5.8 Arsenic in air

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Preamble: Arsenic 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 "Arsenic in air" attribute: Good / established but incomplete in that studies undertaken agree that burning of treated timber in residential heating is the primary source of arsenic. Excellent and well-established in relation to the effects on health effects of arsenic on people, although poor / inconclusive regarding the extent of the impact on arsenic in ambient air on human health.

Part A—Attribute and method

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

The primary concern associated with arsenic in air relates to human health. Arsenic is a known human carcinogen, with most studies based on population exposure to drinking water derived from groundwater with naturally high arsenic [1). These studies show increases in skin cancers and internal cancers of the exposed population. Various studies on occupational exposure also demonstrate causal links between inhaled arsenic and cancer [2,3]. For non-occupational exposed people, dietary sources of arsenic are the primary route of exposure, with food the dominant sources other than in countries where drinking water with naturally elevated arsenic is known to occur [1, 5-7]. The toxicity of arsenic varies depending on its chemical forms with inorganic species of arsenic (most likely to occur in air) considerably more toxic than organic forms (most likely to occur in food) [5].

Overviews of the toxicological effects associated with exposure to arsenic are provided by multiple sources [e.g., 1-7] with cancer, the primary health effect of concern.

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 arsenic in ambient air on human-health in NZ, although internationally estimates of the impact of atmospheric arsenic on health risks have been made [e.g., 8]. However, there are several studies that show elevated arsenic in air, primarily over winter, in various cities and regions across New Zealand. This includes Auckland [9], Tokoroa (Waikato) [10, 11], Wellington [12, 13, 14], Timaru [15]. Richmond [16, 17], Invercargill [18]. Earlier studies and data are also presented in [19], This elevation is attributed to the burning of copper-chromium-arsenic treated timber for home heating [8, 19, 20], with [20] noting that exceptionally high arsenic concentrations of 1860 mg/kg were observed in particulate matter collected from a pre-1994 wood burner in Tokoroa in which 'old-decking' had been burned.

Additionally, various studies on household dust, which may also be inhaled, have also been undertaken. An international study found that New Zealand had the greatest enrichment of arsenic in household dust compared to soil concentrations, which was attributed to the burning of copper-chrome-arsenic treated timber for home heating [21]. Two further studies provide further research on arsenic in household dust in New Zealand [22, 23].

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 data over multiple years, and no trend in arsenic concentrations was observed – rather seasonal variation, with highest concentrations occurring in winter and associated with residential wood-burning was most evident [8, see also B1]. Beyond this there is an unknown historical trajectory of change since arsenic in air has rarely been measured. The primary source of arsenic to NZ air is recognised as residential burning of treated (copper-chrome-arsenic) timber for home heating. As such, the extent of wood-burning in the future – as influenced by winter temperatures - may influence change. There are currently no recognised industrial sources of arsenic emissions, although internationally arsenic from industrial coal-burning activities has been identified as a source of arsenic to air [e.g., 24]. While arsenic from coal burning has been mentioned in a New Zealand context, there is ongoing scrutiny of industrial emissions, and a shift away from coal-fired boilers etc thus it is unlikely any such emissions would increase. Another source of arsenic in ambient air might be expected to be from suspension of soil particles, or localised areas associated elevated arsenic associated with mining waste [25, 26], although these are located away from urbanised areas where people might be exposed. However, the amount of expected change over the next 10-30 years appears minimal.

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 multiple studies that have assessed arsenic associated with particulate matter in air. The majority of studies have been undertaken for source apportionment purposes, using ion-beam analysis (IBA), a non-destructive multielemental analytical technique. The minimum detection limits for As determination by IBA vary from 3-30 ng m^3 depending on the type and thickness of the filter media used to collect samples This compares to the New Zealand ambient air guideline of 5.5 ng m^{-3} (annual average) [4]. More recently source-apportionment studies have also used measurement by XRF (e.g., [9]), while other studies have used aqua regia extraction of filters combined with inductively coupled-mass spectrometry ICP-MS [12, 13] or water extracts of filters with analysis by ICP-MS [15].

Internationally, the European directive 2004/107/EC outlines the requirements for monitoring arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. Associated with this directive are European Standards that specify the determination of particulate matter concentrations in ambient air (EN1241:2023), and EN 14902:2005, which specifies the standard method for analysis of Pb, Cd, As and Ni in PM10 aerosol, through microwave digestion of the samples and analysis by graphite furnace atomic absorption spectrometry or by inductively coupled plasma (quadrupole) mass spectrometry.

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 arsenic 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 1m^3/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 arsenic in particulate matter. The general method outlined in the European standard EN 14902:2005 is similar to that used for determining arsenic 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 arsenic with particulate matter associated with wood-burning – but the association will be dependent on the source of arsenic. Some sources e.g., tyre-wear, brake dust, soil dust will fall into larger particulate size fractions – hence measurement of arsenic 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, various studies have assessed concentrations of arsenic in ambient air, and in household dust in a number of locations across New Zealand. These studies identify the burning of CCA-treated timber in residential wood-burners as the primary source of arsenic in New Zealand air. Outdoor burning of treated timber may also occur e.g., in farm burn piles, although this is unlikely to be captured through existing monitoring. These studies do not provide comprehensive coverage on the state of arsenic 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. It does provide some value in ascertaining whether campaigns to not burn treated timber are effective or need to be stepped up, but arguably regular profiling of this issue could be scheduled in the absence of this information to the same effect but without the monitoring cost.

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 [4] have an annual average guideline value for inorganic arsenic is 0.0055 $\mu g/m^3$.

Internationally, the EU directive 2004/107/EC provides a target value for arsenic of 6 ng/m^3, which is based on the total content in the PM10 fraction averaged over a calendar year. Arsenic is not included in Australian or US air quality standards.

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 1-7). However, there are no known thresholds or tipping points (and no studies undertaken to establish these) associated with arsenic concentrations in ambient air. As noted above, general population exposure to arsenic is more likely via dietary sources.

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, regarding 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 plans, climate change strategies, 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 dominant source of arsenic in New Zealand air is widely recognised to be the burning of copper-chromium-arsenic treated timber in residential wood-burners, with studies in various regions across New Zealand showing marked elevations of arsenic in air over winter periods (see A2). Some elevated arsenic concentrations have also been observed outside of this period, and has been attributed to outdoor burning of treated timber [17]

There are natural sources of arsenic in ambient air, such as soil particles which may contain naturally occurring arsenic, however the contribution of this source has not been quantified.

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 raise awareness of the risks associated with the burning of CCA treated timber e.g. [26], or regional plans that prohibit the burning of treated timber (e.g., 27]. Beyond this, there are general industrial emissions controls, and 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

Part D—Impact analysis

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

Not managing this attribute could result in increased human health impacts, although it is difficult to gauge the potential magnitude of this increase, or indeed if an increase would occur. As noted above, the primary source of arsenic in air is the burning of treated timber in residential wood-burners. There is an increasing use and availability of low emission wood burners to generally manage emissions from residential wood burners and campaigns to raise awareness of the hazards of residential burning of treated timber. However, the extent to which treated timber may be burned is essentially random. It is most likely to be burned if people have a wood burner, cannot afford to buy firewood and have a source of treated timber that could be burned.

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?

Indirectly through primarily through changed winter temperatures, which may result in more or less winter heating, and also indirectly through 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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