Environment Protection Authority

An investigation into metals in domestic tank water around the Newmont gold mine in Cadia

Published by:
NSW Environment Protection Authority
6 Parramatta Square
10 Darcy Street, Parramatta NSW 2150
Locked Bag 5022, Parramatta NSW 2124

Phone: +61 2 9995 5000 (switchboard)
Phone: 131 555 (NSW only – environment information and publications requests)
Fax: +61 2 9995 5999
TTY users: phone 133 677, then ask
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This report has been peer-reviewed by the NSW Environment Protection Authority's independent expert panel.

In June to August 2023, the NSW Environment Protection Authority took water samples from domestic rainwater tanks and corresponding kitchen taps in the area surrounding the Newmont (formerly Newcrest) gold mine in Cadia. This report summarises the results of metal concentrations in these water samples.

Background

The community surrounding the Newmont Corporation gold mine site in Cadia (Cadia Valley Operations) has expressed concern that contaminated dust may be leaving the mine site and contaminating the surrounding land and domestic water tanks.

Many residents in the area around the Cadia Valley Operations mine rely on rainwater tanks for their domestic water supply. In response to community concerns, the EPA offered water tank testing for residential properties that are rainwater-dependent, as part of a broader monitoring program.

This report summarises the results of water testing in the Cadia valley area. This study aimed to:

- characterise the metal concentrations in water from kitchen taps and rainwater tanks in the Cadia valley area
- provide advice to property owners and tenants on the metal concentrations in their drinking water relative to Australian Drinking Water Guidelines (ADWG, NHMRC 2011), including additional information on management of exposure when exceedances of the ADWG were measured
- compare metal-concentration results from tank testing conducted by the EPA, Cadia Valley Operations, NSW Health and the community
- compare metal-concentration results from tank testing in the Cadia Valley area to typical concentrations in Australian rainwater tanks
- assess the relationships between concentrations of metals in water samples and the distance and direction from the mine.

Approach taken

Water samples were collected from 97 properties with domestic rainwater tanks (used for drinking water) in the Cadia valley area between June and August 2023. The EPA sampled water from the kitchen tap (point of use) and water tank taps, where possible, using standard protocols for sampling drinking water from tanks (AS/NZS 5667 1998, AS/NZS 5667 2022). Taps where water is used for drinking and domestic purposes were sampled to best represent the exposure pathway. Taps were flushed with approximately 1L of water prior to sampling. Bore, dam and creek water samples were collected if used to top up water tanks or for stock drinking, at the residents' request. These results have been reported to residents but are not included in this report.

Residential properties were sampled where community members provided an expression of interest to the EPA. Sample locations cannot be provided due to privacy; however, they cover the area surrounding Cadia Valley Operations (approximately 2 to 50 km from the mine, Figure 1).

The samples were analysed for metals of concern including lead, cadmium, nickel, selenium, copper, arsenic and zinc. In addition to the metals of interest, kitchen tap samples were analysed for total dissolved solids, total hardness, true colour, turbidity, pH, nitrate, nitrite, sodium and fluoride. The results of these additional analyses are not included in this report but have been provided directly to residents.

Metals of concern for the sampling program were selected by considering:

- the metals identified as being present through the community's sampling programs
- the nature of Cadia Valley Operations

- potential local sources of metals (e.g. lead flashing on roofs).

