Air Quality Monitoring Report

HOT SPOT REPORT NO 1

JULY 2001

RICHMOND PRIMARY SCHOOL, KESWICK

South Australia

DEPARTMENT FOR environment and heritage

Government of South Australia

Air Quality Monitoring at Richmond Primary School, Keswick.

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SUMMARY

Richmond Primary School is situated near the intersection of South and Richmond Roads, Keswick. The concentrations of nine pollutants were continuously measured for three weeks inside the school grounds in order to identify any health risks from air pollution, particularly from motor vehicles travelling along South Road. The surrounding area also contains a number of small, light industries, such as a crash repairers and a service station, that are potential sources of air pollution.

The pollutants measured were: nitrogen dioxide, ozone, sulfur dioxide, carbon monoxide, particulate matter (PM_{10}), benzene, formaldehyde, toluene and xylenes (meta- and para-). Lead, measured from a site in Thebarton, was also considered in the assessment. All pollutant concentrations complied with the National Environment Protection Measure (NEPM) for Air Quality[1] and other recognised health guidelines[2]. Based on this work, air quality at the school is not a health concern.

INTRODUCTION

The Environment Protection Agency monitored ambient air quality at Richmond Primary School between 13 September and 3 October 2000. Monitoring was conducted to determine whether the replacement of sealed classroom windows with opening windows, to increase classroom ventilation, would pose a health risk to children. There is a classroom situated 10 metres from South Road and another major block of classrooms 40 metres from the road. All classrooms are separated from the road by a high brick wall and dense vegetation.

EPA air quality 'hot spot' monitoring

Ambient air quality refers to the surrounding outdoor air and its background parameters. The EPA conducts ambient monitoring at a number of permanent sites throughout Adelaide (Environment Protection Authority 1998). The air quality at these sites is assessed to determine trends of urban air quality for the whole of Adelaide.

The EPA also conducts 'hot spot' monitoring using a mobile monitoring station. 'Hot spot' monitoring is designed to investigate pollution sources on a local scale. This allows for the assessment of air quality emanating from a point source. Rather than monitoring emissions directly from a stack or chimney, the air is measured as it moves towards areas where it may impact on human health. It is also useful to monitor urban air quality at the street level, where the main source of pollution is the road traffic.

See Appendixes 1 and 2 for a description of the monitoring site's pollutant gas measurement details.

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[1] Carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, lead and particles as PM_{10} are criteria pollutants under the National Environment Protection Measure for Ambient Air Quality (NEPC 1998)

[2] There are no Australian health standards for benzene, formaldehyde, toluene and xylene. World Health Organisation (2000) guidelines and UK air quality standards (Expert Panel on Air Quality Standards 1994) were used.

Sampling site

The mobile air monitoring station (marked as a small square in figure 1) was placed directly next to the classroom closest to South Road. The OPSIS light path was directed along the South Road boundary of the school. Therefore, measurements of pollutant gases that enter the school grounds represent concentrations derived primarily from motor vehicles travelling along South Road. The path length, reflected from the neighbouring crash repairer's workshop, was measured at 130 metres.

See Appendix 2 for a description of the monitoring site's location details.

Figure 1. Map of Richmond Primary School, the location of the monitoring station and the monitoring path.

RESULTS

Nitrogen dioxide (NO_2)

Health effects

At relatively high concentrations, nitrogen dioxide (NO_2) causes inflammation of the airways. There is evidence to show that long-term exposure to NO_2 may affect lung function and that exposure to NO_2 enhances the response to allergens in some individuals. The National Environment Protection Measure for Air Quality (NEPM) short-term air quality standard is 0.120 ppm measured as an hourly average. There is also a longer-term NEPM standard of 0.03 ppm measured over one year.

Sources

All combustion processes in air produce oxides of nitrogen (NO_X). NO_2 and nitric oxide (NO) are both oxides of nitrogen and together are referred to as NO_X. It is NO_2 which is associated with adverse effects upon human health. Motor vehicles account for about 70% of total Adelaide NO_X emissions. Other sources include the electricity supply and domestic wood burning. NO_X is required in the production of ozone and photochemical smog.

Monitoring results

One-hour averages for NO_2 were within the range of 0.008–0.043 ppm and well within the NEPM air quality standard of 0.12 ppm.

The very low NO_2 levels do not pose a health concern.

