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Lead - concentration in Perth's atmospheric environment

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Perth's atmospheric environment**

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1. Introduction

The quality of the air we breathe is affected by emissions from a wide variety of easily identifiable human activities and natural sources. Emissions which will have a significant affect on ambient air quality are those from motor vehicles, industrial and commercial processes, suburban domestic environment and those natural processes of wind blown particulates and bush fire smoke.

Lead is a bluish or silvery-grey soft metal with a melting point of 327° C. Organic lead compounds such as tetraethyl lead and tetramethyl lead are of great importance due to their extensive use as fuel additives. These compounds are colourless liquids with boiling points of 110° and 200° C respectively. Since their volatility is lower than that of most petrol components, the evaporation of petrol tends to concentrate both tetramethyl and tetraethyl lead.

Most of the lead in the ambient atmosphere is in the form of sub-micron sized particles. Some 30 - 50% of these inhaled particles are retained in the respiratory system. Virtually all of this retained lead is absorbed into the body. Particles in the size range of 1 - 3 microns (µm) are also efficiently deposited in the lungs. The subsequent potential for health problems in the human population are well documented in the medical literature.

The mining and smelting of lead ores create pollution problems in some areas. The level of contamination of the surrounding air will depend on the concentration of lead being emitted and pollution control measures at the plant site.

An estimated 80 - 90% of lead in ambient atmosphere is derived from the combustion of leaded petrol. The degree of pollution from this source differs from country to country, depending on motor vehicle model (convertor or non-convertor) and density, and the efficiency of efforts to reduce the lead content of petrol.

Since 1982, the Environmental Protection Authority and its predecessors have an unbroken record of monitoring the concentration of lead in the ambient atmosphere of Perth's central business district. During this time the Environmental Protection Authority has had two monitors at:

- Queen's Building, corner of Murray and William Streets, and
- Environmental Protection Authority's Pollution Control Division, 57 Murray Street.

The Environmental Protection Authority's two monitors, high volume samplers, have collected samples according to the Standards Association of Australia, Australian Standard AS 2724.3 - 1984, for "Ambient air - particulate matter - Part 3 - Determination of total suspended particulates (TSP) high volume sampler gravimetric method". The lead content of each total suspended particulate sample was determined by x-ray fluorescence spectrometry analysis, which was conducted on behalf of the Environmental Protection Authority by Professor B H O'Connor, Curtin University of Technology, Western Australia.

It is the intention of this document to direct the attention to:

- (i) the lead concentration in the atmospheric environment of Perth's central business district and compare it to the air quality goal for lead recommended by the National Health and Medical Research Council and Australian Environment Council (NHMRC/AEC);
- (ii) the lead concentration in the atmospheric environment of Perth's central business district and compare it to the World Health Organisation's (WHO) recommended lead air quality guidelines for Europe;
- (iii) the concentration of lead in premium grade petrol in Western Australia, Australia and countries throughout the world;
- (iv) recent air quality recommendations made by Dr Streecon for the Victorian Environment Protection Authority with specific reference to the concentration of lead in the atmosphere; and
- (v) the spatial variations which may have an effect on the changing atmospheric lead concentration.

2. Lead - NHMRC/AEC air quality goals and central Perth's concentrations

The NHMRC and the Australian Environment Council published its, "National guidelines for control of emission of air pollutants from new and stationary sources - Recommended methods for monitoring air pollutants in the environment" in 1986, recommended an air quality goal for lead at a maximum permissible level in ambient air of $1.5 \mu\text{g}/\text{m}^3$ for a three month average.

Since 1982, data from the Environmental Protection Authority's air quality monitoring location at Queens Building in William Street, Perth indicates that this goal has been rarely achieved in Perth's central business district. A comparison of the data from Queens Building from 1982 to 1990 as a three monthly average is presented in the following Table 1:

Table 1. Queens Building in Central Perth. Three monthly average of atmospheric lead - 1982 to 1990

