

Water Treatment

Cornell Cooperative Extension, College of Human Ecology

Perchlorate

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Perchlorate (ClO_4^-) is a chemical that is used as a solid substance in rocket fuel, fire works, and missiles. It provides oxygen to the combustion process in solid fuels. There are perchlorate manufacturers in 44 states. In 1997 a new analytical detection method became available for perchlorate, and subsequently the detection level was lowered from 400 to $4 \mu\text{g/L}$.¹ The consequence of the lower detection level is that perchlorate is now being found everywhere. It has seeped into many groundwater and surface water sources, and as a result into drinking water, because perchlorate residues were not accurately disposed of, and perchlorate is highly soluble in water. A number of areas in California, Arizona and Utah have high concentrations of perchlorate in either soil or water or both. Recent studies have shown that it is also present in some produce and in drinking water. In figure 1 the extent of the perchlorate contaminated areas around the country is depicted.

Health

Perchlorate can inhibit the uptake of iodide in the thyroid gland. Iodide is necessary for the production of thyroid hormones which are responsible for prenatal and postnatal growth and development. In adults these hormones are responsible for correct metabolism. Perchlorate is such a good inhibitor that in the 1950s it was used as medicine for people with an overly active thyroid gland. It is not in such use anymore though, because better medicine became available and because perchlorate had to be consumed in great amounts to have an effect because it is rapidly excreted from the body. Perchlorate can possibly have adverse health effects if it is present in sufficient amounts and ingested on a daily basis. A number of studies which looked at the health effects of perchlorate on prenatal babies and children give an unclear view.

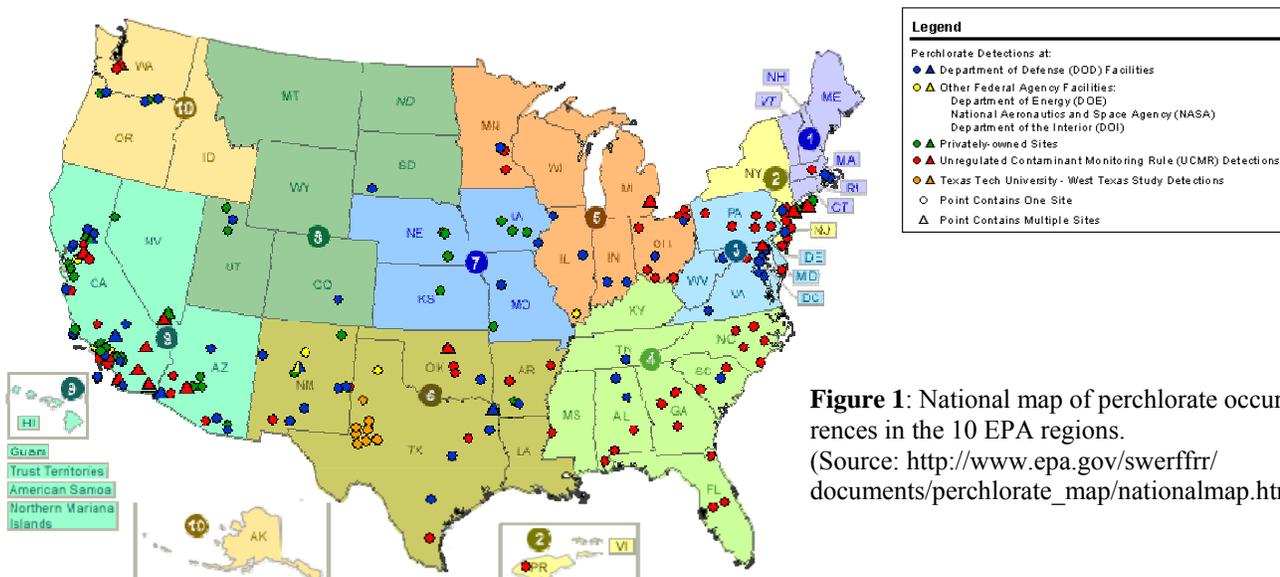


Figure 1: National map of perchlorate occurrences in the 10 EPA regions.
(Source: http://www.epa.gov/swerffir/documents/perchlorate_map/nationalmap.htm)

Some claim perchlorate has no effect on the hormone levels up to concentrations of 120 µg/L^{2,3}, while others stress that even low level perchlorate levels can result in certain damage⁴. It cannot be said with certainty at this moment what the exact effect of a certain concentration of perchlorate is on unborn babies, growing children or adults. Neither is it known over what period of time the exposure has to be to create permanent damage. The EPA (Environmental Protection Agency) has set an official reference dose for perchlorate that according to current research will not be harmful to ingest daily but this standard will remain under intense scrutiny.