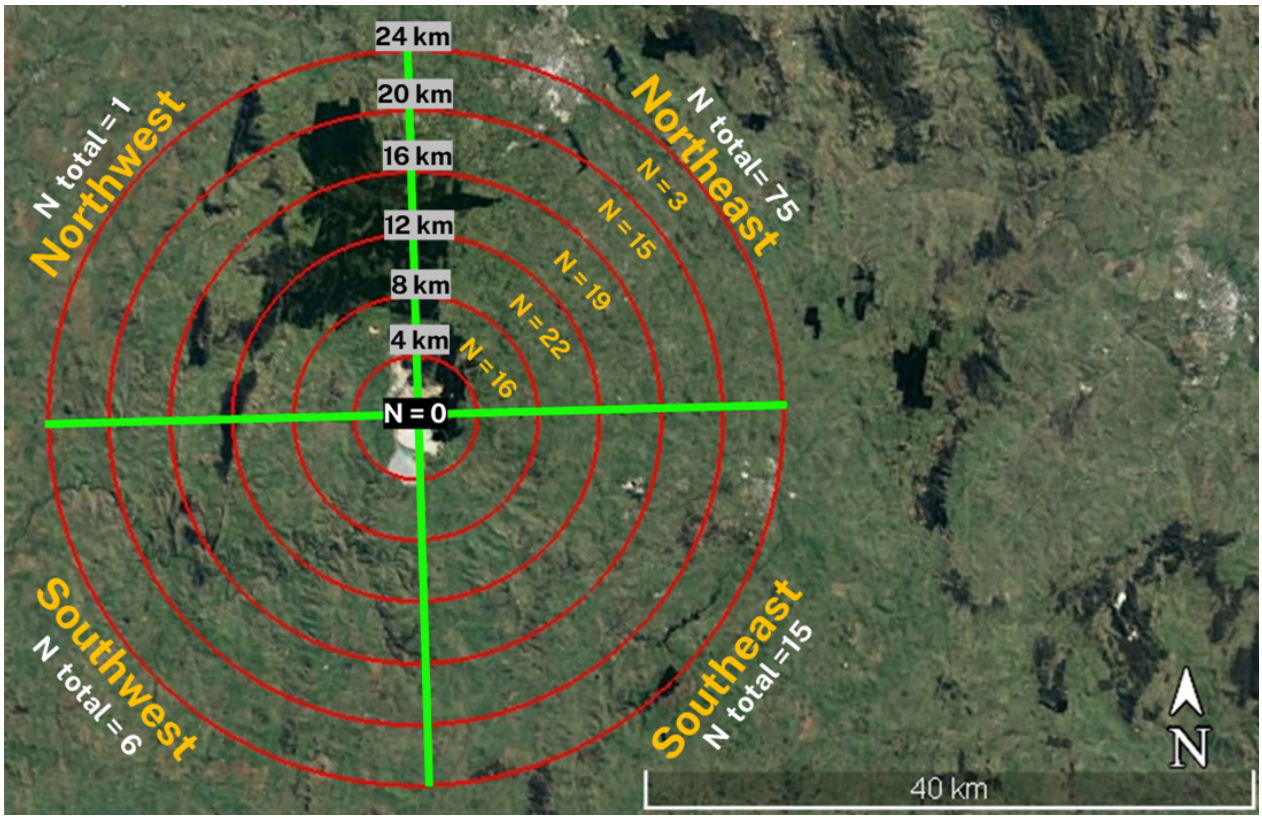
Several measures were taken to assure and control the quality of sampling and analysis protocols.

The rainwater sampling methods used were tailored to each of the types of sample being collected (water samples from tanks and water from taps used for drinking water). For each type of sample, the sampling methods were consistent to allow for comparability. The sampling methods used to collect water from drinking water taps are consistent with nationally and internationally recognised good practice sampling approaches (enHealth 2021, AS/NZS 5667 2022).

Sample field duplicates were collected at a minimum of one duplicate every 20 samples.

NATA accredited analytical procedures were used for preparation and analysis of metals in the samples. Laboratory blanks, duplicates, matrix spikes and certified reference material (CRM) were analysed (1 in 20 samples) and met the general laboratory acceptance criteria.[1]

Figure 1 Number of properties sampled (N) in proximity to the mine



[1] <practical quantitation limit for blanks, relative per cent difference < 20% when results >10 x practical quantitation limit for laboratory duplicates, 70–130% recovery for matrix spikes and 80–120% recovery for CRM.

Test results

The EPA collected 281 water samples, which included samples from 112 kitchen taps and 120 water tanks. There are limitations to this large sampling program that affect the interpretation of the results. Only one sample from each sampling point rather than a series of samples was collected. Also, sampling was done over a couple of months rather than all samples being taken at the same time (for instance, on the same day). Sampling results might have been different if the samples had been taken at other times or under different conditions (such as with a different amount of water in the water tanks).

