environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

# THE HEALTH IMPACT OF VEHICLE EMISSIONS


**Abednego Baker**

Senior Technical Advisor: Risk Assessment, Department of Environmental Affairs

# INTRODUCTION

- Motor vehicles are a major source of air pollution with significant impact on exposures in the ambient environment [1].
- Sources are categorised into on-road e.g. light duty vehicles, trucks, motor cycles; and off-road e.g. vehicles, equipment and engines used off road in situation such as construction and agriculture[2].
- Motor vehicles contribute 50% nitrogen oxide ($NO_x$ and hydrocarbons in urban areas[1].
- In 1998 in the U.S., on-road and off-road sources contributed about 75% of carbon monoxide (CO), 50% of $N_x$ and 40% of volatile organic carbons (VOCs)[3].

[1]HEI, 2010; NAS, 1988 [2]HEI 2010; [3]NAS, 2001

# INTRODUCTION CONT…

***Source: China Daily***

- Air pollution mixture is dependent on among other characteristics, the traffic pattern, fleet composition, the proximity of vehicles to the roads and the availability of other pollution sources[1].
- Exposure of the population is influenced by the concentration of air pollution and the activities of the population[1].

[1]WHO, 2005

# EXPOSURE ASSESSMENT

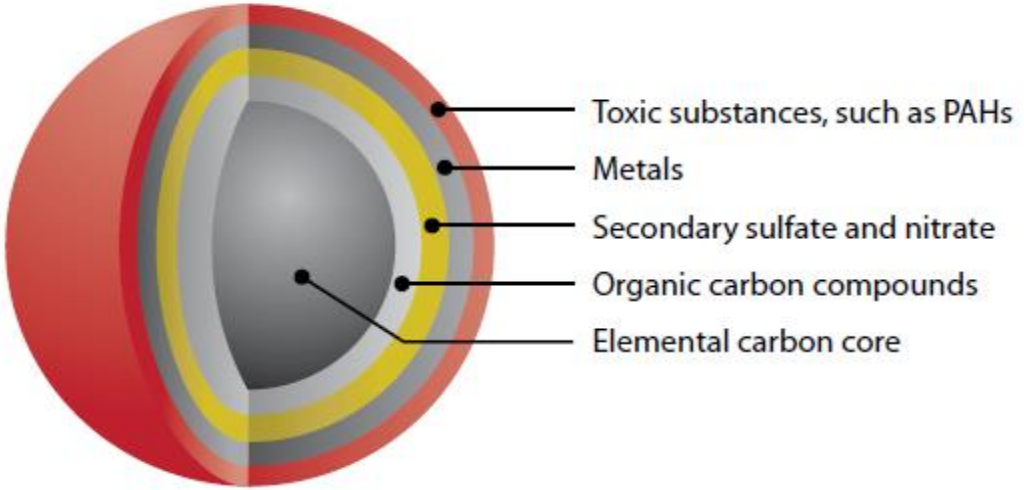
- Emissions from the urban environments are exacerbated by both adverse meteorological conditions and topographic constraints[1].
- Fairy high levels of secondary pollutants can be formed from vehicular emissions in the urban environments[1].
- The emission of $NO_x$ and reactive hydrocarbons are believed to have a significant contribution to ozone ($O_3$) and some oxidising compounds (such as hydrogen peroxide and hydroxyl radical known to influence the oxidation of sulphur dioxide ($SO_2$) to sulphate and $NO_x$ to nitric acid and nitrate) concentrations[1].

Dina Cappiello, Associated Press, 2013

[1]NAS, 2001

# EXPOSURE ASSESSMENT CONT…

- Air pollutants such CO, hydrocarbons, $NO_x$, particulate matter (PM), benzene, formaldehyde, acetaldehyde, 1,3-butadiene, $O_3$, nitrates, inorganic and organic acids are emitted by motor vehicles[1].
- Diesel PM, which is made up of elemental carbon, soluble organic carbon, metallic compounds and trace elements are also released[1].