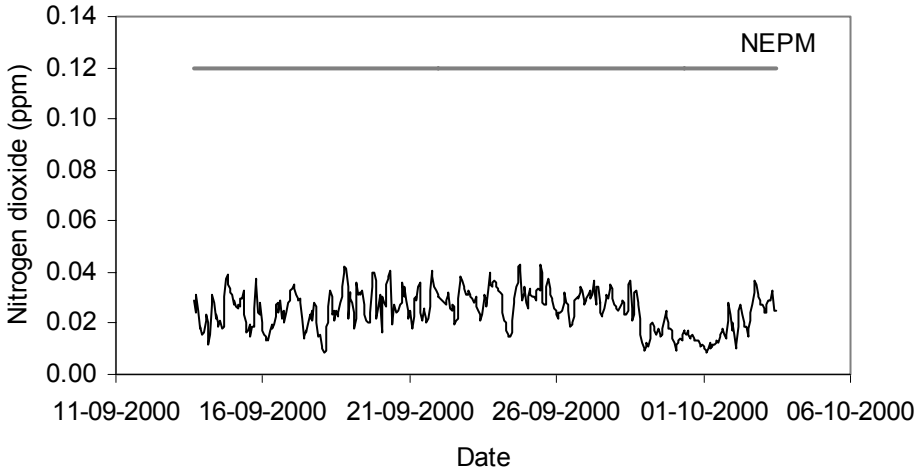

Figure 2. One-hour nitrogen dioxide concentrations and the NEPM air quality standard.

Ozone (O_3)

Health effects

Exposure to elevated concentrations of ozone may cause slight irritation to the eyes and nose. If very high levels of exposure (0.5–1 ppm) are experienced over several hours, damage to the airway lining followed by inflammatory reactions may occur. There is also evidence that minor changes in the airways may occur at lower concentrations, down to about 0.08 ppm. The NEPM air quality standard for ozone is 0.1 ppm as a one-hour mean. A four-hour standard at 0.08 ppm has also been set, a level at which effects in healthy individuals have been demonstrated.

Sources

Ozone at ground level is primarily formed by a complicated series of chemical reactions initiated by sunlight. NO_X and volatile organic compounds (VOCs), derived mainly from man-made sources, react to form ozone. These substances are produced by combustion, industrial processes and activities such as solvent use and petrol distribution and handling. NO_X and VOCs are the most important precursors of elevated levels of ozone. Motor vehicles account for 40% of Adelaide's VOCs. Production can also be stimulated by carbon monoxide, methane or other VOCs which arise from plants, trees and other natural sources.

These chemical reactions do not take place instantaneously, but over several hours or even days depending on the VOCs, and once ozone has been produced it may persist for several days. Ozone measured at a particular location may therefore have arisen from VOC and NO_x emissions many kilometres away, and may then travel further. Maximum concentrations, therefore, generally occur downwind of the source areas of the precursor pollutant emissions.

Monitoring results

One-hour and four-hour averages for ozone were well below the NEPM air quality standard of 0.1 ppm (1 hour) and 0.08 ppm (4 hour). The range was 0.016–0.048 ppm for one-hour averages and 0.017–0.046 ppm for four-hour averages.

The very low ozone levels do not pose a health concern.

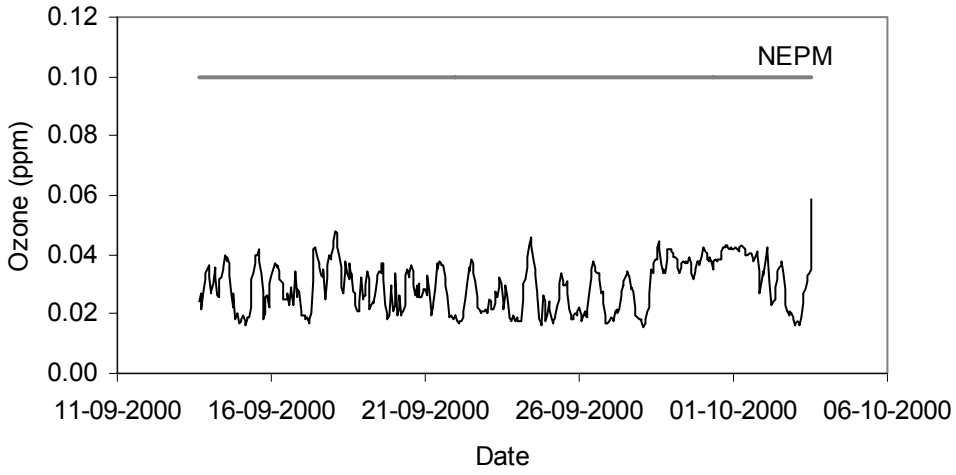

Figure 3. One-hour ozone concentrations and the NEPM air quality standard.

Sulfur dioxide (SO_2)

Health effects

Sulfur dioxide causes constriction of the airways by stimulating nerves in the lining of the nose, throat and airways of the lung. The latter effect is particularly likely to occur in those suffering from asthma and chronic lung disease. The NEPM air quality standard is 0.20 ppm measured over a one-hour averaging period. This standard is intended to reduce the exposure of the population, including individuals who may be particularly susceptible, to levels of sulfur dioxide at which harmful effects are unlikely to occur.

