Volcanic ashfall impacts on water supplies: briefing note

Volcanic ashfall can have serious effects on water supply systems. Systems with intakes on streams and rivers are particularly vulnerable. In some cases, water treatment plants may have to slow down or stop production to remove ash from the treatment train. Water restrictions may need to be imposed on customers, and alternative supplies may need to be provided.

While ash can impact water quality by adding some soluble elements, this is a secondary consideration after water quantity (having sufficient water per person per day for drinking, cooking, washing dishes, hand washing) and microbiological safety of drinking water. The risks posed by waterborne pathogens are more immediate and serious.

Municipal water treatment plants are advised to increase testing of free chlorine residuals throughout the network to ensure disinfection and/or issue residents with a 'boil water' notice and/or advise disinfection of water supplies at the household level. Options for household disinfection include filtration (e.g., through a membrane filter), adding chemical disinfectant such as bleach, or boiling. If the water is visibly cloudy, the suspended solids need to be reduced by settling or filtering prior to disinfection.

Some customers may report unusual metallic tastes in tap water following ashfall. This is almost always due to elevated concentrations of copper, iron, manganese, and/or zinc, for which taste threshold values in drinking-water are generally lower than any health-based guideline values (Table 1). As drinking-water guidelines for most potentially toxic elements are based on a lifetime's exposure to those concentrations, short-term increases are not necessarily of public health concern.

However, as the public are commonly concerned about water contamination by ashfall, rapid analyses of drinking-water are recommended. The main element of health concern released by ashfall is fluorine (F). While F toxicity (fluorosis) has been reported for grazing livestock ingesting ash, concentrations in drinking-water are very unlikely to be high enough to pose a risk.

Suggested parameters to monitor in raw water sources and treated water are presented in Table 1. They are divided into higher and lower priority parameters. These recommendations are based on experience from volcanic eruptions worldwide. Local response efforts should be informed by direct analysis of water (see Table 1/Page 2) and possibly ash (see Page 2). Results should be communicated to the public in a timely manner. It is unknown how long an eruption will continue, and repeat testing may be necessary.

Water demand is likely to be high during ash clean-up operations and, if unchecked, may lead to shortages. As far as possible, treated water supplies should be conserved. During clean-up, the public should be advised to shovel the ash, and to lightly dampen ash surfaces before sweeping, to reduce the hazard of breathing airborne ash. Information on personal protection during ashfall clean-up is available at ivhhn.org/ash-protection.

Summary of actions for emergency managers and public health officials:

- Dampen ash if sufficient water is available, otherwise encourage dry ash clean-up methods (shovelling or sweeping ash rather than using a hose). Conserve treated water supplies.
- Provide alternative water supplies to households in need.
- Initiate rapid analyses of drinking water and communicate results to the public in a timely and informative manner.
- Reinforce advice to the public to disinfect water supplies; advise on methods for doing so and provide equipment and/or supplies for disinfection.

Water sampling and analysis:

For comprehensive advice on water sampling and analysis, refer to the World Health Organization advice here: https://www.who.int/water_sanitation_health/dwq/2edvol3d.pdf

- Water samples should be collected in clean, 1 litre (or larger) polyethylene bottles.
- For grab samples from surface waters:
    - If possible, hold the sample container in a clamp on the end of a pole.
    - Rinse the bottle three times with the water to be sampled.
    - Take samples from approximately 20-30 cm below the surface to avoid surface contamination.
    - If the water is flowing, hold the container open towards the flow. If there is no flow, fill the container by pushing it away from you.
- If sampling treated water from a tap:
    - If taking a sample to check if metals such as copper and lead are leaching from plumbing fittings, collect the first volume without flushing the tap first. Tap should not have been used for 12 hours.
    - Otherwise, flush tap by running for 10-20 seconds before collecting sample.
- Store samples in a cooler at <10 °C and ship to the laboratory as soon as possible.
- pH, turbidity, and free chlorine residual are best measured onsite as samples will change during transport.
- Label samples clearly, and record the following information for each sample: date and time of collection, sampling location/site code, person sampling (for traceability), method of sampling (grab sample, first flush or full flush) and any other useful observations such as weather conditions.
- If possible, have water samples analysed at a laboratory accredited for drinking-water testing (for parameters other than pH, turbidity, and free chlorine residual).
- Portable equipment, such as disposable test kits are convenient and cost-effective, but their reliability varies widely. Ensure periodic benchmarking against certified test methods.