Comparison with Australian Drinking Water Guidelines (ADWG)

The EPA has compared the results of the water samples to the national drinking water guidelines for contaminants in water (NHMRC 2011). These guidelines provide both health and aesthetic guideline values for contaminants. We compared sampling results with both values; however, only the health guideline value exceedances pose a potential risk to human health.

The concentration range and percentage of ADWG exceedances for each metal of concern in kitchen tap and tank water are outlined in Tables 1 and 2, respectively. The concentration range for pH in water samples collected from the kitchen tap was 4.7–9.1. The aesthetic guideline range for pH is 6.5-8.5. This is not a health guideline value but pH <6.5 may be corrosive and pH >8.5 may cause scale and taste problems.

Most results (96%) from kitchen tap samples showed metals concentrations below the ADWG (Table 2). Lead was at or exceeded the ADWG in three kitchen tap samples; however, the level of lead in the tank water samples from these three properties did not exceed the ADWG. Lead may be introduced into water from pollution sources, or via dissolution from natural sources or household plumbing containing lead (for example pipes, solder and brass fittings). Nickel exceeded the ADWG in one kitchen tap sample (0.032 mg/L). Nickel was not detected in the water tank sample from this property. Nickel concentrations are usually very low but up to 0.5 mg/L has been reported after prolonged contact of water with nickel-plated fittings (NHMRC 2011).

Lead was at or exceeded the ADWG in 17 tank water samples. At one property, the concentration of lead in a water tank was 0.24 mg/L. When this tank was re-sampled, the lead concentration was below the ADWG (0.002 mg/L). The next highest concentration of lead measured in a water tank was 0.066 mg/L. Cadmium was at or marginally exceeded the ADWG in two water tank samples (0.002 mg/L and 0.0025 mg/L). Cadmium contamination can come from industrial or agricultural sources or from impurities in galvanised (zinc) fittings, solders and brasses (NHMRC 2011).

The EPA has provided individual residents with advice on treatment methods and best actions to take where exceedances of the ADWG were found.

Other metals in kitchen tap and tank water samples were below the respective ADWG values on the day of sampling.

Table 1 **Metal concentrations in kitchen tap and tank water samples**

Metal	ADWG (Health) (mg/L)	Concentration range (mg/L)	
		Kitchen tap	Tank[1]
Arsenic	0.01	<0.001–0.005	<0.001–0.003
Cadmium	0.002	<0.0001–0.001	<0.0001–**0.0025**
Copper	2	0.001–1.9	<0.001–1.4
Lead	0.01	<0.001–**0.014**	<0.001–**0.24**
Nickel	0.02	<0.001–**0.032**	<0.001–0.011
Selenium	0.01	<0.001	<0.001
Zinc	N/A	0.003–3.6	0.011–6

[1] Water tank samples include one sample collected from a shed downpipe.

Table 2 **Percentage of water samples that exceed ADWG (Health) values at the kitchen tap and tank**

Metal	Samples that exceeded ADWG (Health) (%)	
	Kitchen tap (n=112)	Tank[1] (n=120)
Arsenic	0%	0%
Cadmium	0%	1.7%
Copper	0%	0%
Lead	2.7%	14%
Nickel	0.9%	0%
Selenium	0%	0%
Zinc	N/A	N/A

[1]Water tank samples include one sample collected from a shed downpipe.

Comparison with Cadia Valley Operations, NSW Health and community testing

We have compared EPA testing at the kitchen tap to that undertaken by Cadia Valley Operations and NSW Health. Cadia Valley Operations sampled 112 kitchen taps in March 2023 and the NSW Health Public Health Unit sampled 25 kitchen taps in March 2023. The 25 locations sampled by NSW Health were determined in conjunction with the Cadia Community Sustainability Network (CCSN) and were the locations where CCSN's tank results were elevated. Community sampling of rainwater tanks was undertaken in May, October, November and December 2022. We do not have results from community sampling of kitchen taps to compare to.