Sources

Motor vehicles contribute about 90% of sulfur dioxide in Adelaide. Other sources include fossil fuel combustion, particularly coal burning power plants, and industrial processes such as wood pulping, paper manufacture, petroleum and metal refining, and metal smelting, particularly from ores containing sulfide.

Exposure can also happen from the manufacture of fumigants, food preservatives, bleaches and wine making. It can be ingested by eating preserved foods and by breathing it in, causing a risk to asthmatics and other individuals sensitive to its effects.

Monitoring results

One-hour averages for sulfur dioxide were within the range of 0.002–0.012 ppm and well within the NEPM air quality standard of 0.20 ppm.

The very low sulfur dioxide levels do not pose a health concern.

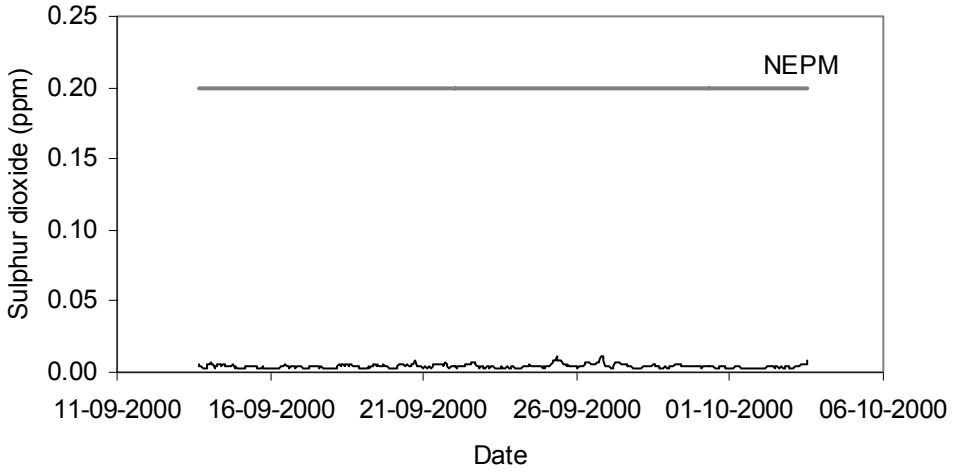

Figure 4. One-hour sulfur dioxide concentrations and the NEPM air quality standard.

Carbon monoxide (CO)

Health effects

The main threats to health from exposure to carbon monoxide are the formation of carboxyhaemoglobin, which substantially reduces the capacity of the blood to carry oxygen and deliver it to the tissues, and blockage of important biochemical reactions in cells. People with an existing disease affecting the delivery of oxygen to the heart or brain, such as coronary artery disease or angina, are likely to be at particular risk if these delivery systems are further impaired by carbon monoxide. The NEPM air quality standard of 9 ppm as a running 8-hour mean is intended to limit the exposure of the population, including susceptible individuals.

Sources

Carbon monoxide is a gas formed by the incomplete combustion of fuels containing carbon. The main outdoor source of carbon monoxide is currently motor vehicles, in particular petrol-engined vehicles, which in Adelaide account for almost 90% of emissions.

Industrial sources include steel plants, foundries, and oil refining and chemical manufacturing facilities.

Monitoring results

The 8-hour averages of carbon monoxide were within the range of 0.036–2.123 ppm and within the NEPM air quality standard of 9.0 ppm.

The very low carbon monoxide levels do not pose a health concern.

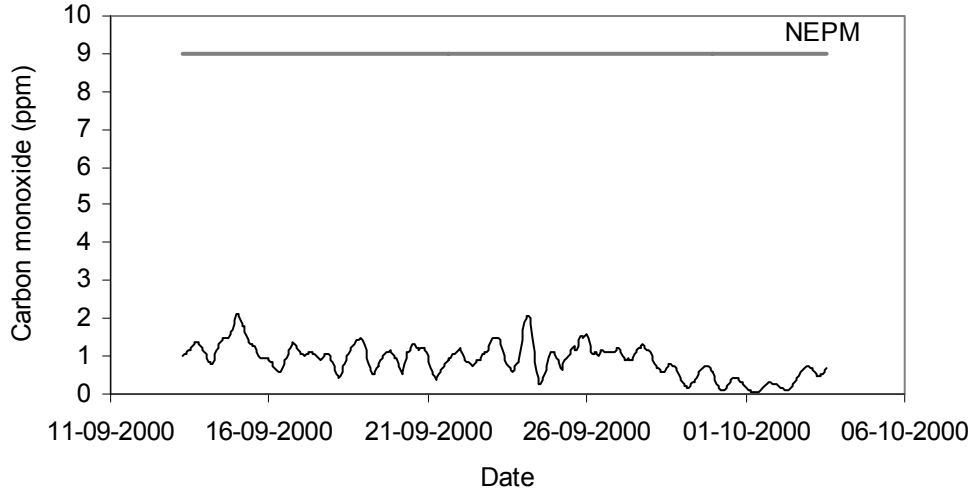

Figure 5. The 8-hour carbon monoxide concentrations and the NEPM air quality standard.