***Elementary composition of diesel particle. Source: NWS DECC, 2008***

[1]US EPA, 2002

# EXPOSURE ASSESSMENT CONT…

| Pollutant (and measurement unit) | City | Near-road | | Distant | | Ratio | Source |
|---|---|---|---|---|---|---|---|
| | | Distance from road (m) | Concentration | Distance from road (m) | Concentration | | |
| Carbon monoxide (ppm) | Los Angeles | 17 | 2.3 | 150 | 0.4 | 5.8 | Zhu et al. (2003) |
| Benzo[a]pyrene (ppb)[a] | Huddersfield | <31 | 0.00087 | 62–920 | 0.00454 | 1.0 | Kingham et al. (2000) |
| | Huddersfield | <31 | 1.98 | 62–920 | 1.15 | 1.1 | Kingham et al. (2000) |
| Benzene (µg/m³) | Delft | 15 | 2.6 | 305 | 1.9 | 1.4 | Roorda-Knape et al. (1998) |
| | Overschie | 15 | 1.8 | 133 | 1.9 | 1.0 | Roorda-Knape et al. (1998) |
| PAH (µg/m³) | Huddersfield | <31 | 0.108 | 69–920 | 0.221 | 1.0 | Kingham et al. (2000) |
| | Huddersfield | <20 | 39.0 | 20–160 | 27.4 | 1.4 | Smallbone (1998) |
| | Delft | 15 | 47.8 | 305 | 30.6 | 1.6 | Roorda-Knape et al. (1998) |
| Nitrogen dioxide (µg/m³) | Overschie | 15 | 44.8 | 260 | 32.1 | 1.4 | Roorda-Knape et al. (1998) |
| | Tokyo | <20 | 60 | >150 | 32 | 1.9 | Nakai et al. (1995) |
| | Huddersfield | <31 | 1.25 | 62–920 | 1.06 | 1.2 | Kingham et al. (2000) |
| | Osaka | 5 | 44.0 | 150 | 36.0 | 1.2 | Funasaka et al. (2000) |
| PM10 (µg/m³) | Delft | 15 | 32.2 | 305 | 30.6 | 1.1 | Roorda-Knape et al. (1998) |
| | Overschie | 15 | 32.1 | 260 | 32.3 | 1.0 | Roorda-Knape et al. (1998) |
| PM2.5 (µg/m³) | Delft | 15 | 20.1 | 305 | 18.5 | 1.1 | Roorda-Knape et al. (1998) |
| | Overschie | 15 | 20.8 | 260 | 19.6 | 1.1 | Roorda-Knape et al. (1998) |
| | Huddersfield | <31 | 17.8 | 62–920 | 19.5 | 1.1 | Kingham et al. (2000) |
| PM1.0 (µg/m³) | Osaka | 5 | 44 | 150 | 36 | 1.2 | Funasaka et al. (2000) |
| Soot/elemental carbon/ black smoke (µg/m³) | Delft | 15 | 14.9 | 305 | 7.4 | 2.0 | Roorda-Knape et al. (1998) |
| | Overschie | 15 | 12.2 | 260 | 8.7 | 1.4 | Roorda-Knape et al. (1998) |
| | Osaka | 5 | 12.3 | 150 | 8.1 | 1.5 | Funasaka et al. (2000) |
| | Los Angeles | 17 | 21.7 | 150 | 6.5 | 3.3 | Zhu et al. (2003) |

***Pollutant concentrations and exposure ratios for people living near busy streets, compared with more distant locations, in six cities. Source: WHO 2005***

# EXPOSURE ASSESSMENT CONT…

- The emission of pollutants from motor vehicles is influenced by a vehicle type (light- or heavy-duty vehicles, age, operating and maintenance conditions), exhaust treatment and engine lubricants used[1].
- Cold-start operation emits high levels of pollutants such as hydrocarbon, carbon monoxide, and nitrogen oxide[2].
- Exposure occurs in three scales of distance namely near field (0 to 0.2 km), the urban scale (0.2 to 20 km), and regional scale (20 to 2,000 km). Elevated exposures occurs in the near field environment and the people mostly affected are pedestrians, people in nearby buildings, cyclists, and vehicle passengers[3].
- Studies have revealed that the highest exposures normally occur at a distance ranging from 50 to 100 metres from roadways[4].