There is variability in the sampling methodology (flush time), tank condition (water volume) and season among the various sampling programs. The effect of the sampling method on the result can be very significant. One reason for different results between different sampling programs may be due to differences in sampling methods. Therefore, when comparing results between sampling it is important to compare sampling methods. Examples of differences between tap sampling methods

that can influence the result include the duration of water stagnation prior to sampling, flushing time prior to sampling (if pre-flushing was applied), the volume of water flushing prior to collecting water (if a defined first volume was turned over), velocity/flow rate of the tap during sampling, the volume of the sample container, whether aerators were retained or removed, sample preservation method, and whether total or dissolved metals are analysed.

These confounding factors make the results difficult to compare, as sampling methods varied between the three testing programs. We have not compared results from individual residents but instead the overall range of metal concentrations and per cent exceedances of ADWG (Table 3).

Comparison of metal results from kitchen tap water

The maximum concentration of copper, lead and nickel was higher in water samples collected by Cadia Valley Operations in March 2023 (Sage 2023) than in those from the EPA's sampling campaign. The NSW Health results for kitchen tap water were the lowest, with no exceedances of ADWG. The variability observed among sampling programs is probably due to differences in sampling protocols and conditions at the time of sampling.

Cadia Valley Operations did not flush water through taps and piping prior to sampling; the EPA flushed 1 L prior to sampling (according to WHO 2007); and NSW Health flushed for 3 minutes prior to sampling. A long-term unpublished study by NSW Health showed that the water standing in metal pipework overnight frequently showed lead and copper concentrations above ADWG values (enHealth 2011). Flushing the water for three minutes removed any built-up contamination, except where lead was present in the catchment area of the water source. Flushing is typically done before sampling from rainwater tanks (Morrow 2007, Martin 2010, Chubaka 2019, Triantafyllidou 2021).

Comparison of metal results from water tanks

Similar to the EPA results, where there were exceedances of copper, lead and nickel guidelines at the kitchen tap sampled by Cadia Valley Operations, there were no exceedances at the water tanks, indicating the source of contamination could be internal plumbing and/or tap fixtures. The concentration of cadmium exceeded the ADWG at both the kitchen tap and water tank of one residence sampled by Cadia Valley Operations, whereas the EPA water sampling program had no exceedances of the cadmium ADWG at the kitchen tap but did have one exceedance in a water tank.

Higher levels of ADWG exceedances were found in rainwater tanks (Table 4). The water from rainwater tanks is not expected to meet the guideline values for a number of parameters, including microbial parameters. Water treatment is required to routinely meet drinking water guidelines. Significantly higher concentrations of metals were measured in tank samples collected independently by the community (Table 4). Community samples were collected with a bailer lowered to the bottom of the rainwater tank rather than from the tap or top of the tank. This bailer technique collects sediment from the bottom of the tank as well as water, which will cause significantly higher metal concentrations in samples. Water with sediment in it would neither be expected to meet the Australian drinking water guidelines nor be representative of what would be consumed.

Table 3 **Concentration ranges (mg/L) of metals in water samples and exceedances of ADWG (%) collected from kitchen taps by the EPA, NSW Health and Cadia Valley Operations**

Bold values indicate an exceedance of the ADWG guideline.

Metal	ADWG (Health) (mg/L)	Concentration range (mg/L)		
		NSW EPA (Jun–Aug 2023) n=112	**Cadia Valley Operations (Mar 2023) n=155**	**NSW Health (Mar 2023) n=25**
Arsenic	0.01	<0.001–0.005	<0.001–0.003	<0.001–0.001
Cadmium	0.002	<0.0001–0.001	<0.0001–**0.003 (0.06%)**	<0.0001–0.0002
Copper	2	0.001–1.9	<0.001–**3.5 (2%)**	0.003–1.099
Lead	0.01	<0.001–**0.014 (2.7%)**	<0.001–**0.031 (2%)**	<0.0002–0.007
Nickel	0.02	<0.001–**0.032 (0.9%)**	<0.001–**0.134 (0.6%)**	<0.0004–0.009
Selenium	0.01	<0.001	Not measured	<0.007
Zinc	N/A	0.003–3.6	<0.005–4.7	0.02–2.61

Table 4 **Concentration ranges (mg/L) of metals in water samples and exceedances of ADWG (%) collected from water tanks by the EPA and the community**

Bold values indicate an exceedance of the ADWG guideline.