Removal

At the moment there is no cost efficient way to remove low concentrations of perchlorate from water. Several techniques that work for nitrate and nitrite may also work for perchlorate as proposed by Motzer (2001)⁵ and Gullick et al (2001). These techniques are: activated carbon, membrane separation, chemical reduction/ultraviolet oxidation, ion exchange reverse osmosis, electro dialysis and bioremediation. The AWWA (American Waterworks Association) is currently defining which solution would be the best for low concentrations. For information about these separate techniques consult the water quality fact sheets at <http://www.cce.cornell.edu/factsheets/wq-fact-sheets/index.htm>.

Water Contaminant Unit: µg/L = ppb = parts per billion

Perchlorate standards

The problem with perchlorate is that it may cause health problems, but the threshold concentration for causing these problems in children, pregnant women and adults has yet to be established. In 1998 the EPA put perchlorate on its Drinking Water Contaminant Candidate list.

Since February 2005 the EPA has set an official reference dose according to the NAS (National Academy of Sciences) a not-for-profit organization that has issued a standard of 0.7 µg/kg per day. The NAS did not establish a water standard, but, based on the number above the Table 1 could be made. For an adult drinking an normal amount of water, that would permit 24.5 ppb as shown in Table 1. However, the EPA's working assumption in these cases is that drinking water only accounts for 20% of total consumption, in stead of 100% what the 24.5 ppb standard does.

Several investigations by researchers have given different recommendations (2 µg/kg per day Strawson et al (2004)⁷, 0.07 µg/kg per day Nas (2005)⁸) and can be explained in several ways. Several state governments have issued rulings in advance of the EPA, while adhering to the draft drinking water standard. All have set different standards as shown in table 2.

*"[A]n estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime."

Table 1: If the NAS Standard were used as a value for the determining the drinking water standard, the following values would be possible. (Source: Environmental, Science and Technology Online, Science news January 19 2005)⁶

Water consumption	Drinking-water standard (ppb)		
	% Perchlorate dose from water		
70-kg male	100%	80%	60%
1 liter/day	49.0	39.2	29.4
2 liters/day	24.5	19.6	14.7
50-kg pregnant female	100%	80%	60%
2 liter/day	17.5	14.0	10.5
2.5 liters/day	14.0	11.2	8.4
4-kg baby consuming only fluids			
0.6 liters/day	4.7	n/a	n/a

Table 2: Current water standards for perchlorate in 6 different states
(Source: <http://www.anaheim.net/utilities/waterservices/perchlorate.htm>)

State	Level (in ppb or µg/l)	Notes
California	6	The public health goal level
Arizona	14	Department of Environmental Quality's protective health-based guidance level
Massachusetts	1 or 18	Interim guidance level. 1ppb for sensitive individuals (infants, children, pregnant women and persons with hypothyroidism) and 18 ppb for others
Nevada	18	Public notice standard
New York	18	Advisory level
Texas	4	Commission on Environmental Quality's Interim Action Level

The EPA has issued an official reference dose, which converts into a drinking water equivalent level of 24.5 ppb. This level is substantially higher than the EPA level was before and if applied to babies (see table 1) it seems to be too high.

Conclusions

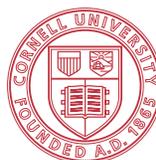
Perchlorate will likely be shown to have a health effect on babies, children, pregnant women and other adults, but at what concentrations and during what period of time is not certain at the moment. The affected states are taking precautions by using the EPA's current reference dose and drinking water equivalent level.

References

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