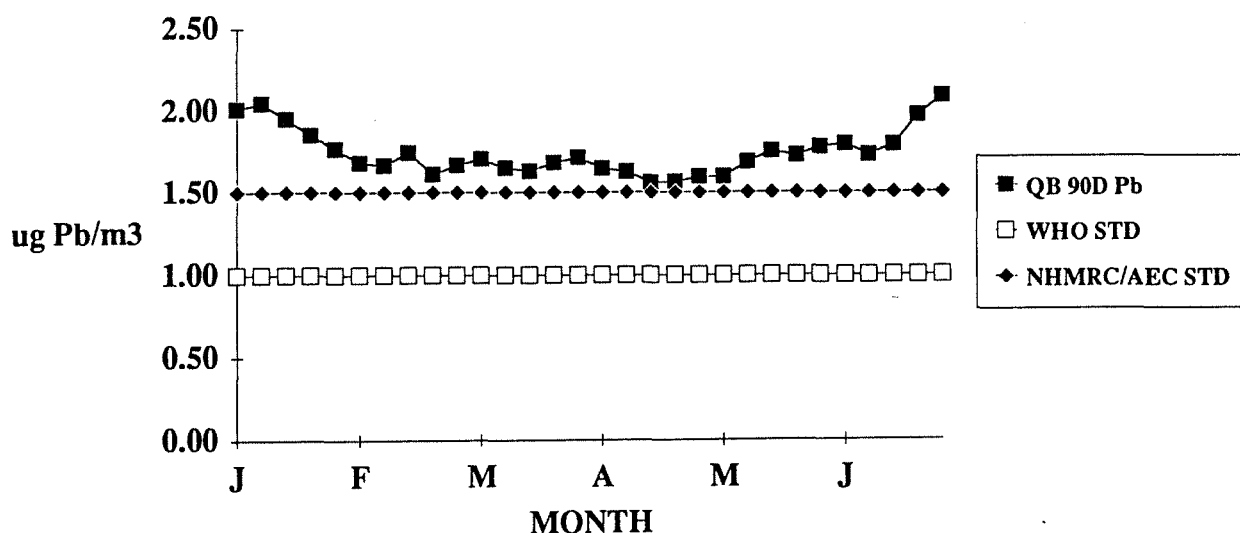
Atmospheric lead concentrations expressed as $\mu\text{g Pb}/\text{m}^3$ at 0 degrees Celsius and 101.3 kPa

Year	Jan- Mar	Apr-Jun	Jul-Sept	Oct-Dec	NHMRC/AEC STD
1982	2.25	3.21	2.52	2.40	1.50
1983	2.14	2.84	3.13	1.90	1.50
1984	1.62	2.31	2.46	1.85	1.50
1985	1.66	2.09	1.74	1.81	1.50
1986	1.60	1.86	1.24	1.72	1.50
1987	1.05	1.99	2.11	1.86	1.50
1988	1.33	1.66	1.64	1.59	1.50
1989	1.55	1.71	2.09	1.90	1.50
1990	1.53	1.94	1.58	1.52	1.50

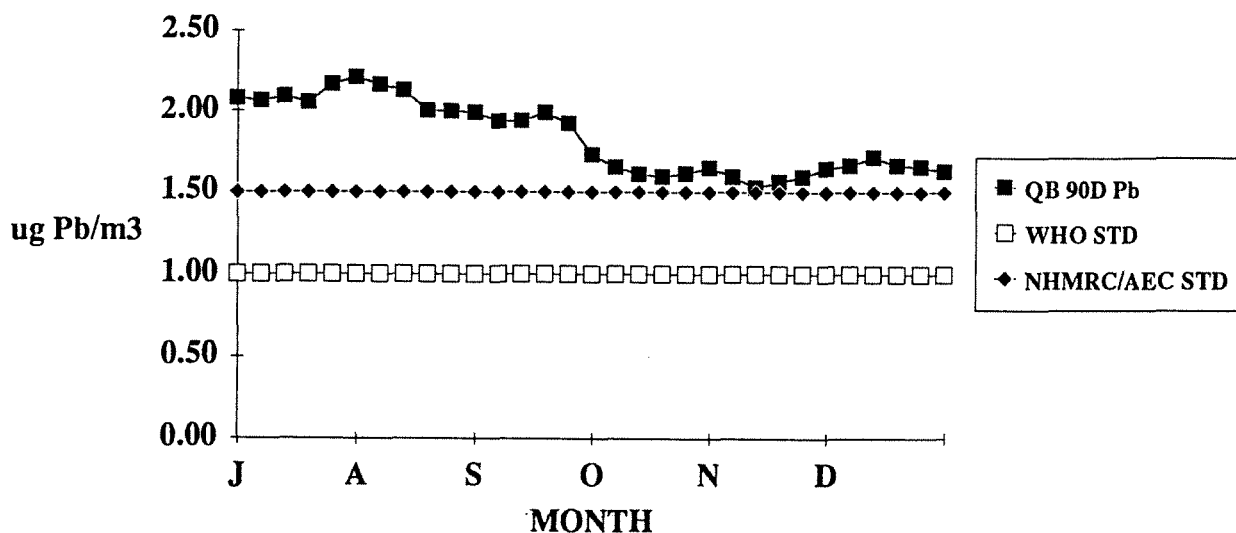
The data shows that over the last nine years only on three occasions has the atmospheric lead concentration in central Perth been lower than the NHMRC/AEC's three monthly average air quality goal.

