5.10 Lead in air

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Preamble: Lead in ambient air is primarily associated with particulate matter in air, hence discussion and measurement of this attribute focusses on analysis of the composition of particulate matter.

State of knowledge of the "Lead in air" attribute: Good / established but incomplete in that studies show that lead is present in ambient air, but poor / inconclusive regarding the extent of the impact of human health.

Part A—Attribute and method

A1. How does the attribute relate to ecological integrity or human health?

The primary concern associated with lead in air relates to human health. Lead is a highly toxic element, with the major concern being the cognitive and neurobehavioural deficits that are observed in children exposed to lead [1]. Effects on blood-pressure are the most sensitive effects of lead toxicity on adults with the full range of health effects associated with exposure to inorganic lead and compounds include, but are not limited to neurotoxicity, developmental delays, hypertension, impaired haemoglobin synthesis, and male reproductive impairment. The effects of lead exposure have often been related to the blood lead content, which is generally considered to be the most accurate means of assessing exposure.

Overviews of the toxicological effects associated with exposure to lead are provided by multiple sources [e.g., 1-3].

Since the removal of lead from petrol in New Zealand in 1996, the main source of non-occupational exposure is lead-based paints on and around houses built before 1970 and particularly before 1945 [4]. Beyond this, food intake, and drinking water, in particular where lead has been used in the plumbing system, may also result in exposure [1].

A2. What is the evidence of impact on (a) ecological integrity or (b) human health? What is the spatial extent and magnitude of degradation?

There is no evidence of impact of lead in ambient air on human-health in NZ. There are some studies that provide concentrations of lead in air, with some evidence of higher concentrations in winter e.g., Auckland [5], Tokoroa (Waikato) [6], Richmond [7]. These current observations of elevated lead concentrations in winter were attributed to the burning of lead-painted timber [5]. One study that links lead with lower cognitive function in NZ suggests poor air quality as a cause [8], but neither that study nor the cited reference [9] provide any information on ambient lead concentration (but see A3 for more information). Ongoing monitoring in Auckland at an industrial site, Penrose, showed a decrease in annual average concentrations from2.3 ng /m^3 in 2021 to 8 ng /m^3 in 2022 [28].

Despite the banning of lead in petrol, a recent international study suggested that historical gasoline-derived lead remains an important source of lead in the urban environment due to its persistence and effective remobilization [10]. A study in Timaru over from June to August 2010 found water-extractable lead concentrations of 1 ng /m3, and 12.6 ng/mg [11].

A3. What has been the pace and trajectory of change in this attribute, and what do we expect in the future 10 - 30 years under the status quo? Are impacts reversible or irreversible (within a generation)?

Data from Henderson in Auckland provides the only analysis of concentrations over time, and this shows a decreasing trend over 2007-2021 [5]. Beyond this there is an unknown historical trajectory of change since lead in air has rarely been measured. The lead concentrations in air in Henderson over the period 2007 to 2021 ranged between 2 to 12 ng /m^3 [5]. This contrast with an earlier study undertaken at two sites in Christchurch over 1987-1989 that found much higher lead concentrations of 70 and 155 ng/m^3, with particulate concentrations of 4820 and 6320 µg lead/g [12]. Vehicle emissions were considered to be the dominant source with a minor contribution from coal and soil. In New Zealand lead in petrol was phased out from 1986 prior to banning in 1996.

Additionally, some studies on household dust, which may also be inhaled, have also been undertaken. An early study of 120 house in Christchurch in 1987 found a geometric mean concentration of 573 µg lead/g with petrol lead and lead-based paints identified as the significant sources of lead in house dust [13]. A more recent international study, which included results from New Zealand houses found that increasing home age was associated with greater lead concentrations, with legacy sources (lead-paint) considered to be the dominant source [14]. [15] also provides further research on lead in household dust in New Zealand.

A4-(i) What monitoring is currently done and how is it reported? (e.g., is there a standard, and how consistently is it used, who is monitoring for what purpose)? Is there a consensus on the most appropriate measurement method?

No regular monitoring of this attribute is currently undertaken in New Zealand, although as noted in A2, there have been some studies that have assessed arsenic associated with particulate matter in air. The majority of these studies have been undertaken for source apportionment purposes, using ion-beam analysis (IBA), a non-destructive multielemental analytical technique. Some more recent studies e.g., [5] use XRF, which generally provides better detection limits. Some studies have also used water extracts of filters with analysis by ICP-MS [11].