Particulate matter (PM_{10})

Health effects

PM_{10} refers to particulate matter less than 10 micrometres (μm) in diameter. Particulate air pollution is associated with a range of impacts on health, including effects on the respiratory and cardiovascular systems, asthma and mortality.

The most applicable evidence has related daily average concentrations of particles to effects on health, therefore the PM_{10} NEPM is measured over 24 hours. The NEPM air quality standard is 50 $\mu g/m^3$ as a 24-hour average.

Sources

Unlike the individual gaseous pollutants, which are single, well-defined substances, particles (PM_{10}) in the atmosphere are composed of a wide range of materials arising from a variety of sources. Concentrations of PM_{10} comprise: primary particles, arising from combustion sources (mainly motor vehicles, which in Adelaide contribute 40%); secondary particles, mainly sulphate and nitrate formed by chemical reactions in the atmosphere; and coarse particles, suspended soils and dusts, sea-salt, biological particles and particles from construction work.

The relative contribution of each source type varies from day to day, depending on meteorological conditions and quantities of emissions from mobile and static sources. The fine particle fraction ($PM_{2.5}$) is composed predominantly of primary and secondary particles. Particles in the range from $PM_{2.5}$ – PM_{10} generally consist of coarse particles.

Monitoring results

One-day averages for PM_{10} particles were within the range of 15–30 $\mu g/m^3$ and within the NEPM air quality standard of 50 $\mu g/m^3$.

The low levels of particulate matter as PM_{10} do not pose a health concern.

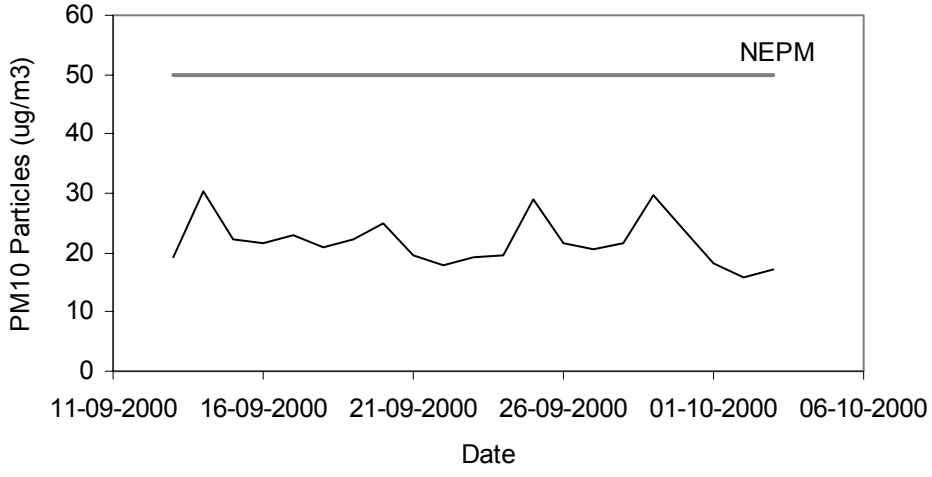

Figure 6. One-day particulate matter (PM_{10}) concentrations and the NEPM air quality standard.

Benzene (C_6H_6)

Health effects

Benzene is a recognised human carcinogen. Studies of industrial workers exposed in the past to high levels of benzene have demonstrated an excessive risk of leukaemia, which increased in relation to their working lifetime exposure. Because it is a carcinogen, no absolutely safe level can be specified for ambient air concentrations of benzene and, as yet, there is no ambient standard for benzene in Australia. In their 1994 report, the UK Expert Panel on Air Quality Standards (EPAQS) recommended an air quality standard of 0.005 ppm (16.25 μg/m^3) as an annual mean, a level which they concluded represents an exceedingly small risk to health. EPAQS (1994) considered the advice of the Department of Health's Committee on Carcinogenicity, that exposure to benzene should be kept as low as practicable.

Sources

Benzene is a volatile organic compound. In Adelaide, the main source is the combustion and distribution of petrol, of which benzene is a minor constituent. Benzene is also formed during the combustion process from aromatics in the petrol. Motor vehicles make up 70% of emissions. Smoke from domestic wood fires and emissions from lawn-mowers and some industries are also significant contributors.