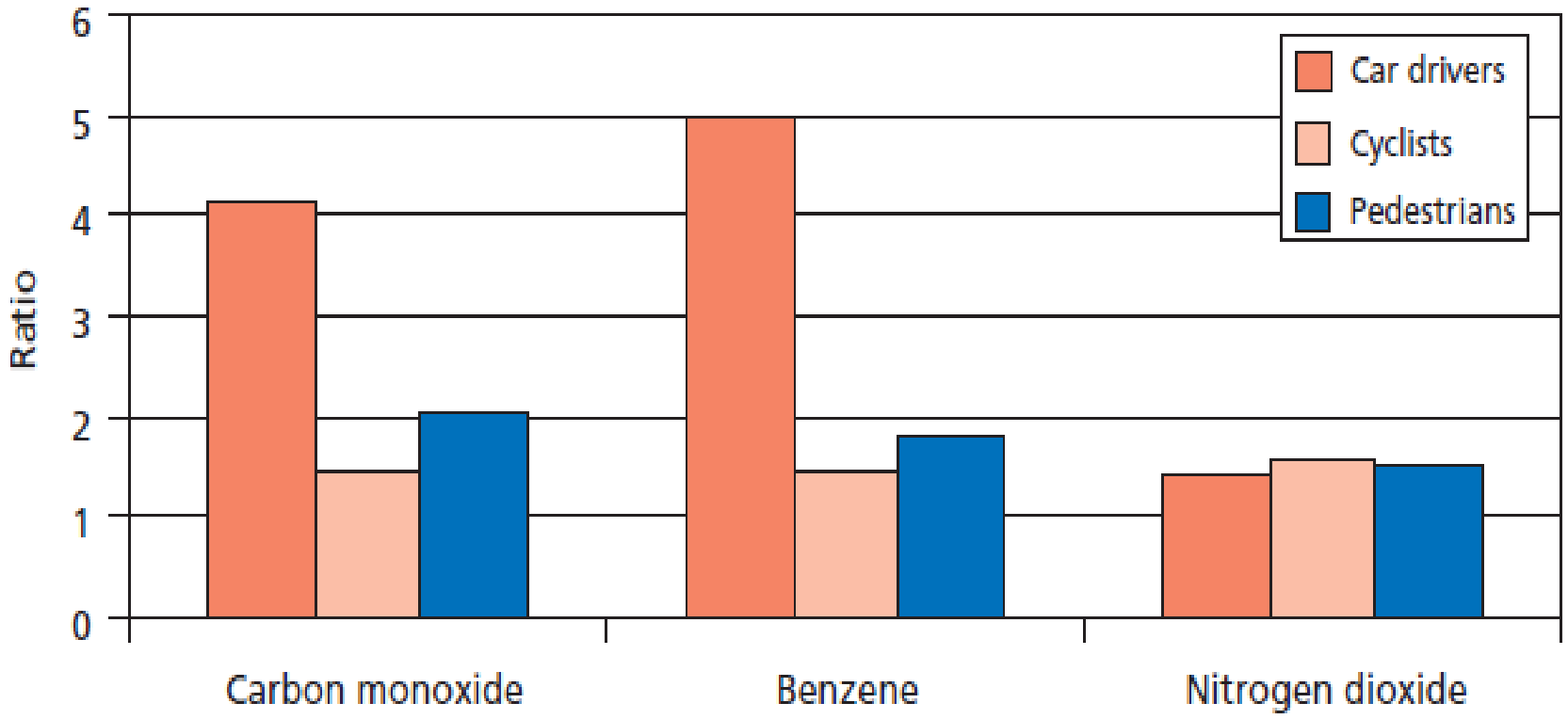
[1]HEI, 2010; [2]Singer et al, 1999; [3]NAS, 2001; [4]WHO, 2005