Atmospheric lead data in the total suspended particulate fraction from the Environmental Protection Authority's Queens Building location has been analysed for 1990 in the form of a 90 day running mean value for the entire year. This analysis was made for direct comparison with the NHMRC/AEC's 90 day data as shown in Table 1. The 90 day running mean data has been divided into two figures, January to June and July to December. The data indicates that in 1990 in Perth's central business district there was no compliance with the NHMRC/AEC's recommended air quality guideline for atmospheric lead.

ATMOSPHERIC LEAD 90 DAY RUNNING MEAN IN TSP FRACTION - CENTRAL PERTH - JANUARY TO JUNE 1990



**ATMOSPHERIC LEAD 90 DAY RUNNING MEAN IN TSP
FRACTION - CENTRAL PERTH - JULY TO DECEMBER 1990**



Note:-

QB is the EPA's Queens Building location.

NHMRC/AEC is the 90 day average guideline.

WHO is the World Health Organisation annual guideline.

During 1988 the Environmental Protection Authority established an atmospheric lead monitoring network across Perth's metropolitan region. This network, comprising nine monitoring locations used high volume samplers and AS 2724.3 - 1984 to provided atmospheric lead data until August 1990. This data also indicates that in areas of high motor vehicle density the NHMRC/AEC's three monthly goal was exceeded and/or rarely achieved. The incidence of lead in Perth's ambient atmosphere is principally related to the composition of the motor vehicle population (leaded vs unleaded), density of motor vehicle traffic, the concentration of lead in leaded petrol and petrol consumption.

A comparison between atmospheric lead concentrations in Melbourne and Perth over similar periods, indicate that Melbourne's values are significantly lower for the NHMRC/AEC's three monthly average. Melbourne's traffic density was much higher, however it has a lower lead concentration in leaded petrol (Explanatory Documentary for Streton Report, 1990).

3. Lead - WHO guidelines and central Perth's concentrations

The World Health Organisation has established atmospheric lead concentrations in its publication "Air Quality Guide-lines for Europe", WHO regional publications, European Series No. 23. The WHO guideline states, "A guideline in the range of 0.5 - 1.0 μg lead per m^3 (long-term, e.g. annual mean) is recommended; this incorporates a protection (safety) factor close to 2."

Since 1982, data from the Environmental Protection Authority's Authority air quality monitoring location at Queens Building in William Street, indicates that this goal has never been achieved in Perth's central business district. A comparison of the data from Queens Building from 1982 to 1990 as an annual mean is presented in the following Table 2:

Table 2. Queens Building in Central Perth. Annual mean of atmospheric lead - 1982 to 1990

Atmospheric lead concentrations expressed as $\mu\text{g Pb/m}^3$ at 0 degrees Celsius and 101.3 kPa

Year	Annual mean value	Maximum Value	WHO Std
1982	2.60	4.80	0.5 - 1.0
1983	2.52	5.30	0.5 - 1.0
1984	2.06	4.46	0.5 - 1.0
1985	1.83	5.36	0.5 - 1.0
1986	1.61	3.58	0.5 - 1.0
1987	1.76	3.73	0.5 - 1.0
1988	1.56	3.91	0.5 - 1.0
1989	1.83	3.19	0.5 - 1.0
1990	1.67	3.96	0.5 - 1.0

The maximum values of atmospheric lead are values recorded in the sample period of 24 hours.

