

## PERCHLORATE FACT SHEET

| Contaminant  | In Water As  | Maximum Contaminant Level (MCL*)   |
|--|--|--|
| <b>Perchlorate</b>   | $\text{ClO}_4^-$   | California MCL (2007) = 6 $\mu\text{g/L}$<br>Massachusetts MCL (2006) = 2 $\mu\text{g/L}$<br>US EPA national MCL pending |
| <b>Sources of Contaminant</b>  | Inorganic chemical used in the manufacturing of fireworks, explosives, and rocket propellants. Low levels may naturally occur as well. |  |
| <b>Potential Health Effects</b>  | Inhibits the absorption of iodine by thyroid glands, leading to developmental and learning disabilities in children.                   |  |
| <b>Treatment Methods</b>   | Reverse Osmosis<br>Anion Exchange (Regenerable and non-regenerable)<br>Distillation  |  |
| <small>*Maximum Contaminant Level (MCL) — The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.</small> |  |  |

Perchlorate is both a naturally occurring as well as a man-made inorganic chemical. Perchlorate is an oxidizer used in the manufacturing of fireworks, explosives, and other pyrotechnics. In the United States, contamination of soil and water is found predominantly in areas where the manufacture, use, and storage of munitions and rocket propellants took place over the last 50 years. The US General Accounting Office (GAO) determined perchlorate had contaminated groundwater at the locations where the chemical had been stored. Food crops and vegetables grown on contaminated soils may show higher concentrations of perchlorate. Total ingestion of perchlorate thus consists of that due to food and that due to drinking water. Perchlorate can also be formed as a byproduct of in situ chlorine synthesis also using ozone such as sea water aquariums and swimming pools.

Perchlorate inhibits the absorption of iodine by the thyroid gland which results in decreased secretion of certain thyroid hormones causing a condition called Hypothyroidism. Prolonged Hypothyroidism is known to lead to developmental and learning disabilities in infants and children.

**CHEMISTRY**

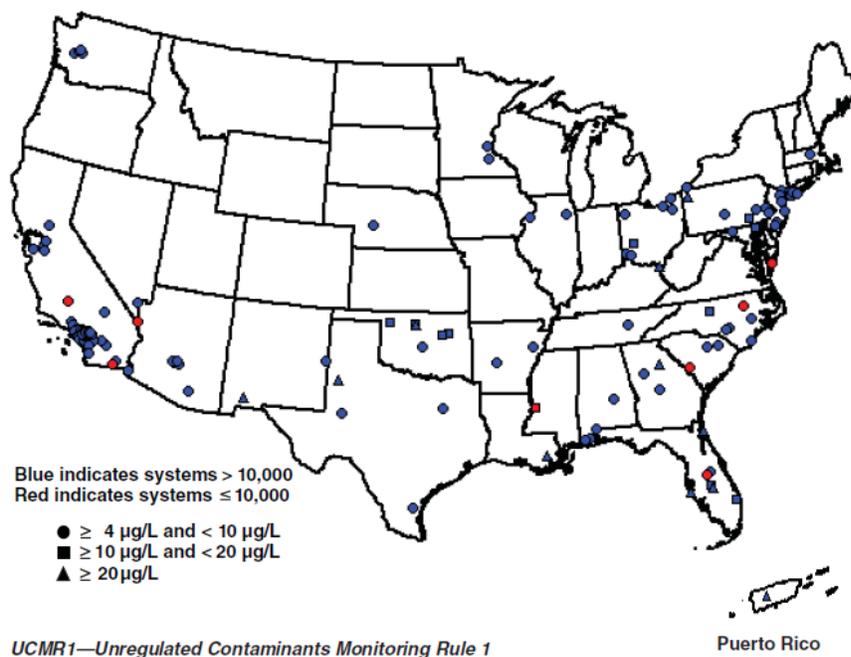
## WQA Technical Fact Sheet: Perchlorate

Perchlorates are salts of perchloric acid, written with a formula  $\text{ClO}_4^-$ . They are very soluble in water. Perchlorates belong to a class of oxyanions of chlorine. It may also be written as Chlorate (VII), which shows its +7 oxidation state. The perchlorate ion is the most stable and least reactive oxidizer of all generalized chlorates, despite the fact that it has the highest oxidation state.