Analysis of volcanic ash to assess potential to contaminate water sources:

Ash leachate analyses are carried out to determine the concentrations of readily available elements on ash particle surfaces, which can be released into water sources and affect water quality. The IVHHN standardised leachate protocol is available for this purpose. *Note that ash leachate analyses should not be compared directly with drinking-water standards. These standards relate to potable water supplies.*

For water treatment plant managers:

For concise, evidence-based advice on how to prepare for, respond to, and recover from volcanic ashfall, see the poster for water treatment plant managers here: https://www.gns.cri.nz/Home/Learning/Science-Topics/Volcanoes/Global-Ash-Impact-Posters

Much of the above advice on water sampling and analysis is based on 'Sampling and Monitoring for Small Drinking-water Supplies', available at: https://www.health.govt.nz/system/files/documents/publications/sampling-monitoring-small-drinking-water-supplies.pdf

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Table 1 Parameters to monitor in water supply systems following volcanic eruption

Priority parameters	Monitor in:		Reason for monitoring	WHO Health-based Guideline Value[1]	WHO acceptability threshold value[1]
	Source water	Treated water			
pH	✓	✓	pH has no direct impact on consumers but is important in water treatment. pH should be <8 for effective disinfection with chlorine, water with pH<7 is more likely to be corrosive towards pipes and plumbing fittings[1]. Volcanic emissions are typically acidic. This may lower pH in some surface waters, although this is typically minor. Adjustment of treated water pH may help prevent corrosion of the pipe network.		
Turbidity	✓	✓	For effective disinfection, turbidity reduction should achieve turbidity of 0.2 NTU or less, on average[1]. Visible turbidity in treated water reduces its acceptability. Volcanic ashfall suspended in surface raw water sources can cause turbidity levels to exceed operating thresholds for water treatment plants.		2.5 NTU (appearance)[2]
Free chlorine residual		✓	Free chlorine residual at the far end of distribution systems should remain above 0.5 mg/L to ensure disinfection throughout the system.	>0.5 mg/L	
Fluoride (F)[3]	✓	✓	Health concern: F commonly elevated by ashfall. Sometimes added during water treatment for oral health.	1.5 mg/L	
Aluminium (Al)	✓	✓	Aesthetic concern (colour): Al commonly elevated by ashfall. Can also be elevated by addition of alum as a coagulant in water treatment.		0.1 mg/L (colour, forms deposits)
Copper (Cu)	✓	✓	Aesthetic (staining and taste) and health concern: Cu sometimes elevated by ashfall. Can be elevated by corrosion of plumbing materials in acidic conditions.	2 mg/L	1 mg/L (staining) 2.5 mg/L (taste)
Iron (Fe)	✓	✓	Aesthetic concern (colour): Fe commonly elevated by ashfall.		0.3 mg/L (colour, taste)

Lead (Pb)		✓	Health concern: Pb very unlikely to be elevated by ashfall. Can be elevated by corrosion of plumbing materials in acidic conditions.	0.01 mg/L	
Manganese (Mn)	✓	✓	Aesthetic (colour and taste) and health concern: Mn commonly elevated by ashfall.	0.4 mg/L	0.1 mg/L (staining, taste) 0.2 mg/L (forms deposits)
Sulfate (SO_4)	✓	✓	Aesthetic concern (taste, possible laxative effect): SO_4 commonly elevated by ashfall.		250 mg/L (taste) 1000 mg/L (laxative effect)
Zinc (Zn)	✓	✓	Aesthetic concern (taste): Zn sometimes elevated by ashfall. Can be elevated by corrosion of galvanised plumbing materials in acidic conditions.		3 mg/L (appearance) 4 mg/L (taste)
Parameters to be monitored if resources permit					
Arsenic (As)		✓	Health concern: As unlikely to be elevated by ashfall. Monitor to allay customers' concerns.	0.01 mg/L	
Barium (Ba)		✓	Health concern: Ba sometimes elevated by ashfall.	1.3 mg/L	
Boron (B)		✓	Health concern: B sometimes elevated by ashfall.	2.4 mg/L	
Cadmium (Cd)		✓	Health concern: Cd very unlikely to be elevated by ashfall. Monitor to allay customers' concerns.	0.003 mg/L	
Chromium (Cr)		✓	Health concern: Cr very unlikely to be elevated by ashfall. Monitor to allay customers' concerns.	0.05 mg/L	
Mercury (Hg)		✓	Health concern: Hg very unlikely to be elevated by ashfall. Monitor to allay customers' concerns.	0.006 mg/L	
Nickel (Ni)		✓	Health concern: Ni sometimes elevated by ashfall. May also be elevated by corrosion of plumbing materials in acidic conditions.	0.07 mg/L	

1 Guidelines for drinking-water quality: fourth edition incorporating the first addendum. Geneva: World Health Organization; 2017. Licence: CC BY-NC-SA 3.0 IGO. https://www.who.int/publications/i/item/9789241549950. The values provided refer to treated water.

2 An acceptability threshold for turbidity is not provided in the WHO Guidelines for Drinking-water Quality. This value comes from Drinking-water Standards for New Zealand 2005 (Revised 2018) https://www.health.govt.nz/publication/drinking-water-standards-new-zealand-2005-revised-2018.

3 Long-term exposure to fluoride concentrations >1.5 mg/L is associated with an increased risk of dental fluorosis. For countries with warmer climates, this guideline value may need to be revised downward to account for increased water consumption. https://www.who.int/water_sanitation_health/dwq/chemicals/fluoride.pdf