# EXPOSURE ASSESSMENT CONT…

- Direct exposure may occur inside vehicles as a result of their idling and from entrainment of air from other vehicles[1].
- Several European studies demonstrated elevated concentration of pollutants inside vehicles as compared to background levels, with exposures higher in buses and cars, and lower in cyclists and walkers[2].
- Under certain conditions however, cyclists and walkers/runners may be more exposed due to their high breathing rates resulting in the inhalation of large volumes of pollutants[2].
- Studies have shown that bicyclists breathe twice as much air as a driver due to high physical activity[2].

[1]NAS, 2001; [2]WHO, 2005

# EXPOSURE ASSESSMENT CONT…




***The ratio of exposure of road users to background levels of pollutants in Amsterdam, Netherlands. Source: WHO, 2005***

# THE HEALTH IMPACT

- According to the National Academic Sciences (2001), the heath impact of the pollutants is dependent on the physicochemical characteristics of the pollutants, their concentration inhaled, and the rates and routes by which the deposited pollutants are cleared from the respiratory tract or transported to other organs.
- WHO (2005) has associated air pollution from motor vehicles with increased mortality risk as a result of cardiopulmonary causes and significant risk of respiratory morbidity. Evidence of the exacerbation allergic reaction in the asthmatics, increase risk of myocardial infarction and adverse outcomes of pregnancy such as premature birth and low birth weight, has been reported following motor exhaust exposure.
- Künzli et al (2000) concluded that air pollution caused 6% of total mortality per annum, half of which is attributed to vehicle emissions.

# THE HEALTH IMPACT CONT…

- A study by Hoek et al (2002) in the Netherlands have associated cardiopulmonary mortality and living near major roads. The study revealed that elevated concentration of ultrafine particles may result in pulmonary inflammation and the release of mediators in the blood yielding increased plasma viscosity, which could lead to cardiovascular events including death. This is supported by the Health Effect Institute (HEI, 2010), who concluded that exposure to motor vehicle air pollution result in premature mortality among exposed populations.
- Rosenlund et al (2008) concluded that exposure to residential traffic-related air pollution increases the risk of fatal coronary heart disease.
- Nordling et al (2008) have associated exposure to vehicle emissions during the first year of life with persistent wheezing, lower peak expiratory flow and sensitization to pollen at 4 years of age.

# THE HEALTH IMPACT CONT…

- Particulate matter exposure is associated with oxidative stress resulting in respiratory and systemic inflammatory responses. Araujo et al (2008) suggests that this leads to chronic bronchitis, lung cancer, asthma and atherosclerosis.
- A study by Ulfvarson et al (1987) revealed that exposure to motor vehicle emissions may result in genotoxicity. This was supported by Lewtas (1983), who concluded that extracted diesel and petrol organics from motor vehicle particulates provided strong evidence of mutanenicity in terms of gene mutation, DNA damage and chromosomal aberration.
- U.S. EPA (2002) has reported that acute exposure to diesel emissions may result in the irritation of the eyes and respiratory tract, and respiratory symptoms such as cough and phlegm. Neurophysiological symptoms such as lightheadedness and nausea have also been reported.

# THE HEALTH IMPACT CONT…

- A study by Salvi et al (1999) demonstrated that short-term exposure to diesel emissions result in systemic and pulmonary inflammatory response in healthy humans. Significant increase of neutrophils and B lymphocytes in airway lavage together with histamine and fibronectin increase have been observed in healthy volunteers exposed to diesel emissions for a period if one hour.
- Rudell et al (1996) associated acute exposure to diesel emissions with bronchoconstriction symptoms in healthy non-smoking volunteers aged between 20 and 37. Irritation of the nose, eyes and increase unpleasant smell was observed.