Metal	ADWG (Health) (mg/L)	Concentration range (mg/L)	
		NSW EPA (Jun–Aug 2023) n=120	**Community (May–Dec 2022) n=25**
Arsenic	0.01	<0.001–0.003	<0.001–**0.011 (4%)**
Cadmium	0.002	<0.0001–**0.0025 (1.7%)**	<0.0001–**0.007 (12%)**
Copper	2	<0.001–1.4	0.001–1.2
Lead	0.01	<0.001–**0.24 (14%)**	0.001–**0.841 (48%)**
Nickel	0.02	<0.001–0.011	0–**0.047 (20%)**
Selenium	0.01	<0.001	Not measured
Zinc	N/A	0.011–6	0–51.1

Metals in Australian rainwater tanks

A review of literature was conducted to gain an understanding of the concentrations of metals observed in rainwater tanks throughout Australia. Arsenic, cadmium, copper, lead, nickel and zinc were detected in most Australian studies that tested for these metals. Using these studies[2] from around Australia, concentration ranges (min–max) were derived for comparison with the water tank data from the EPA investigation. The sampling protocols are different between the studies, adding a layer of uncertainty to the data, but they are used as a comparison to show the range of typical concentrations found throughout Australia. The majority of these studies sampled from tanks not kitchen taps.

The comparison of typical ranges of metals in rainwater tanks from the literature to the EPA data from kitchen taps and water tanks (Table 5) shows that the EPA data falls within the typical ranges observed elsewhere in Australia.

Table 5 Concentration ranges for water samples observed in rainwater tanks across Australia

Metal	Concentration range (mg/L)		
	NSW EPA investigation (Kitchen tap) n=112	NSW EPA investigation (Tank) n=120	From the literature
Arsenic	<0.001–0.005	<0.001–0.003	LOR–0.007
Cadmium	<0.0001–0.001	<0.0001–**0.0025**	0.00001–**0.007**
Copper	0.001–1.9	<0.001–1.4	0.01–**3.47**
Lead	<0.001–**0.014**	<0.001–**0.24**	LOR–**3.24**
Nickel	<0.001–**0.032**	<0.001–0.011	LOR–**0.03**
Selenium	<0.001	<0.001	LOR–0.00056
Zinc	0.003–3.6	0.011–6	0.0012–26.0

A range of metals is commonly found in Australian rainwater tanks. These metals are often attributed to materials used for roofs (such as galvanised iron), as well as fittings, pipes and taps and the water tank itself. Other sources of metals include general air pollution from vehicles and planes, metal manufacturing and mining. Lead is a metal that is very commonly found in rainwater tanks and other drinking water sources and is the most concerning due to its significant health effects, particularly to children (WHO 2022). In a national survey, lead was detected in 79% of tested rainwater tanks and 9% of tanks showed lead concentrations higher than or equal to the ADWG value (Chapman et al. 2008). Most studies attribute the source of lead in drinking water from rainwater tanks to building materials, plumbing, galvanising, lead flashing/paint, etc. found on the roof or tank. Due to the frequent detection and high concern for lead exposure, enHealth (2021) has provided guidance on how to reduce exposure to lead (and other metals) through drinking water. Recommendations include, for example, the flushing of taps to remove stagnant water before water is used for drinking.

[2] Chapman et al. 2008; Chubaka et al. 2018; Huston et al. 2012; Kus et al. 2010; Kus et al. 2011; Magyar 2007; Magyar 2008; Martin et al. 2010; Morrow et al. 2007; Morrow et al. 2010; Rodrigo et al. 2010; Spinks et al. 2005.

In previous studies from the literature without a known point source of pollution, the percentage of tanks to exceed the lead ADWG at some point in a sampling period ranged from 9% to 56% (with one outlier study having as high as 81% of tanks exceeding drinking water guidelines (Chubaka et al. 2018)). The exceedances of lead in previous studies ranged from the limit of reporting to 0.67 mg/L (with an outlying study reporting as high as 3.24 mg/L in one tank). Variations in the percentage and concentrations of lead exceedances among studies is likely due to flush time, sample size, conditions of the tank, and catchment area and geographic location.