## OCCURRENCE

Brandhuber, et al (2009) reported the occurrence of perchlorate in the United States based on surveys by the US EPA, Arizona, California, Massachusetts and Texas. See Figure 1, below. Other recent reports can be found from the US General Accounting Office (USGAO, 2010), and the US Geological Survey (Kalkhoff et al, 2004). Of 3,865 public water systems sampled, perchlorate was found in 160 systems in 26 states at a level greater than 4  $\mu\text{g}/\text{L}$  (ppb). The highest density of perchlorate in drinking water was found in Southern California, West Central Texas, along the East Coast between New Jersey and Long Island, and in Massachusetts. Of the testing to date, no perchlorate has been detected in the drinking water of northern Great Plains, the central and northern Rocky Mountains, Alaska or Hawaii. The highest concentration of perchlorate was 12  $\mu\text{g}/\text{L}$ . Today more than 11 million people have perchlorate concentration in their public drinking water at concentration of at least 4  $\mu\text{g}/\text{L}$ .

Figure 1: UCMR1 Perchlorate Detections (Brandhuber, et al, 2009)



Perchlorate has been detected in a wide variety of foods consumed in the United States and is of particular concern for children under the age of two, due to their body weight.

## HEALTH EFFECTS

The perchlorate anion can have significant impact on functioning of the human thyroid gland which produces many of the essential hormones for growth and functioning of metabolic processes. Perchlorate is very similar to the iodide ion and interferes with absorption of iodide by the thyroid gland. Prolonged effect of this condition leads to thyroid hypertrophy and eventual Hypothyroidism. Hypothyroidism in adults leads to chronic metabolic disorders; in pregnant women it can lead to abnormal fetal growth. Decreased mental growth is seen in infants and young children.

Perchlorate is quickly absorbed by the digestive system and appears in the blood stream within a few hours. Once in the bloodstream, perchlorate is quickly absorbed by the thyroid gland. Perchlorate does not appear to be modified in the body due to degradation or covalent bonding. Perchlorate is also rapidly eliminated by the body and its half-life is 8-12 hours.

In 2005, the National Research Council (NRC) examined the Health Implications of Human Perchlorate Ingestion and recommended the maximum concentration of perchlorate that a person can ingest per day without any harm. Based on their analysis and risk assessment, NRC came up with a no-observable-effect level (NOEL) for inhibition of iodide uptake by the thyroid at 0.007 mg/kg weight /day (also called Reference dose or RfD). Assuming the weight of an “adult” at 70 kg, consuming 2 liters per day of water, and a ten-fold safety factor this translates into Drinking Water Equivalent Level (DWEL), or Health Reference Level (HRL), of 24.5 µg/L (ppb). HRL or DWEL is defined as a lifetime exposure concentration (of a contaminant) protective of adverse, non-cancer health effects, that assumes all the exposure to a contaminant is from drinking water (normal exposure to a particular contaminant is due to drinking water, food ingested and air breathed where applicable). But since drinking water contributes about 62% of the total ingested perchlorate, the remaining from food, the actual DWEL or HRL should be 15 µg/L (ppb). This 15 µg/L was the single HRL that the US EPA had set in October of 2008. This was strictly an advisory recommendation and at that time the US EPA decided against setting a mandatory federal MCL, although individual states when asked to set their own MCLs when necessary.

The US EPA's 2008 decision to not regulate perchlorate came under criticism from the scientific and environmental communities. Their objection was that the US EPA had used the adult weight of 70 kg in determining the Reference Dose. NRC in its 2005 report had identified pregnant and lactating women, infants, developing children and people with iodine deficiency and thyroid disorders as a more vulnerable population. Infants and children eat and drink more on a per-body weight basis than adults, therefore eating a normal diet and drinking water with 15 µg/L perchlorate may result in exposure greater than the reference dose. The US EPA estimated the effect on sensitive subgroups by using physiologically based pharmacokinetic modelling with certain assumptions, which still did not satisfy certain scientific and environmental communities. Hence in 2009, a decision was made by US EPA to revisit the earlier decision, and after due consideration, it has decided to set a national MCL for perchlorate. This MCL was due to be announced in August of 2013, but as of March 2014, this has not

## WQA Technical Fact Sheet: Perchlorate

yet been determined. Based on the above information in all probability the MCL can be expected at level equal or lower than 4 µg/L.

