

LES RISQUES SANITAIRES LIES AUX GAZ VOLCANIQUES ET GEOOTHERMIQUES

Un guide pour le public





4. TRANSPORT ET SÉQUESTRATION DE LA POLLUTION VOLCANIQUE

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Les gaz HF et HCl sont rapidement dilués dans l'air, se dissolvent facilement dans l'eau et peuvent affecter les réserves d'eau à proximité de l'éruption. Si des cendres sont également émises, le fluorure et d'autres contaminants peuvent alors adhérer à la surface des particules de cendres et se déplacer beaucoup plus loin dans la direction du vent.



5. QUELS SONT LES EFFETS DES GAZ ET DES AÉROSOLS VOLCANIQUES SUR LA SANTÉ?

Les personnes sont exposées aux gaz et aux aérosols volcaniques par la respiration ou par le contact avec la peau et les yeux. Les effets néfastes sur la santé peuvent varier de légers à graves, avec occasionnellement des expositions se révélant mortelles. Les effets sur la santé dépendent du type et de la concentration du gaz dans l'air, de la durée d'exposition et de la sensibilité de la personne. Notre nez et nos voies respiratoires peuvent filtrer, dissoudre et/ou neutraliser certains gaz et aérosols, réduisant ainsi la quantité qui atteint les poumons. Cependant, les gaz sulfureux, le HF, le HCl et les aérosols volcaniques sont acides et peuvent irriter les surfaces humides de nos voies respiratoires et de nos poumons. Le CO₂ et le H₂S peuvent provoquer l'asphyxie.

People should be aware of potential health effects when visiting a volcanic or geothermal environment. In some areas, travelling alone is not advised in case immediate assistance is needed. If someone in your group becomes ill or collapses, you should all immediately leave the area. Move the affected person into fresh air and contact emergency rescue services, if needed.

Temporary volcanic air pollution health effects

Physical symptom	SO ₂	H ₂ S	CO ₂	HF/HCl	PM*
Irritation of the nose, throat, eyes, or skin	x	x	x	x	x
Cough and/or phlegm	x	x	x	x	x
Chest/lung tightness or irritation	x	x	x	x	x
Shortness of breath	x	x	x	x	x
Headache	x	x	x	x	x
Aggravation of asthma (wheezing)	x	x		x	x
Fatigue and/or dizziness	x	x	x		
Rapid breathing			x		
Nausea	x	x	x		
Cardiovascular effects (at high concentrations)	x			x	x

*PM - particulate matter includes volcanic sulfate aerosols.
Evidence of some effects is derived primarily from urban pollution studies.

Specific information

SO₂ The sensitivity of individuals varies, however, people with asthma are particularly sensitive to SO₂, and exposure may worsen their symptoms. Asthmatics should follow their Asthma Action Plan, if they have one, and carry relief medication with them in volcanic areas. The general population should avoid exposure to SO₂ above recommended air quality levels (which are country specific). Exposure to high concentrations (more than around 40 parts per million or ppm) can cause nausea, vomiting, stomach pain and damage to the airways and lungs. At very high concentrations (more than 100 ppm), SO₂ can cause rapid unconsciousness, pulmonary edema and death. Exposure to a combination of SO₂ and respirable particles may increase negative health effects. The long-term health effects of persistent exposure to low concentrations of volcanic SO₂ are still being evaluated.



H₂S Exposure to high concentrations (more than 100 ppm) of H₂S, or long periods spent at low concentrations, can cause a person's sense of smell to become fatigued. So, the ability to smell H₂S as a warning sign can be misleading, since sometimes the 'rotten egg' aroma can't be detected. Repeated exposures can result in health effects at concentrations that were previously tolerated without ill effect. The U.S. Occupational Safety and Health Administration (OSHA) sets a maximum exposure limit of 20 ppm for workers but notes that as little as 2-5 ppm may cause irritation of the eyes, headache, nausea, or breathing problems in some asthmatics. As concentrations increase, symptoms may include fatigue, loss of appetite, dizziness, or respiratory tract irritation. Very high exposures (more than 500 ppm) can cause rapid unconsciousness or death within minutes.