Monitoring results

One-hour averages for benzene were within the range of 0.006–0.014 ppm, with an average for the entire sampling period of 0.009 ppm. Comparable levels are measured in other Australian capital cities (Berko *et al* 2000; Department of Environment Protection 2000).

The Department of Human Services (Environmental Health Branch) has advised that the concentrations measured do not pose a health concern.

Commitments to improve fuel quality standards, motor vehicle emission controls and engine technologies to international standards will now result in decreases in benzene levels throughout Australia (Coffey Geosciences Pty Ltd 2000; Best 2000).

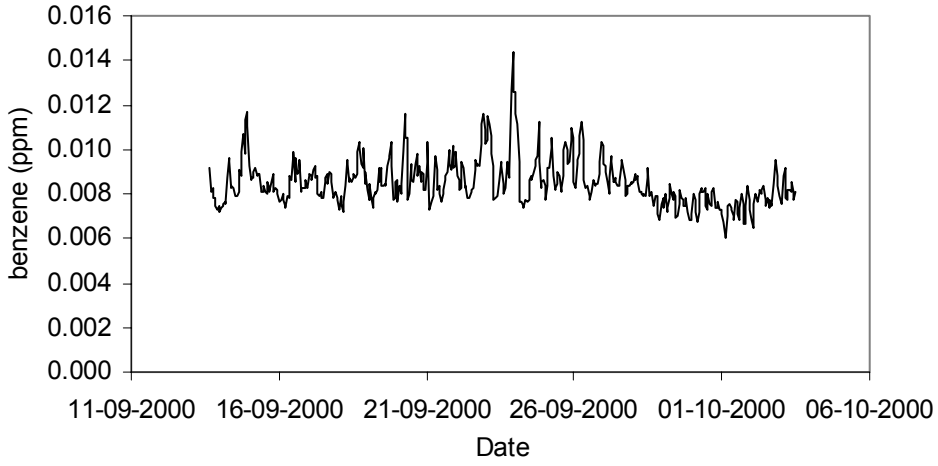

Figure 7. One-hour benzene concentrations.

Toluene (C_7H_8)

Health effects

Long-term exposure to low to moderate levels of toluene can cause tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, loss of appetite and hearing loss. Inhaling a high level of toluene in a short time can make a person feel light-headed, dizzy or sleepy. Repeated exposure to high levels can cause permanent brain and speech damage, vision and hearing problems, loss of muscle control and poor balance. Toluene can be smelled at 8 ppm. The World Health Organisation (2000) air quality standard is 0.27 ppm (1000 µg/m^3) measured as a 30-minute average.

Sources

Toluene is a colourless liquid with a distinctive sweet and pungent smell. It occurs naturally in crude oil. Toluene is produced during the process of making motor vehicle fuel and other fuels from crude oil, in making coke from coal and as a by-product in the manufacture of styrene. It is also used in making paints, paint thinners, fingernail polish, lacquers, adhesives, rubber, and in some printing and leather tanning processes.

Monitoring results

The 30-minute averages for toluene were within the range of 0–0.027 ppm. Although there is considerable variability in the measurements, the peak result of 0.027 ppm is an order of magnitude lower than the WHO guideline of 0.27 ppm.

The very low toluene levels do not pose a health concern.

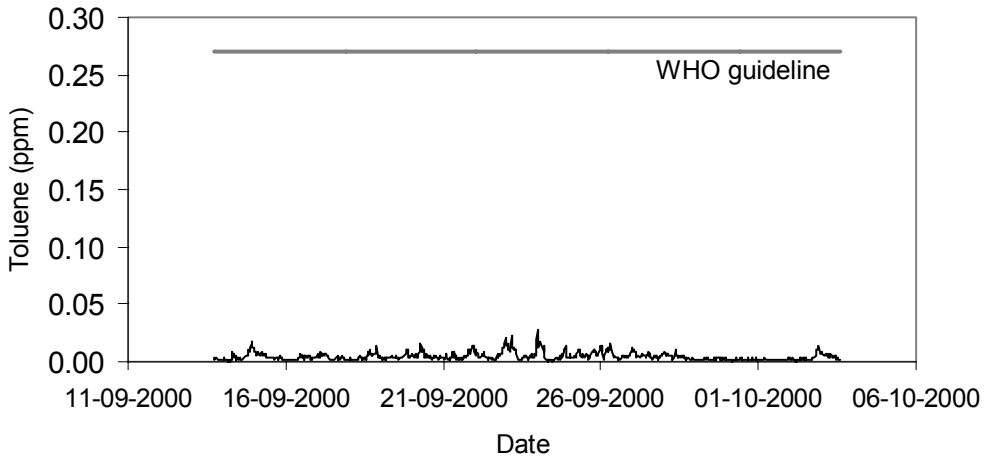

Figure 8. The 30-minute toluene concentrations and the WHO air quality guideline.

