oxides (SO2, SO3), Soot and unburned hydrocarbons, **Particulate Matter (PM 10, PM 2.5).**

The problem of **particulate matter** specifically and air pollution as a whole, has been aggravated by the large number of public and private owned vehicles which are poorly maintained and outdated. In addition large number of two and three wheelers powered by two stroke engines emits white smoke with partly burnt gasoline and lubricant oils which is also very rich of **particulate matter.** Annual average for Particulate Matter at the Fort-Railway-Air Quality Monitoring Station is 150 micro grams/m3. But according to the national air quality standard it should not exceed 100 micrograms/m3. Though the situation in Colombo is such, no attention is being paid yet, to the problem of Air Borne PM and its human health effect.

Based on results from recent epidemiological and toxicological studies, this article attempts to give an insight; ***How does Airborne Particulate Matter (PM) cause adverse health effects and pose greatest risk to human health?***

Particulate Matter (PM) *is a complex mixture of solid or liquid particles suspended in the air that vary in size and composition.* Epidemiological studies have shown associations between short-term exposure to PM and increases in morbidity and

Dr. Ruwan Wijayamuni *

mortality, particularly among individuals with respiratory or cardiovascular disease.

Over the past decade, many epidemiological studies using advanced statistical techniques have shown an association between short-term exposure to PM levels and increases in daily mortality and symptoms of certain illnesses. For example, they have shown an increase in death due to respiratory and cardiovascular diseases and a worsening of symptoms in people with asthma.

Widespread exposure to particles may significantly affect public health. Studies of specified populations ("Cohort" studies) conducted over prolonged time periods in different communities have reported associations between long-term PM exposure and increased death rates due to cardiovascular disease as well as an increased incidence of respiratory disease.

It has been known for decades that short-term exposure to high levels of PM air pollution is associated with increases in the number of deaths (e.g. in air pollution episodes such as the thick London fogs of the 1950s). A resent study discovered persistence of epidemiological evidence of PM's effects on mortality and morbidity even when alternative explanations have been largely addressed.

The sources of Airborne Particles

The sources of PM are numerous; naturally occurring processes and human activities all contribute to total ambient PM. Naturally occurring PM includes road side dust, sea salt in coastal areas and biologic material in the form of pollen, spores or plant and animal debris. In urban environments, particles arise mainly as a result of combustion from mobile sources such as cars, buses, ships, trucks and construction equipment and from stationary sources such as heating furnaces, power plants and factories. A significant fraction of PM, referred to as secondary particles, are produced by chemical reactions in the atmosphere; nitrogen oxides, sulfur dioxide and organic compounds react with ozone and other reactive molecules (including free radicals) to form nitrates, sulfates and other particles.

People are exposed to PM not only indoors, from cigarette smoke, home cooking sources (such as wood burning stoves) but also from outdoor PM sources that easily penetrates the indoor environment. Indoor exposure may be substantial because this is where most people spend the majority of their time. However, in the outdoors, people tend to be more active, which increases respiration, and may inhale a larger amount of air in any given time period than people who remain indoors.

The Physical and Chemical characteristics of Particles

PM is a complex mixture of solid and liquid particles which can vary in size, composition and concentration, depending on the sources generating the particles and such factors as geographic location, season, day and even time of day.

Size

The size of ambient air particles ranges over a wide scale, from approximately the size of just a few atoms to about the thickness of a human hair (0.005 to 100 um in diameter).

Exposure to airborne particulates and its Ill Affects on Cells & Tissues

The body responds to particulate exposure with the same multi-layered defense system that is used to defend itself against other foreign material such as bacteria and viruses. That is, by attempting to prevent entering and then by

* Leader of Research Team investigating Blood Lead Levels and Related Health Impacts of City Traffic Policemen.

trying to expel the foreign matter. The first important barrier is cells and fluids that the foreign material must get through before it enters the tissues of the body. Fluid secretions, such as mucus lining the airways and ciliated cells are important elements of this system. Thus, many particles, especially larger ones, are trapped and removed by the nose. Particles irritating receptors on nerve cells in the airways, trigger sneezing and coughing, which also helps to remove PM. In addition to these mechanisms, epithelial cells are tightly joined at the surface of a tissue, preventing material from entering between the cells.

If foreign material gets past these defenses and enters the tissue, a second line of defenses is activated. The "scavenger" cells known as macrophages (white blood cells that reside in the tissues and in the air spaces of the lungs) and neutrophils (white blood cells found in the blood stream that supplies the lung and other tissues) ingest the foreign material and attempt to destroy it. This inflammatory response to particulates may damage the epithelial cell layer at the surface of the tissue and other cells in the airway (such as macrophages), which results in the loss of integrity of the tissue's defenses. As a consequence there may be increased exposure to and reduced capacity to defend against microorganisms.

One of the proteins (cytokines) produced by the inflammatory response in the airways stimulates the liver to secrete a set of molecules known as acute-phase reactants. These molecules, which include C-reactive protein and fibrinogen, appear in the circulation within 6 to 24 hours. Fibrinogen binds to platelets and contributes to their aggregation. This can result in increased coagulability (enhanced ability of the blood to clot) and multiple effects throughout the cardiovascular system. Also some studies indicate that ultrafine particles in particular or components that may detach or dissolve from particles may move out of the airways and rapidly gets into the bloodstream and reach other tissues to trigger effects at distant sites. Epidemiological studies have also described associations between PM exposure and other vascular factors which are independently associated with increased risk of cardiovascular disease, such as fibrinogen, plasma viscosity, platelet count, C-reactive protein, endothelin levels and blood pressure, which could affect susceptibility to the acute effects of PM.