Internationally, sampling and analysis of lead in ambient air is specified under the Australian National Environmental Protection measure [16] with measurement of lead concentrations in particular matter– Particulate metals high or low volume sampler gravimetric collection – Inductively coupled plasma (ICP) spectrometric method specified in AS/NZS 3580.9.15:2014. The Determination of Suspended Particulate Matter – Total suspended particulate matter (TSP) - High volume sampler gravimetric method is specified under AS/NZS 3580.9.3:2015. In the UK sampling is specified under the UK with sampling of the PM10 fraction of particles is carried out using Digitel DPA-14 ambient air samplers over one-week periods at sites, in accordance with BS EN 12341:2009 and analysis of these samples occurs by Inductively Coupled Plasma - Mass Spectrometry (ICP-MS), in accordance with European Standard EN 14902:2005 at NPL's UKAS-accredited laboratory [17] . In the US, various methods are specified under the list of designated references and equivalent methods [18].

A4-(ii) Are there any implementation issues such as accessing privately owned land to collect repeat samples for regulatory informing purposes?

Monitoring for this attribute would most sensibly be co-located at existing air-quality monitoring sites, thus there are unlikely to be any additional access issues. However, space to fit equipment, if additional is required, may be an issue at some locations.

A4-(iii) What are the costs associated with monitoring the attribute? This includes up-front costs to set up for monitoring (e.g., purchase of equipment) and on-going operational costs (e.g., analysis of samples).

Currently there is no existing ongoing monitoring of this attribute. Where existing air quality sampling includes the use of instruments that collect particulate matter on filters e.g., Partisol samplers, these filters may be able to be used for analysis to determine arsenic concentrations. However, method evaluation is required to determine whether lead can be detected in the particulate mass typically captured by these instruments or whether a higher volume sampler is required; for example, Partisol samplers can sample at between ~0.6-1.2 m3/hr with the USEPA specifying 1m3/hr (16.7 L/min) for regulatory sampling, however other instruments can sample at different rates, higher or lower.

Currently there is no commercially available method for the determination of lead in particulate matter. Some of the general method outlined in AS/NZS 3580.9.15:2014 is similar to that used for determining lead in soils hence it would seem feasible for commercial laboratories to develop the method if there was sufficient demand.

A5. Are there examples of this being monitored by Iwi/Māori? If so, by who and how?

We are not aware of any monitoring of this attribute being undertaken by iwi/hapū/rūnanga

A6. Are there known correlations or relationships between this attribute and other attribute(s), and what are the nature of these relationships?

There may some correlation with PM2.5 concentrations, given the association of lead with particulate matter – but the association will be dependent on the source of lead. Lead associated with residential wood-burning of lead-painted timber is more likely to be associated with lead derived from e.g., brake dust, soil dust will fall into larger particulate size fractions – hence measurement of lead will depend on particle size being measured. Regardless of particulate size, any relationship with particulate mass is still likely to be variable depending on the contribution of different sources.

Part B—Current state and allocation options

B1. What is the current state of the attribute?

As noted in A2, there are small number studies that have assessed concentrations of lead in ambient air. These studies do not provide comprehensive coverage on the state of lead in air across all of NZ towns and cities. Given the random and sporadic occurrence of burning of treated timber – in residential wood-burners or outdoor burn piles, the value of undertaking additional monitoring to fill these gaps is perhaps debateable.

B2. Are there known natural reference states described for New Zealand that could inform management or allocation options?

To our knowledge, there are no known natural reference states for this attribute.

B3. Are there any existing numeric or narrative bands described for this attribute? Are there any levels used in other jurisdictions that could inform bands? (e.g., US EPA, Biodiversity Convention, ANZECC, Regional Council set limit)

New Zealand ambient air guidelines [19] have a 3-month moving average guideline value for lead in PM10 of 0.2 µg/m3. This is similar to the US National Ambient Air Quality guideline of 0.15 µg/m3 of Pb in total suspended particles as a 3-month average [20].

Lead is not included in the EU directive 2004/107/EC, although the UK Air quality standards regulation (2010) provide a limit value of lead concentration in PM10 of 0.5 $\mu g/m^3$ expressed as an annual mean. This is the same at the Australian air quality standard set under the Australian National Environment Protection (Ambient Air Quality) Measure [16].

B4. Are there any known thresholds or tipping points that relate to specific effects on ecological integrity or human health?