4. Lead - the concentration of lead in premium grade petrol in Western Australia, Australia and countries throughout the world.

In obtaining an accurate reflection of the concentration of atmospheric lead the spatial variation in the concentration of lead in leaded petrol plays an important role. As well the Environmental Protection Authority has endeavoured to obtain as much information as possible from national and international sources on the concentration of lead in petrol. The following provides what is currently available to the Environmental Protection Authority on the concentration of lead in leaded petrol.

4.1 Western Australia

The following data has been supplied to the Environmental Protection Authority by BP Refinery (Kwinana) Pty.Ltd. which indicates that the lead concentration in premium grade petrol is about 0.80 g Pb/L, whilst in unleaded petrol it is about 0.010 g Pb/L. The following Table 3 provides annual average concentrations of lead in premium grade petrol supplied by BP Refinery (Kwinana) Pty.Ltd.to the Western Australia market.

Table 3. Annual average concentrations of lead in premium grade petrol

Year	Annual average	Maximum value	Minimum value
1982	0.75	0.85	0.43
1983	0.80	0.83	0.43
1984	0.74	0.82	0.28
1985	0.67	0.83	0.27
1986	0.61	0.83	0.28
1987	0.68	0.83	0.37
1988	0.59	0.83	0.28
1989	0.79	0.96	0.29
1990	0.80	0.84	0.38

Note: 1988 - Data from January to June, 1990 - Data from January to July.

Unleaded petrol: Since 1986 all values less than 0.001 g Pb/L in both grades.

All values are expressed as grams lead per litre (g Pb/L).

4.2 National - Australia

Australia replaced leaded regular with unleaded petrol in 1 January 1986.

Comparison values from around Australia of the lead concentration in leaded petrol, expressed in g Pb/L:

- New South Wales - Sydney and major cities 0.40, country 0.84
- Australian Capital Territory - 0.40 (recently changed)
- Victoria - 0.30
- South Australia - 0.65
- Tasmania - 0.40
- Queensland - 0.72 (it is believed that this value has been recently reduced to 0.40)

The values given are typical annual averages and the data obtained from environmental agencies in each state.

4.3 International

Comparison values from around the world of the lead concentration in leaded petrol, expressed in g Pb/L:

- United States of America - legal limit 0.026 g Pb/L.
- Canada - (max) 0.29 g Pb/L.
- European Economic Community - EEC Countries generally between 0.15 and 0.40 g Pb/L, but most limit lead to 0.15 g Pb/L (Austria, Finland, Norway, Sweden, Switzerland 0.15.g Pb/L)
- Europe general - Italy 0.40 (max) g Pb/L, Luxembourg 0.14 g Pb/L, Netherlands 0.15 (max) g Pb/L, Poland 0.30 g Pb/L, Portugal (max) g Pb/L, Monaco (max) 0.40 g Pb/L.
- Other countries - Malta (max) 0.84 g Pb/L, Brunei (max) 0.40 g Pb/L, Burma (max) 0.56 g Pb/L, China 0.78 g Pb/L, Hong Kong (max) 0.14 g Pb/L, Indonesia (max) 0.40 g Pb/L, Japan nil, South Korea (max) 0.32 g Pb/L, Laos (max) 0.40 g Pb/L, Bermuda (max) 0.15 g Pb/L, Mexico 0.15-0.28 g Pb/L, Greenland (max) 0.40 g Pb/L.