CO₂ While CO₂ is present in our atmosphere at around 400 ppm (0.04%), exposure to 50,000 ppm (5%) can cause labored breathing, headaches, sweating, and increased heart rate. As concentrations increase, dizziness, muscular weakness, mental confusion, drowsiness, ringing in ears, and vomiting can occur. At very high concentrations (more than 100,000 ppm; 10%), CO₂ can cause rapid unconsciousness, asphyxiation and death.

HCl and **HF** Both of these gases are usually minor components of a volcanic plume, but can cause acute irritation of the skin, eyes, nose, throat, and lungs. Special caution should be taken if you are close to an area where lava is entering the ocean (Section 1). Very high concentrations of HCl (50-100 ppm) can cause swelling of the breathing passage and pulmonary edema (a build-up of fluid and swelling in the lungs) that can lead to death. HF concentrations greater than 50 ppm are dangerous even for brief exposures.

Sulfate aerosol In urban populations, studies have shown that both short and long-term exposure to $PM_{2.5}$ or PM_{10} may cause respiratory and cardiovascular disease, and premature death. It is not yet known if the health effects of exposure to sulfate aerosols are the same as urban PM exposures.

Radon Short-term exposure to radon gas is symptomless. Long-term exposure to elevated radon concentrations (for example, indoor exposures) is a cause of lung cancer.

The above effects of gases at different airborne concentrations are from the U.S. Agency for Toxic Substances and Disease Registry (ATSDR). Also see www.ivhhn.org/information/information-different-volcanic-gases.



Sensitive groups

People vary in their susceptibility to air pollution, and some groups may be more likely to experience ill effects. Sensitive groups include:

- ❖ People with asthma, lung or heart problems
- ❖ Older adults
- ❖ Infants and children
- ❖ Pregnant women



Exposure to volcanic and geothermal gases may worsen symptoms for people who have pre-existing health conditions. Older adults may also be sensitive to effects because of declining lung and heart health. Children are more sensitive than adults because they breathe faster, are more active, and have larger lungs in proportion to their body size than adults. Their noses are less efficient at filtering gases and particles and they frequently mouth breathe, bypassing the filtering effect of the nose. Sensitive groups should be especially cautious and follow recommended actions in volcanic settings (see next section).





6. PROTECTING YOURSELF FROM VOLCANIC AND GEOTHERMAL EMISSIONS

Be prepared

- ✦ Understand the hazard:
 - ✦ Get familiar with any websites that monitor the air quality (e.g., SO₂, PM) and weather forecasts for the area. Changes of wind patterns could carry emissions into your area.
 - ✦ Stay informed about the volcanic conditions in your area and be aware of the concentrations of volcanic gases and aerosols. Eruptions and gas emissions may change suddenly, so stay alert.
 - ✦ Each volcanic setting is different and the specific gas hazards will vary.
- ✦ Follow general disaster preparedness guidelines:
 - ✦ Stay informed about civil and health protection information specific to your location.
 - ✦ Keep an emergency supply kit in your home (food, water, essential medicine etc.) should you need to leave the area or shelter in place.
 - ✦ Have an evacuation plan, pack all essential items, and be prepared to rapidly evacuate your family and pets.
 - ✦ Make a family plan on how to communicate with, and account for, each family member.
 - ✦ Keep medications handy. If you have asthma or other lung or heart conditions, keep your relief medication available and use as prescribed. If you don't have medications, but feel you might need them, call your doctor.