Studies where a pollution point source is apparent were not included in Table 5, as contaminant concentrations would not be relevant to typical Australian concentrations. For example, Heysworth and Mullan (2009) found lead concentrations exceeding the ADWG in 30.6% of tanks within 1 km of the Esperance Port in Western Australia (where lead carbonate was being shipped) and in 13.9% of tanks more than 2 km from the Port.

There is typically a variation in the concentration of lead (and other metals) with season (Martin et al. 2010, Simmons et al. 2001, Huston et al., 2012, Triantafyllidou & Edwards 2012, Chubaka et al. 2018). This means that the risk of elevated lead levels may not pose serious health risks if only occurring rarely, so long as the level is not high enough to be toxic in a single dose (Morrow et al. 2007).

Relationship between concentrations of metals and distance from the mine

The EPA sampled water from water tanks and kitchen tap surrounding Cadia Valley Operations. The sample analysis and data assessment were undertaken by scientists from the NSW Department of Planning and Environment. Statistical data analysis was conducted to answer two specific questions:

- Is there a statistically significant relationship between the concentrations of metals in water from water tanks and kitchen taps and the distance of sampling locations from Cadia Valley Operations?
- Is there a statistically significant relationship between the concentrations of metals in water from water tanks and kitchen taps and the sampling locations relative to Cadia Valley Operations? The prevailing wind direction is towards the northeast (Todoroski Air Sciences 2023).

The sampling locations were categorised according to their distance and direction from the mine. The number of sampling points in each location and distance categories are shown in Figure 1. The map does not include exact sampling locations to protect the privacy of residents who took part in the sampling program.

Principal component analysis and regression analysis were used to determine whether there is a relationship between the distance of the sampling points or the location of sampling points and concentrations of metals measured in water samples. Neither the principal component analysis nor the regression analysis showed any meaningful relationships between distance/location and concentrations of metals measured in water tank or kitchen tap water. However, such a relationship may be masked by confounding factors that can also contribute metals to water tanks. These confounding factors (such as roofing and fitting materials) have been discussed in more detail in the sections above.

Due to the possible influence of confounding factors on metal concentrations in water samples the statistical analysis was also done for the dataset on metals in surface soils from the EPA's Soil Monitoring Program, which was published in August 2023 (NSW EPA 2023). There are fewer factors that influence concentrations of metals in soils compared to the data from water tanks, making it a more suitable dataset to assess relationships between distance and direction from the mine. The same statistical analysis (principal component analysis and regression analysis) were

conducted on the metal concentration data in surface soils surrounding Cadia Valley Operations (30 soil samples). No statistically significant relationships were found between metal concentrations in surface soils and distance or direction from the mine.

What do the results mean?

Key observations from the results of the EPA's tank water testing in the Cadia valley area are as follows:

1. There were exceedances to the health based ADWG values for lead (2.7% at kitchen tap, 14% in tanks), nickel (0.9% at kitchen tap) and cadmium (1.7% in tanks).
2. Concentrations of key metals found in this investigation are within typical concentrations found in Australian rainwater tanks. It is likely that many or all of the exceedances found are from domestic and local sources of contamination such as roofing, plumbing and other atmospheric fallout such as that from aircraft emissions, industrial and roadside dust.
3. Exceedances of the ADWG were most common for lead; however, the percentage of exceedances for lead found in this investigation were within typical levels found in Australian rainwater tanks.
4. These results indicate the importance of maintaining catchments, tanks and tank water distribution systems in accordance with guidance provided by NSW Health, including first-flush diverters, regular tank cleaning and flushing. Property owners may also consider installing filtration to reduce potential contamination of their drinking water.
5. No statistically significant relationship was found between concentrations of metals in water samples (from water tanks and kitchen taps) and distance or direction from the mine.

   No statistically significant relationship was found between concentrations of metals in soil samples and distance or direction from the mine.

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