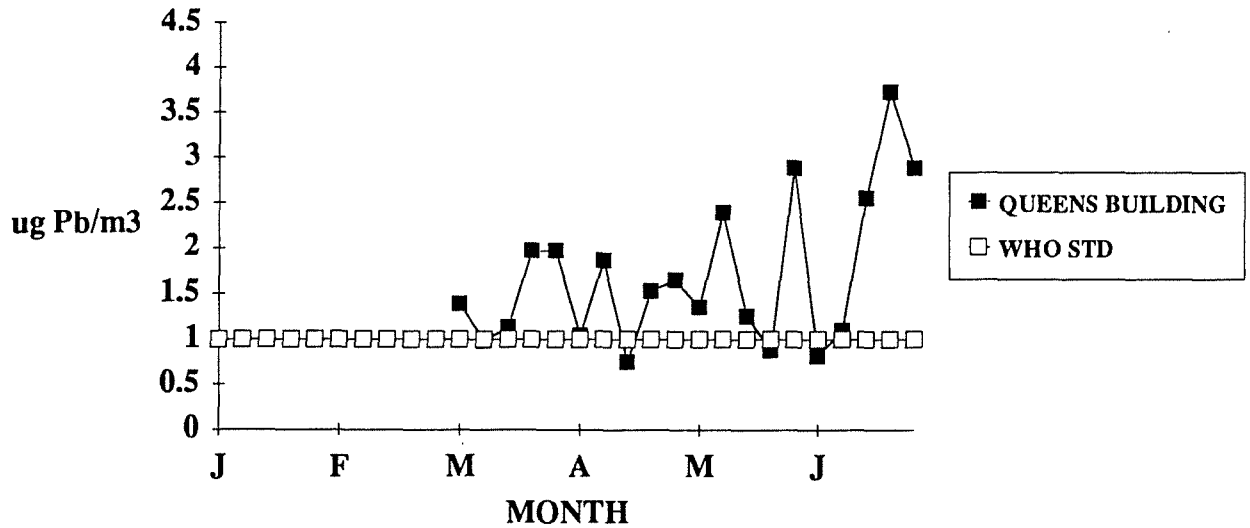
5. Lead - recent air quality recommendations made by Dr Streeton for the Victorian Environment Protection Authority with specific reference to the concentration of lead in the atmosphere.

In a recent review of the Victorian, "State Environment Protection Policy (The Air Environment)" Dr Streeton stated, "Lead in urban atmospheres is contained in small particles that are readily inhaled and can enter the lung. They are then absorbed into the bloodstream and add to the lead derived from food and water. Long term exposure to low levels of lead can affect: the nervous system, the body's ability to make blood, and blood pressure. Young children are particularly susceptible."

Streeton's Recommendation:- It is Dr Streeton's recommendation that in view of concern arising from the latest overseas research on the effects of lead on health, that the present acceptable limit for lead should be 1.0 microgram per cubic metre measured as a 3 month average to avoid adverse health effects."

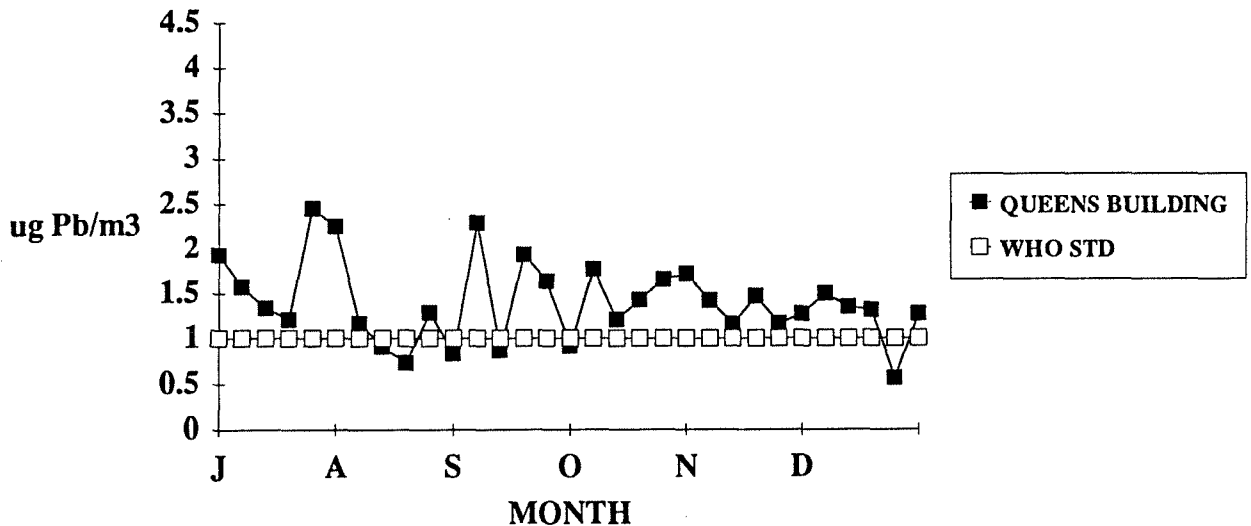
Commenting on the small particles (which is generally accepted as those with a diameter less than 10 microns, PM₁₀) the Environmental Protection Authority has been monitoring this respirable dust fraction of Perth's central business district since March 1990 and its atmospheric lead concentration. The data is present in the following graph:

**ATMOSPHERIC LEAD CONCENTRATIONS IN PM10 FRACTION -
CENTRAL PERTH - JANUARY TO JUNE 1990**



The PM10 atmospheric lead concentration data collected by the Environmental Protection Authority from its Queens Building monitoring location indicates that greater than 90% of the central cities atmospheric lead concentration is within this respirable fraction.