Protect yourself

- ✦ Take care of yourself:
 - ✦ Do not smoke and avoid secondhand smoke.
 - ✦ Stay hydrated. Drink plenty of liquids to help loosen congestion. Warm or hot liquids may help some people.
 - ✦ Manage congestion or irritation. Over-the-counter nasal sprays or eye drops can help reduce symptoms for some people.
 - ✦ People with a pre-existing health condition should carefully monitor their health and contact their doctor as necessary.
 - ✦ If you are experiencing chest pain, dizziness and weakness, breathing difficulties, or other unusual symptoms you should contact a medical professional.
- ✦ Reduce your exposure:
 - ✦ In an active volcanic or geothermal environment, move upwind and away from the smell of the gases, if you find yourself in uncomfortable concentrations.
 - ✦ Limit strenuous activities during poor air quality. Outdoor work, exercise and exertion increase your chances of being affected by the gases and aerosols. Try to breathe through the nose and reduce mouth breathing while outdoors.

- ❖ Stay indoors when there is poor outdoor air quality. Close all doors and windows, and seal up large gaps to the outdoors (for example, using tape or plastic sheeting). Be aware of becoming overheated as a result of sealing your house. Even if your house is not well-sealed, it may still offer some protection. If available, consider visiting indoor areas that are better-sealed and/or have air conditioning (for example, commercial buildings or businesses).
- ❖ Try to eliminate sources of indoor pollutants (for example, smoking, candles/incense, un-vented cooking and heating stoves, or other appliances which produce smoke or carbon monoxide).
- ❖ Reduce indoor pollution with an air cleaner. If possible, close doors and windows and use an air cleaner to help reduce the levels of gases and aerosols that have entered. To reduce particles, you need a particle filter ('HEPA' filter) and, to reduce SO₂, you need an acid gas filter for the air cleaner. Air conditioners (outside vent closed and set to recirculate) and dehumidifiers can also help to improve indoor air quality.



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- ❖ Refresh the air in your home or building after pollution levels drop by opening doors and windows.
 - ❖ Leave the area if appropriate. If indoor areas have poor air quality, consider temporarily relocating to a less impacted area.
 - ❖ Restrict volcanic emissions from entering your vehicle. Temporarily close your windows and vents and turn your fan and air conditioner off when driving in heavily-affected areas. Be aware of becoming overheated as a result of sealing your vehicle.
 - ❖ Facemasks designed to filter particles are not effective for gases but are helpful for aerosols and ash. See www.ivhhn.org/ash-protection for more detail. There are commercial masks specific for filtering gases, but these are not recommended for the general public. This is because safe use of gas masks requires correct mask and/or filter cartridge selection, fit testing, and training on correct use, maintenance and storage.
 - ❖ Monitor children for changes in their health. Adults should ensure that children's exposure is reduced by limiting exertion, staying indoors or leaving the area.
 - ❖ If a home or building is in a geothermal area, then good ventilation is important to reduce potential indoor concentrations of radon and CO₂. In areas with radon, testing for indoor concentrations may be advised.



7. OTHER EFFECTS OF VOLCANIC EMISSIONS

Contamination of water supplies

- ❖ **Acid rain:** Acid rain can dissolve harmful metals, such as lead, from metal roofs and plumbing systems, into catchment drinking water. If you have lead-bearing nails, flashing, paint or other materials, they should be removed from your roof catchment system. If possible, downspout pipes should be disconnected from tanks before acid rain or ashfall events and reconnected afterwards.
- ❖ **Human health impacts:** Gastrointestinal problems (nausea, vomiting, stomach pain and/or diarrhea) have been reported by people drinking water contaminated by volcanic emissions, likely due to dissolved metals. Volcanic emissions may also raise fluoride concentrations in roof-collected drinking water which, when consumed on a regular basis, may contribute to fluorosis. This condition can damage developing teeth and, potentially, the bones. In some situations where water is scarce, roof-collected water may still be the best source of domestic water.
- ❖ **Actions to minimize human health risks:** If your regular drinking water supply has been disrupted, then use water that is bottled, boiled, filtered, or chemically disinfected. Roof-collected drinking water should always be treated to reduce or eliminate microbes. In high-risk areas, if possible, drinking water should be tested by an accredited laboratory for chemical contaminants, including fluoride. This is particularly important for children under 8 years old. Let the tap run before using the water, because water standing in pipes for long periods (like overnight) can contain higher levels of dissolved metals.