From toxicological data there are various thresholds that have been identified as leading to different effects (see 1-3). However, there are no known thresholds or tipping points (and no studies undertaken to establish these) associated with lead concentrations in ambient air. As noted above, exposure to leaded paint is likely to result in greater exposure than via ambient air.

B5. Are there lag times and legacy effects? What are the nature of these and how do they impact state and trend assessment? Furthermore, are there any naturally occurring processes, including long-term cycles, that may influence the state and trend assessments?

The existence of lag times and legacy effects for this attribute is unknown/uncertain.

B6. What tikanga Māori and mātauranga Māori could inform bands or allocation options? How? For example, by contributing to defining minimally disturbed conditions, or unacceptable degradation.

A high standard of air quality is an outcome sought by iwi/hapū/rūnanga. In addition to discussing this attribute directly with iwi/hapū/rūnanga, in regard to air quality, there is likely to be tikanga and mātauranga Māori relevant to informing bands, allocation options, minimally disturbed conditions and/or unacceptable degradation in treaty settlements, cultural impact assessments, environment court submissions, iwi environmental management and climate change plans etc.

Part C—Management levers and context

C1. What is the relationship between the state of the environment and stresses on that state? Can this relationship be quantified?

The current primary source of lead in New Zealand air is suggested to arise from the burning of lead-painted timber [5, 21], as with arsenic in air associated with the burning of treated timber this is likely to be a random source. Tetraethyl lead is listed as an additive in Avgas, although is restricted to <0.14% weight, equivalent to <0.85 g lead/L fuel, and there is an EPA approval for aviation gasoline and racing gasoline (Avgas 100 and Avgas 100LL) under the Hazardous Substances and New Organisms Act 1996 (HSNO Act) [22]. A recent international study suggested that remobilisation – at least in the highly urbanised city of London [10]. The extent to which this is a source in New Zealand air is unknown.

Lead may also be found in vehicle non-exhaust emissions– including associated with brake-pad wear [23] and lead tyre-weights [24], with some studies indicating that due to increasingly strict emissions control on vehicle exhaust emissions, non-exhaust emissions are increasing as a proportion of total vehicle emissions [25]. Similarly, an increasing proportion of electric vehicles will also increase the relative significance of vehicle non- exhaust emissions.

C2. Are there interventions/mechanisms being used to affect this attribute? What evidence is there to show that they are/are not being implemented and being effective?

C2-(i). Local government driven

Some councils have campaigns to not burn painted timber e.g. [26], or regional plans that prohibit the burning of painted (e.g., 27]. Beyond this, there are requirements for monitoring particulate matter under the National Environmental Standard for Air Quality.

C2-(ii). Central government driven

C2-(iii). Iwi/hapū driven

Iwi/hapū planning documents such as Environmental Management Plans and Climate Change Strategies/Plans may contain policies/objectives/methods seeking to influence air quality outcomes for the benefit of current and future generations. We are not aware of other interventions/mechanisms being used by iwi/hapū/rūnanga to directly affect this attribute.

C2-(iv). NGO, community driven

C2-(v). Internationally driven

Internationally, the Geneva convention on long-range transboundary air pollution requires parties to reduce emissions of lead (and cadmium and mercury) from industrial sources, combustion processes and waste incineration. The protocol on heavy metals was amended in 2012 to introduce more stringent emission limit values (ELVs) for emissions of particulate matter and of cadmium, lead and mercury applicable for certain combustion and other industrial emission sources that release them into the atmosphere. The emission source categories for the 3 heavy metals were also extended to the production of silico- and ferromanganese alloys. New Zealand does not appear to be a signatory to this convention and hence has no obligations in this regard.

Part D—Impact analysis

D1. What would be the environmental/human health impacts of not managing this attribute?

There is likely negligible impact on human health of not managing lead in ambient air, given the current low concentrations in air, and the absence of significant sources. As noted in A1, exposure to lead-based paints in pre-1960 houses is likely to be more significant source that should be managed [4].

D2. Where and on who would the economic impacts likely be felt? (e.g., Horticulture in Hawke's Bay, Electricity generation, Housing availability and supply in Auckland)

Although uncertain, the expectation is that managing or not managing this attribute will have minimal economic impacts.

D3. How will this attribute be affected by climate change? What will that require in terms of management response to mitigate this?

Climate change may indirectly affect this attribute through changes primarily associated with changes in dust generated from soil as a result of climate related events. Evaluation of the significance of this hazard is required to ascertain whether, and how, management is required to mitigate this.

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