Formaldehyde (CH_2O)

Health effects

When formaldehyde is present in the air at levels at or above 0.1 ppm, acute health effects can occur including watery eyes, burning sensations in the eyes, nose and throat, nausea, coughing, chest tightness, wheezing, skin rashes and other irritating effects. Formaldehyde affects people in various ways. Sensitive people can experience symptoms at levels below 0.1 ppm. The WHO recommends that exposure should not exceed 0.05 ppm, and its guideline is 0.08 ppm (100 μg/m^3) measured as a 30-minute average.

Sources

Formaldehyde is an important industrial chemical used to make other chemicals, building materials and household products. It is used in glues, wood products, preservatives, permanent press fabrics, paper product coatings and certain insulation materials. Incomplete combustion from motor vehicles, cigarette smoking, and burning wood, kerosene and natural gas releases formaldehyde.

Monitoring results

The 30-minute averages for formaldehyde were within the range of 0.005–0.036 ppm. The results comply with the WHO guideline of 0.08 ppm.

The very low formaldehyde levels do not pose a health concern.

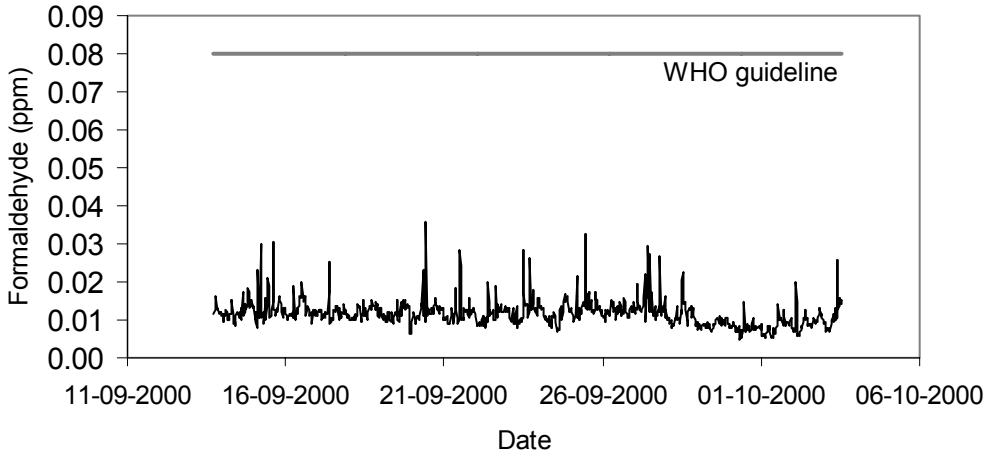

Figure 9. The 30-minute formaldehyde concentrations and the WHO air quality guideline.

Meta-, para- and ortho-xylene (C_8H_{10})

Health effects

Short-term exposure to high levels of xylene or chemical mixtures containing xylene causes irritation of the skin, eyes, nose and throat, difficulty in breathing, impaired function of the lungs, delayed response to a visual stimulus, impaired memory, stomach discomfort, and possible changes in the liver and kidneys.

Concentrations of 100–299 ppm of inhaled xylene can cause eye, nose and throat irritation, delayed response to a visual stimulus, and poor memory. The lowest level at which the odour of xylene can be detected in air ranges from 0.1 ppm to 2.0 ppm. The WHO guideline is 1.1 ppm (4800 μg/m^3) measured as a 24-hour average.

Sources

Sources include motor vehicles, chemical and petrol manufacture, polyester manufacture, manufacture of paints, dyes and lacquers, commercial and household painting, woodburning stoves and fireplaces, forest and bush fires, and tobacco smoke.

Monitoring results

The 24-hour average ranges for meta- and para-xylene were 0.007–0.008 ppm and 0.002–0.003 ppm respectively. Ortho-xylene was not included in the analysis due to measurement difficulties.

A ratio of meta- plus para-xylene to ortho-xylene was assumed at 2.74[3]. If it is also assumed that the isomer distribution is equal, then measured ortho-xylene could raise the average by 25%. The average 24-hour xylene range would therefore be 0.013 ppm, well below the WHO guideline of 1.1 ppm. The graph below shows hourly variability of meta- and para-xylene throughout the monitoring period.

The low xylene levels do not pose a health concern.