Health of domestic animals, livestock and plants

- ❖ **Acidic emissions:** Acid gases, aerosols and acid rain can affect livestock, crops, flowers and foliage. Plants can show damage within a few hours of exposure although some plants are more susceptible than others. Open fields are most vulnerable but crops under cover can still be exposed to gases. Rinsing plants with fresh water, immediately upon exposure, can help minimize the chemical damage.
- ❖ **Animal health impacts:** Grazing animals may experience health effects from exposure to excess fluoride and sulfur through breathing or ingesting contaminated water and feed. Excess fluoride intake over time can result in dental or skeletal fluorosis. Short-term, very high fluoride intake can lead to acute fluoride poisoning, which can be lethal. Excessive sulfur intake from high concentrations in feed, water, or the environment can lead to neurological disorders, or mineral imbalances. Breathing SO₂ gas may also cause respiratory effects in animals.
- ❖ **Actions to minimize animal health risks:** To reduce exposure by ingestion, ensure a clean water and food supply. Farmers may want to protect exposed feed by covering it. Farmers and pet owners should monitor the health of their animals especially for eye, dental, gastrointestinal and/or breathing problems. Farmers and ranchers may want to consult a veterinarian about providing supplementary feed or minerals for livestock, or for other assistance, as necessary. If possible, consider moving animals to a non-affected area.

Damage to infrastructure

- ❖ Volcanic emissions and acid rain can quickly corrode metal, including farming, building and utilities infrastructure. In some cases, it may be possible to substitute more resistant materials.



8. SOURCES

Agency for Toxic Substances and Disease Registry (USA). Toxic substances web portal for **hydrogen sulfide** (CAS#:7783-060-4), **sulfur dioxide** (CAS#:7446-09-5), **hydrogen fluoride** (CAS#:7664-39-3) and **hydrogen chloride** (CAS#:7647-01-0), 2018.

California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (USA). **Evidence on the developmental and reproductive toxicity of sulfur dioxide factsheet**, 2011.

College of Tropical Agriculture and Human Resources, University of Hawaii. **Volcanic Emissions website**, 2018.

Hansell, A., Oppenheimer, C. (2004). **Health hazards from volcanic gases: A systematic literature review**. Archives of Environmental Health, 59(12), 628-639.

Kullman, G. J., Jones, W. G., Cornwell, R. J. & Parker, J. E. (1994). **Characterization of air contaminants formed by the interaction of lava and sea-water**. Environmental Health Perspectives, 102(5), 478-482.

Occupational Safety and Health Administration (USA). **Hydrogen sulfide hazards website**, 2018.

National Fluoridation Information Service (New Zealand). **Dental fluorosis – is it more than an aesthetic concern?** NFIS Advisory, 2014.

National Research Council of the National Academies (USA). **Acute exposure guideline levels for selected airborne chemicals**. Volume 8. Chapter 9: Sulfur dioxide, 2010.

U.S. National Institute of Health, National Library of Medicine. **Carbon dioxide haz-map**, 2020.

World Health Organization. **Air quality guidelines for particulate matter, ozone, nitrogen oxide and sulfur dioxide: global update 2005: summary of risk assessment**. ISBN 92 890 2192 6, 2005.

World Health Organization. **Review of evidence on health aspects of air pollution – REVIHAAP Project report**, 2013.



For further information, please visit:

Volcanic ash hazards and protection:

ivhhn.org/pamphlets;

volcanoes.usgs.gov/volcanic_ash

Volcanic gases:

ivhhn.org/information/information-different-volcanic-gases

Local volcano monitoring observatories:

wovo.org/observatories

Example of volcano-specific color-coded SO₂ levels and
recommended actions:

hiso2index.info/assets/FinalSO2Exposurelevels.pdf