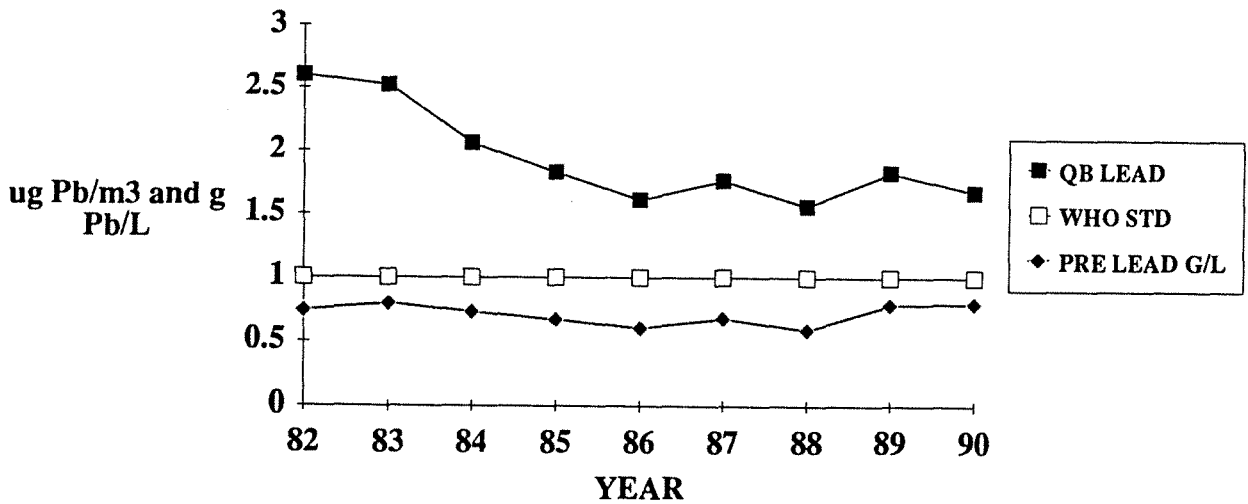
**ATMOSPHERIC LEAD CONCENTRATIONS IN PM10 FRACTION -
CENTRAL PERTH - JULY TO DECEMBER 1990**



6. Spatial variations in central Perth's atmospheric lead concentration.

The variation in the spatial distribution of the concentration of lead in the ambient atmosphere can vary with the density of motor vehicles, distribution of leaded and unleaded vehicles and the concentration variation of lead in leaded petrol. The following graphical presentation shows the variation in the concentration of leaded petrol and the concentration of atmospheric lead for 1982 to 1990 at the Environmental Protection Authority's Authority Queens Building and Murray Street monitoring locations.

**ATMOSPHERIC LEAD IN CENTRAL PERTH AND
CONCENTRATION OF LEAD IN PREMIUM GRADE PETROL -
ANNUAL AVERAGE FOR 1982 TO 1990**