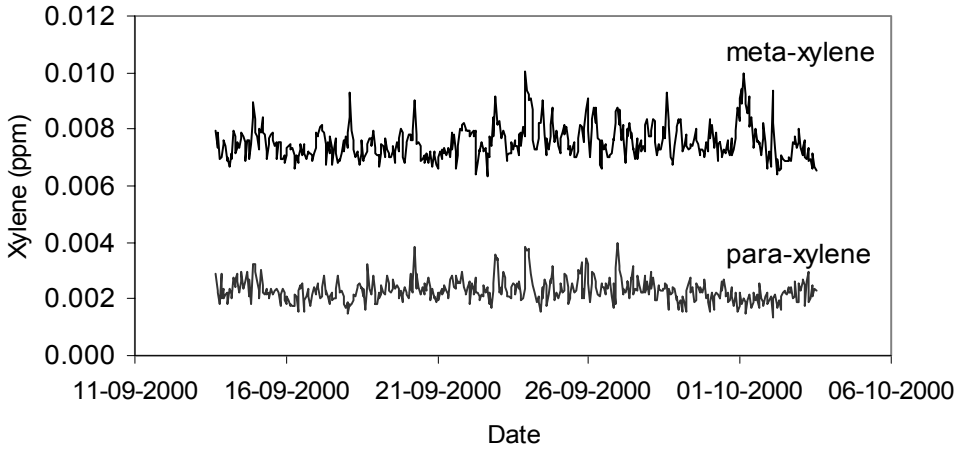

Figure 10. One-hour xylene concentrations.

[3] The meta-, para-xylene to ortho-xylene ratio was determined from a monitoring study in 1994 using OPSIS equipment (Mitchell *et al* 1994).

Total suspended particulate lead (Pb)

Health effects

Exposure to high levels of lead may result in toxic biochemical effects, which in turn cause problems in the formation of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system. The possible effect of lead on brain development in children, and hence their intellectual development, is the greatest cause for concern.

The NEPM lead standard is 0.50 µg/m^3 as an annual average. At this level effects on the health of children, the group most vulnerable to impairment of brain function, are undetectable. Only a small fraction of total lead intake occurs through inhalation. Food and water are two of the main sources for most people. Lead is deposited with dust and rain on crops and on the soil.

Sources

Lead is the most widely used non-ferrous metal and has a large number of industrial applications, both in its elemental form and in alloys and compounds. The single largest use globally is in the manufacture of batteries. It has been used as a petrol additive to enhance the octane rating.

Most of the national airborne emissions of lead have arisen from petrol-engined vehicles. In Adelaide motor vehicles contribute to more than 95% of total emissions. However, the general sale of leaded petrol in Australia began to decrease from 1986, following the implementation of tighter fuel quality standards. The reduction in the lead content of leaded petrol and the increasing use of unleaded petrol have led to significant reductions in urban lead levels.

Monitoring results

Lead data was sourced from the Thebarton air quality monitoring site on the corner of South and Henley Beach Roads as annual averages for the period 1994 to 1999. It is likely that the Thebarton site demonstrates slightly higher lead values than those expected at the Richmond Primary School site. This is due to the Thebarton site's greater exposure to traffic compared with the primary school, which is separated from the road by a large brick wall. Lead levels have declined since 1994, when the annual average was 0.99 µg/m^3. Since 1995 all levels at Thebarton have complied with the NEPM of 0.50 µg/m^3. In 1999 the annual average for lead was 0.23 µg/m^3.

On this basis lead levels do not pose a health concern.

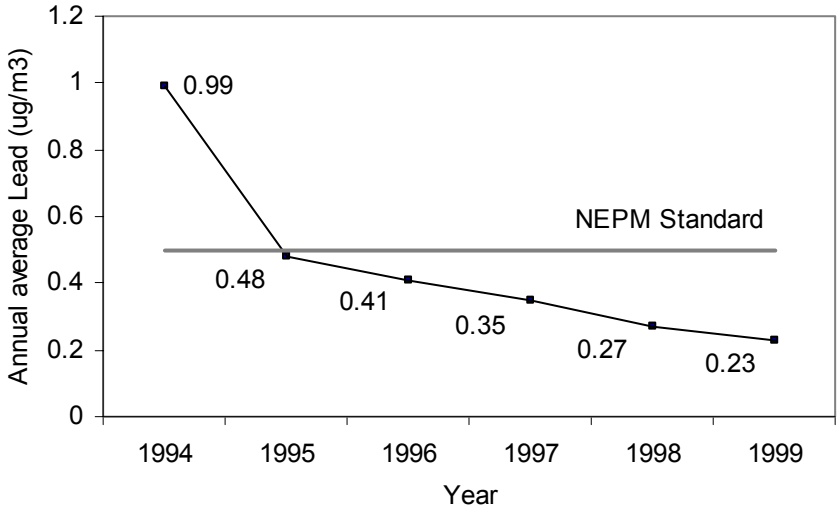

Figure 11. Annual average lead at Thebarton and the NEPM air quality standard.

CONCLUDING REMARKS

The findings of the monitoring program indicate that the air quality at Richmond Primary School is generally good. All pollutants measured are at levels that do not pose a health concern.