In 2013, American Water Works Association analyzed the national cost of compliance for perchlorate MCL between 2 to 24 µg/L. It found that \$120 million per year will be needed for compliance with an MCL of 4 µg/L. This cost is lower than other drinking water regulations, such as \$320 million for Arsenic MCL of 10µg/L. This is because the number of Public Water Systems affected is expected to be few (3% based on 90<sup>th</sup> percentile perchlorate concentrations). But costs to smaller water systems serving a population of less than 500 can be significant (\$3/1000gallons).

In Canada concentrations of perchlorate in drinking water are very low ( $\leq 1\mu\text{g/L}$ ) and there is no enforceable standard.

## TREATMENT METHODS

|  |  |
|--|--|
| <b>Residential</b><br><b>Point-of-Entry</b><br><b>Point-of-Use</b> | <b>Anion Exchange (Regenerable and non-regenerable)</b><br><b>Reverse Osmosis</b><br><b>Distillation</b> |
| <b>Municipal</b>   | <b>Anion Exchange</b>  |

**Visit [WQA.org](http://WQA.org) and/or [NSF.org](http://NSF.org) to search for products certified to NSF/ANSI 58 and NSF/ANSI 62 for perchlorate reduction.**

Perchlorate can be removed by anion exchange to levels of 4 µg/L or lower. However, the commercially available anion resins have different relative selectivity for perchlorate. They range in relative selectivity over chloride from 4-5 for gel acrylic SBA (Strong Base Anion) Type I to greater than 2,500 for a highly selective bi-functional resin (often referenced as “bi-quat”) developed by Oak Ridge National Laboratories (ORNL). On this scale, Gel Styrenic Type I and Type II resins have selectivity of 100-150 while Nitrate Selective resins have selectivity of greater than 200. In general, anion resins are not regenerable with salt. Therefore, they should be considered as one time use.

It is important to select the right anion exchange resin and it is essential to consult the resin manufacturer regarding the suitability of their resin for any application. Consideration must be given to the other anions that may be present in the water to be treated. Some of the competing ions for perchlorate are sulfate, nitrate, bicarbonate and chloride. Depending on the relative concentration of any competing anions and the selectivity of the resin, the competing ions may saturate the resin before the adsorption and saturation of perchlorate, resulting in competing anions desorbing into the water. In the case of nitrate this can result in the unintended effect of exceeding the MCL of 10 for nitrate nitrogen. It is very advisable to use two column of resins as lead and lag ones to capture the release of competing ions such as nitrate. Weak base anion resins are not as effective as the Strong Base Anion. Typical breakthrough capacities for acrylic SBA Type I is around 500 bed volumes (about 3700 gallons per cubic foot of resin) while that for styrenic SBA Type I or Type II is 5000 bed volume (37,000 gal/cu

## WQA Technical Fact Sheet: Perchlorate

ft) both using Redlands, CA water.(Francis Boodoo/ Purolite). The capacity of the bi-quat resins may exceed 70,000 bed volumes of >500,000 gal/cu ft.

Before using a particular anion resin to remove perchlorate, it is essential to analyze the water and consult with an expert in anion resins. Non-regenerable anion exchange devices are also a viable treatment option that can be disposed of when saturated.

Reverse Osmosis is capable of removing perchlorates from 100 µg/L to less than 6 µg/L. The data on independent testing of commercially available RO devices under NSF/ANSI 58 can be obtained on [www.NSF.org](http://www.NSF.org) and [www.WQA.org](http://www.WQA.org).

A Task Force from the Joint Committee of NSF International for drinking water treatment devices has been working on a protocol for certification of perchlorate reduction using anion exchange resins. Certification for perchlorate reduction claims will be offered by ANSI accredited certification bodies, such as NSF International and the Water Quality Association's Gold Seal.

## REGULATIONS

There is no MCL for perchlorate, however the US EPA has had an advisory HRL of 15 µg/L since 2008. This is due to be changed. Currently only California and Massachusetts have set the MCL of 6 µg/L and 2µg/L respectively. The following States have set a Public Health Goal; Arizona -14µg/L; New York – 5 µg/L; Maryland – 1 µg/L; New Mexico – 1 µg/L; New Hampshire – 1 µg/L.

Three states have set an enforceable Action Levels: New York – 18 µg/L; Nevada – 18 µg/L; Texas – 4 µg/L If the Action Level is exceeded, the water treatment company is obliged to take appropriate action to reduce the concentration in water below Action Level.

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