# THE HEALTH IMPACT CONT…

| Health Effects | Source |
|---|---|
| Increased mobility and mortality risk due to respiratory and cardiopulmonary causes | WHO, 2005 |
| Cardiopulmonary mortality | Hoek et al, 2002 |
| Coronary heart disease | Rosenlund et al, 2008 |
| Lung cancer | Beelen et al, 2008 |
| Persistent wheezing, lower peak expiratory flow and sensitization to pollen | Nordling et al, 2008 |
| Chronic bronchitis, lung cancer, asthma and atherosclerosis | Araujo et al, 2008 |
| Mutation of genetic material of cells, and chromosomal and DNA damage | Ulfvarson et al, 1987; Lewtas, 1983 |
| Irritation of the eyes and respiratory tract, cough, phlegm, lightheadedness and nausea | US EPA, 2002 |
| Systemic and pulmonary inflammatory response | Salvi et al, 1999; Nordenhäll et al, 2000 |
| Bronchoconstriction symptoms | Rudell et al, 1996 |

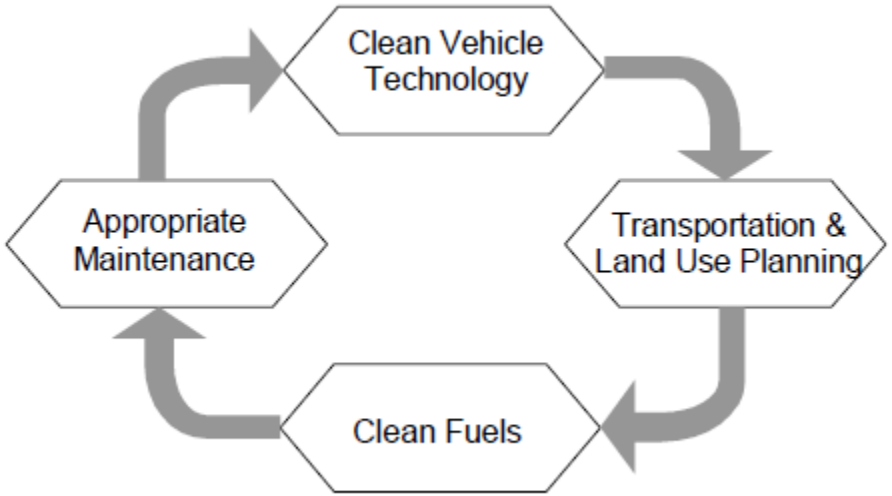
***Summary of the health effects of vehicle emissions***

# CONCLUSION AND RECOMMENDATION

- The review of the health impact of vehicle emissions revealed that exposure to ambient motor vehicle emissions poses a significant health risk.
- A number of studies revealed that motor vehicle emissions is made up of various pollutants which have the potential to result in adverse health effects including carcinogenicity, mutagenicity, cardiovascular mortality and the aggravation of the health of the vulnerable group such as people with compromised health conditions like the asthmatics, children and the elderly.
- Some studies have reported that acute exposures have resulted in hospitalisation due to respiratory conditions while heath effects such as carcinogenicity, mutagenicity, cardiovascular health conditions have been linked to chronic exposures.