Note:-

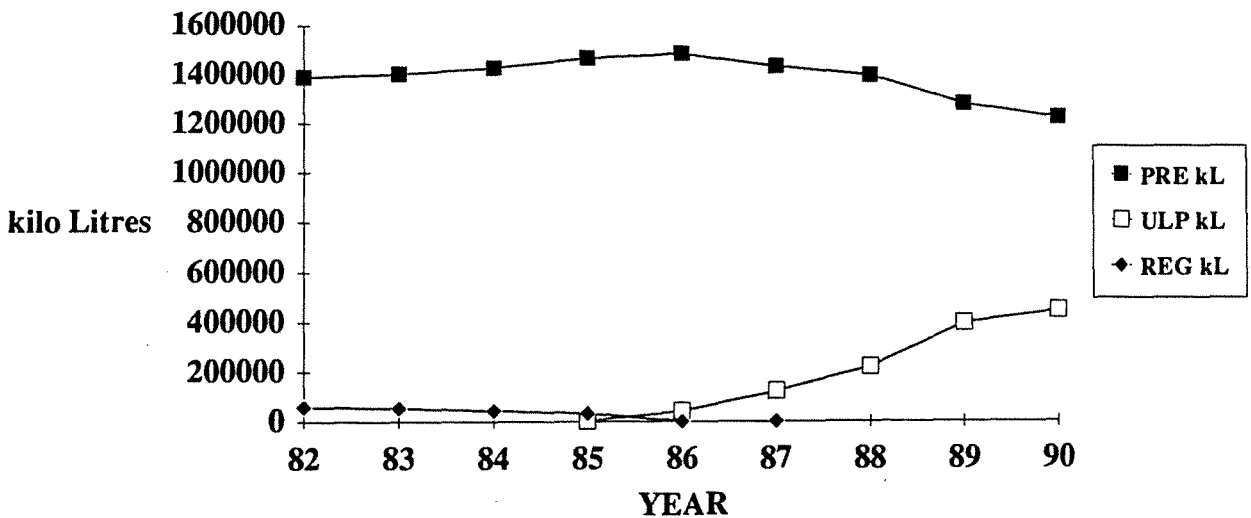
QB lead is EPA's William Street location, Queens Building.

PRE lead is the lead concentration in premium petrol.

WHO is the World Health Organisation's ambient air quality guideline.

The Environmental Protection Authority has obtained data on the volume of petrol sales in Western Australia from the Australian Bureau of Agricultural and Resource Economics (ABARE) and this is presented in the following graph:

VOLUMES SALES OF PETROL IN WESTERN AUSTRALIA 1982 TO 1990



Note:-

PRE kL Volume sales of premium grade petrol in Western Australia.

REG kL Volume sales of regular petrol in Western Australia.

ULP kL Volume sales of un-leaded petrol in Western Australia.

The data indicate that the total quantity of lead available for emission to the atmosphere has not maintained a close relationship with the reducing consumption of premium leaded petrol, but is more closely coupled to its lead concentration. The introduction of unleaded petrol in 1986 does not appear to have a significant influence on the reduction of atmospheric lead. This feature could be attributed to the composition of the vehicle population, particularly the percentage of vehicles still using premium leaded petrol. It was estimated that vehicles using lead free petrol only account for less than 30 percent of the total vehicle population.

The lead concentration in Western Australia's premium petrol is the highest in Australia. The average lead concentration from 1982 to 1990 of 0.713 gPb/L is approximately twice most comparable figures currently being used across Australia. When world values are compared the lead concentration value for Western Australia is very much out of line with health, pollution and environmental concerns related to atmospheric lead concentrations.

The variation in traffic flow south of the intersection of William and Murray Streets should be considered in the spatial variations which may influence the changes in atmospheric lead concentration. The Main Roads Department of Western Australia have supplied the following data on traffic flows passing the monitoring location in William Street, Perth. The value, AAWT in the following Table 4 expresses an annual average weekday traffic flow and such a figure represents an estimate average 24 hour traffic volume on weekdays throughout a 12 month period.

Table 4. Traffic Flow in William Street Central Perth south of Murray Street and the ambient atmospheric lead concentration at Queens' Building

Year	Traffic flow	Atmospheric lead	WHO Standard
1985/86	19 950	1.72	0.5 - 1.0
1987/88	26 340	1.65	0.5 - 1.0
1988/89	24 321	1.70	0.5 - 1.0
1989/90	27 306	1.75	0.5 - 1.0

Note:- Atmospheric lead concentration is calculated as the average of the years quoted. Year value given in Table 2. Lead values expressed as $\mu\text{g Pb/m}^3$.

7. Conclusion

Data collected on the atmospheric lead concentration in Perth's central business district since 1982, national and international comparisons of lead in leaded petrol and the recent recommendation by Dr Streeton on the safety concentration of atmospheric lead indicates that a defined line of action is required in Perth and Western Australia. It is evident that atmospheric lead concentrations in central Perth and by inference throughout the metropolitan region has reached values which are no longer acceptable by comparison with current national and international air quality goals and guidelines.

8. References

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