The PM may lead to higher levels of fibrinogen, in tern increasing plasma viscosity and the ability of blood to coagulate. This may result in an increased tendency to form clots and thrombi which means, aggregations of platelets and other blood components causing vascular obstruction. Aatherosclerosis, which is characterized by a thickening and hardening of the arteries with deposits of cholesterol and other fats, plus fibrin and inflammatory cells (formation of a plaque) and narrows the arteries and decreases the arterial blood flow. In atherosclerosis, the functions of endothelial cells, the cells lining the blood vessel are also impaired. This results in additional production of mediators that promote vasoconstriction, the narrowing of blood vessels. Therefore it is obvious that individuals with atherosclerosis are particularly at risk

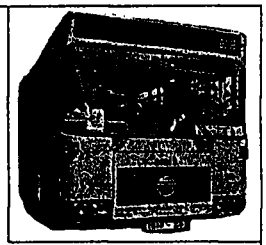
If a thrombus form on the plaque's surface or bleeding occur into the plaque, the entire artery may be blocked. If this occurs in a coronary artery, the supply of oxygen to the heart muscle is reduced or cut-off. This condition is known as myocardial ischemia and may lead to heart damage and arrhythmias, disturbances in the rhythmic beating of the heart. Arrhythmias, such as ventricular fibrillation, may have serious and potentially fatal consequences because they can lead to a myocardial infarction - MI (heart attack). In addition to vascular changes that result in arrhythmias, may also develop as a consequence of changes in the neural control of heart function. Annette Peters and colleagues have tried to explore a link between short-term exposure to PM 2.5 and the rapid incidence of MI. They have evaluated a small group of patients whose arrhythmias were controlled by an implanted cardiac defibrillator, whether exposure to air pollution and ultrafine particles, could have triggered the nonfatal infarction. Their findings indicate the triggering of the implanted cardiac defibrillator was associated with ambient levels of PM 2.5 and PM10.

Deposition of particles in the airways can stimulate nerve cells in the underlying tissue as well. Activation of these cells has been suggested to lead to changes in the nervous system's control of the pattern of breathing, the heart rate and heart rate variability and to affect other cardiac electrophysiological parameters. Such changes may be rapid and temporary and may resolve quickly; but changes may last longer depending on the level and pattern of exposure and the PM type to which the host is exposed. Stephen Holgate and colleagues found airway inflammation in healthy subjects after exposure to diesel exhaust. They evaluated in healthy people and in those with mild asthma the effects of exposure to a lower concentration of diesel exhaust than they had used in earlier studies. They found small increases in inflammatory markers (such as lung neutrophil levels) in healthy but not asthmatic subjects. One possible consequence of such damage to the airways in that the individual may become more susceptible to respiratory infections if exposed to viruses or bacteria. A second possible consequence is that it may decrease respiratory function in a person whose airways are already damaged by conditions such as Bronchitis or Asthma. As a result, the symptoms of Asthma for example may be exacerbated.

On individuals whose airway, cardiac or vascular tissues have been previously damaged, these changes are thought to have a greater impact.

Toxicity features of particles

Several recent epidemiological studies have reported associations between various health effects and different sizes and/or chemical components of the particles to which the study populations had



been exposed. In a recent study in Germany, levels of both fine and ultrafine (PM<0.1) particles were associated with increased mortality. These findings provided the first evidence that ultrafine particles were associated with human mortality, but did not indicate whether ultrafine particles were more toxic than larger particles. Erich Wichmann and colleagues characterized the sizes of particles in the ambient air of Erfurt Germany, reported that over a three-year period the concentrations of both ultrarfine and fine particles (PM 0.1-2.5) were associated with increased daily mortality. In another study, Morton Lippmann and colleagues found that four of the five size fractions they evaluated were associated with increased morbidity and mortality. These were total suspended particles sizes upto about 40 um in aerodynamic diameter found in ambient air; PM10; PM10-2.5 and PM2.5. The magnitude of the association was similar for all four fractions. The largest particle size fraction (between 10 um and about 40 um) was not associated with increased morbidity and mortality. The investigators also reported that the particles fractionated by size were more significantly associated with health outcomes than were the two chemical components of ambient PM, acidity and sulfate, evaluated in the study.

Conclusion

Most of the studies conducted throughout the world draw a more complete picture of the cardiac, pulmonary and vascular effects of PM exposure in humans. Though the reported results are not always consistent from study to study, previously cited epidemiological studies show that people with respiratory or cardiovascular disease are more susceptible to the effects of PM exposure. In conclusion study findings present a credible view of how even low-level exposure to PM may alter the cardiovascular and pulmonary systems and pose a great threat to people even without underlying cardiovascular or respiratory conditions.

Though the Air Borne PM situation in Colombo is bad and getting worse day by day, no attention is being paid yet, to this problem and its human health effects. Accordingly it is essential to take prompt action to reduce PM in air that we all breath. Otherwise, it will reverse all our achievements in the *life expectancy at birth* (which is 72 years and 74 years for males and females respectively) that Sri Lankans are enjoying today and will lead our nation to not only to poor quality, unhealthy life but also premature death.

Hence, the civil society, regularly institutions, relevant ministries, industries and local authorities have an urgent and important role to play in protecting public health●