# CONCLUSION AND RECOMMENDATION CONT…

- Given the seriousness of the impact above, it is recommended that effective vehicle emission control strategies should be developed and implemented
- Vehicle maintenance and inspection programmes should be developed to ensure the effectiveness of the vehicle emissions-control systems




***Source: Indonesian Multi-sectoral Action Plan Group On Vehicle Emissions Reduction***

# REFERENCES


- Araujo JA, Barajas B, Kleinman M, Wang X, Bennet BJ, Gong KW, Navab M, Harkema J,Sioutas C, Lusis AJ, Nel AE. Ambient Particulate Pollutants in the Ultrafine Range Promote Early Atherosclerosis and Systemic Oxidastive Stress. American Heart Association. DOI: 10. 1161/CIRCRESAHA. 107. 164970, 2008.
- Health Effects Institute (HEI). Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. Special Report 17, Boston, Massachusetts, 2010.
- Hoek G, Brunekreef B, Goldbohm S, Fischer P, van den Brandt PA. Association Between Mortality and Indicators of Traffic-Related Air Pollution in the Netherlands: A Cohort Study. Lancet; 360: 1203–09, 2002.
- Künzli N, Kaiser R, Medina S, Studnicka M, Chanel O, Filliger P, Herry M, Horak Jr F, Puybonnieux-Texier V, Quénel P,
- Schneider J, Seethaler R, Vergnaud J-C, Sommer H. Public-Health Impact of Outdoor and Traffic-Related Air Pollution: A
- European Assessment. Lancet; 356: 795–801, 2000
- Lewtas J. The Evaluation of The Mutagenicity and Carcinogenicity of Motor Vehicle Emissions in Short-Term Bioassays. Environmental Health Perspectives; 47: 141-152, 1983
- National Academy of Sciences (NAS). Evaluating Vehicle Emissions Inspection and Maintenance Programs. National Academy Press, Washington, DC, 2001.
- National Academy of Sciences (NAS). Air Pollution, the Automobile, and Public Health. National Academy Press, Washington, DC, 1988.

# REFERENCES


- New South Wales Department of Environment and Climate Change (NSW DECC). NSW Cleaner Vehicles and Fuels Strategy: DECC 2008/327, 2008 www.environment.nsw.gov.au
- Nordenhäll C, Pourazar J, Blomberg A, Levin J-O, Sandström T, Ädelroth E. Airway inflammation following exposure to diesel exhaust: a study of time kinetics using induced sputum. European Respiratory Journal; 15: 1046-1051, 2000
- Nordling E, Berglind N, Mele E, Emenius G, Hallberg J, Nyberg F, Pershagen G, Svartengren M, Wickman M, Bellander T. Traffic-Related Air Pollution and Childhood Respiratory Symptoms, Function and Allergies; Epidemiology;19: 401–408, 2008.
- Rosenlund M, Picciotto S, Forastiere F, Stafoggia M, Perucci AC. Traffic-Related Air Pollution in Relation to Incidence and Prognosis of Coronary Heart Disease. Epidemiology; 19: 121–128, 2008.
- Rudell B, Ledin M-C, Hammarström U, Stjernberg N, Lundback B, Sandström T. Effects on symptoms and lung function in humans experimentally exposed to diesel exhaust. Occupational and Environmental Medicine; 53:658-662, 1996
- Salvi S, Blomberg A, Rudell B, Kelly F, Sandtröm T, Holgate ST, Frew A. Acute inflammatory responses in the airways and peripheral blood after short-term exposure to diesel exhaust in healthy human volunteers. American Journal of Respiratory and Critical Care Medicine; 159:702–709, 1999.
- Ulfvarson U, Alexandersson R, Aringer L, Svensson E, Hedenstierna G, Hogstedt C, Holmberg B, Rosen G, Sorsa M. Effects of exposure to vehicle exhaust on health. Scandinavian Journal of Work, Environment and Health; 13(6):505-512, 1987.

# REFERENCES


- United States of America Environmental Protection Agency (US EPA). Health Assessment Document for Diesel Engine Exhaust. EPA-600/R-02-076, 2002. http://www.epa.gov/ttn/atw/dieselfinal.pdf
- World Health Organization (WHO). Health Effects of Transport-Related Air Pollution. Copenhagen, Denmark, 2005.