More information concerning the health effects and sources of each pollutant can be found on the National Pollutant Inventory website at http://www.environment.gov.au/epg/npi

APPENDIX 1 – POLLUTANT GAS MEASUREMENT

The mobile air quality monitoring station measures pollutants (except CO and PM_{10}) using an OPSIS differential optical adsorption spectrophotometry (DOAS) method. This is based on the relationship between the number of molecules in the light path and the quantity of light absorbed. The instrument beams light over a chosen path and then evaluates the light lost from molecular absorption along the path. The absorption spectrum just registered from the light path is then compared with the spectrums of different pollutants. As each gas has its own unique absorption spectrum, it is possible to identify and determine the concentrations of several different gases in the light path at the same time. See http://www.opsis.se

Carbon monoxide is measured using a non-dispersive infrared (NDIR) analyser, of the gas filter correlation type. A pre-filtered air sample is drawn through a sample cell. Infrared radiation is beamed through the sample cell and a carbon monoxide-free reference cell. The detector measures some of the infrared light absorbed by carbon monoxide in the sample. By comparing the light intensity received by the detector through the cell with a similar cell containing reference gas, the concentration of carbon monoxide is determined. See http://www.thermo.com/

The TEOM (tapered element oscillating microbalance) mass measurement system was used for the continuous measurement of particulate mass (PM10) concentrations. It relies on an instrument that draws air through a filter at a constant flow rate, continuously weighing the filter and calculating, every ten minutes, the mass concentration. See http://www.rupprechtandpatashnick.com.

Lead data was also sourced from the EPA's Thebarton air monitoring site, situated on the corner of South Road and Henley Beach Road. Lead is calculated as annual averages for the period 1994 and 1999. Lead is measured using high volume samplers.

APPENDIX 2 – RICHMOND PRIMARY SCHOOL SITE METADATA

Site Information (Metadata)	
Site Name	Richmond Primary School Hot Spot Site

Site Details	
Street address	8 Surrey Road, Keswick
Date established	13/09/2000
Date terminated	03/10/2000
Siting guidelines (AS 2922-1987) exceptions	None
Description of surrounding land use	Main road and light industry, residential and school.
Description of nearby emission sources	Motor vehicles, crash repairer

Map Coordinates	
Datum	AGD 84
Projection	AMG Zone 54
Easting	278095
Northing	6130366

Notes on data validation and assessment

Zero, span, calibration equation parameters & quality assurance procedures

Zero corrections in ppm: CO 1.1, NO_2 0.01, O_3 0.02, SO_2 0.0035, BEN 0.007, FOR 0.01, MXY 0.01, PXY 0.001.

Correcting measurement results from $\mu g/m^3$ to ppm. See OPSIS (1999*) Analyser Software, version 7.2 User's Guide*. OPSIS, Sweden.

Data validated and checked in accordance with Draft NEPM requirements. See Lorimer GS (2000) *Air quality data handling and reporting. DRAFT*. A report to NEPC, November 2000, Melbourne.

Notes of time and nature of events that may influence data validation or interpretation

No events that influenced data.

Measurements of ortho-xylene were discarded due to results being an order of magnitude higher than m and p-xylene. Problem associated with instrument malfunction.

Pollutants Measured

NO, NO_2, SO_2, O_3, benzene, toluene, formaldehyde, meta- and para-xylene

Particulate matter (PM_{10})

Carbon monoxide (CO)

Instrument Types

Make	OPSIS	Make	Rp	Make	Thermo Electron
Model	ER130 & AR500	Model	TEOM PM_{10}	Model	NDIR analyser
Serial number	E672	Serial number	140AB221849807	Serial number	48-16574-162
Minimum detection level	1-10 ppb (dependant on path length = 130m)	Minimum detection level	N/A	Minimum detection level	0.05 ppm or 2%
Units	$\mu g/m^3$	Units	$\mu g/m^3$	Units	ppm
Measurement cycle	10 minutes	Sampling rate	10 minutes	Sampling rate	20 seconds
Logging interval of raw data	10 minutes	Logging interval of raw data	10 minutes	Logging interval of raw data	10 minutes
Data return	100 %	Data return	100 %	Data return	100 %
Clock adjustment equation	Period ending	Clock adjustment equation	Period ending	Clock adjustment equation	Period ending

ACKNOWLEDGMENTS

The Richmond Primary School study was conducted in response to a request for monitoring by the Department of Administrative and Information Services, Building Management Division, on behalf of the Department of Education, Training and Employment.

The Environmental Health Branch of the Department of Human Services (Health Commission) provided advice on health standards and risk for all parameters.

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See also http://www.environment.gov.au/epg/fuel/ for further information on Australian fuel quality standard improvements.

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