MiningWatch Canada
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MiningWatch Canada
Chromite Series
Fact Sheet # 03

Living near a CHROMITE MINE OR FERROCHROME FACILITY:

things you should know[1]

Introduction

Chromite is a mineral that contains the element chromium. The major use for mined chromite is the production of ferrochrome, an iron-chromium alloy used to make stainless steel.

Recently, chromite deposits have been identified in Northern Ontario, Canada. Located 500 km north-east of Thunder Bay in a pristine area dubbed the "Ring of Fire", they are the largest deposits found in North America. Cliffs Natural Resources is evaluating a plan for an open pit/underground chromite mine and ore processing facility in the Ring of Fire and a ferrochrome production facility to be located somewhere in Ontario. A number of other companies also have plans for mining chromite and other metals in the area.

This fact sheet is part of a series produced by MiningWatch Canada about the risks of chromium mining and processing. Additional fact sheets and a more extensive review of relevant scientific research entitled *Overview of Chromium*, *Chromite and Toxicity*, are also available on our website. References for the information presented in this fact sheet can be found in the full review.

Is chromium dangerous?

The two most common types of chromium are trivalent chromium (Cr-III), which is found in the mineral chromite, and hexavalent chromium (Cr-VI). While Cr-III is considered an essential trace element in human diets, high doses can cause health problems and harm sensitive plants and animals. Human activities such as chromite mining and ferrochrome processing can convert Cr-III into Cr-VI, which is 100-1000 times more toxic than Cr-III and is known to cause cancer.

[1] Information taken from: An Overview of Chromium, Chromite and Toxicity by MiningWatch Canada, 2012.

"The existence and treatment of wastes from stainless steel and ferrochrome production remain a challenge and an issue of concern"

Ma and Garbers-Craig 2006

Though the intent of chromite mining is to remove the chromite from the ore for production of ferrochrome, the process is not 100% effective, so mining and smelting wastes including dust, wastewater, tailings, waste rock and slag (produced during ferrochrome separation from the ore) can still contain chromium (including Cr-VI). Other heavy metals and chemicals of concern may also be in the wastes. As with other types of mining wastes, chromite mine wastes have the potential to cause serious environmental contamination, as has occurred in places around the world where these wastes have been inadequately managed.

Because there has never been a major chromite mine in North America, most of the concerns about chromium toxicity in Canada and the US (including the film Erin Brokovich) are not about chromite mining but "downstream" industrial uses of chromium. Based on what we know about chromium and experiences in other parts of the world, we know that mining and processing chromite also poses significant risks of contamination if poorly managed.

How are people exposed to chromium?

If you lived near a chromite mine or ferrochromium production plant, you could be exposed to chromium through:

- skin contact with contaminated soil or water;
- breathing contaminated air;
- drinking contaminated water or eating contaminated food, dust or soil (for example, from dirty hands or food)

Units of Measurement:

1 million micrograms (ug) equals 1 gram (g).

1 thousand milligrams (mg) equals 1 gram.

1 thousand grams equals 1 kilogram (kg).

There are many cases of contamination from chromite mines and ferrochrome production plants. For example, heavy metal pollution from dust depositing around an open pit chromite mine in Kemi, Finland resulted in higher levels of chromium and other heavy metals in pine tree bark. Unfortunately, no studies were found that investigated how these pollution levels affected the health of plants and animals.

In India, drainage from a chromite mine and its overburden piles caused chromium contamination of 250-3000 ug Cr/L in surface water. Another Indian study sampling near an open pit chromite mine recorded high Cr-VI levels in groundwater (30 - 800 ug/L) and surface water (30 - 140 ug/L). These concernations are far above the Canadian and American Cr-VI Water Quality Guidelines for Protection of Aquatic Life (1 and 16 ug/L respectively) and the Dutch regulation for *total* chromium in groundwater (30 ugCr/L).

In Zimbabwe, ferrochrome furnace dust emitted from a smelter stack polluted soils with chromium 700m from the furnace, where 700 mgCr/kg soil was measured. The furnace emitted an average of 54.6 tonnes of chromium per year from the one stack (of six).

For every tonne of ferrochrome created, up to 18-25kg of dust may be collected. Ferrochrome arc furnace dust is categorized as toxic waste in Canada.

In the Hunan Province of China, a ferroalloy plant deposited slag directly on the ground and discharged wastewater into the sewage system that runs through agricultural land. This resulted in long-term soil and vegetable contamination. In the soil, total chromium content ranged from 90 - 6200 mg/kg and Cr-VI ranged from 0.1 - 252 mg/kg.

How can chromium affect human health?

Skin contact with Cr-VI can cause inflammation, eczema, open sores and permanent sensitization that causes a skin condition called allergic contact dermatitis (ACD). Eczema and ACD have been found in populations exposed to environmental chromium contamination.

Ingestion of large amounts of Cr-VI can cause nausea, vomiting, stomach and intestine damage, anemia, kidney and liver damage. Cr-VI ingestion has been linked to a number of

[2] Cancers of: skin, lung, lip/oral cavity/pharynx, breast, liver, kidney, bladder, gastrointestinal tract, urinary tract, testes, prostate, brain, stomach, bone, lymphoma and leukemia

cancers[2] and is starting to be considered a likely human carcinogen. Many of these affects have been observed in populations exposed to chromium contaminated drinking water.

Breathing in Cr-III and Cr-VI can irritate the nose, throat and lungs and produce inflammation. Cr-VI inhalation during chromium industrial work is known to cause nosebleeds, ulcers and holes in the septum (structure between your nostrils), asthma, lung cancer, sinonasal cancer and possibly other cancers. Breathing Cr-VI seems to be the most dangerous route of exposure. General population exposure to chromium contaminated soils has been linked to lung cancer.

Very few studies exist regarding potential reproductive and development effects on humans. Links between chromium exposure in the workplace and decreased sperm production and health have been documented. Informal observations have noted a high number of birth defects and pregnancy complications in people exposed to chromium.

What have studies of environmental chromium contamination and human health found?

As with other population health studies, studies investigating cases where chromium contamination may have caused public health effects are inherently challenged by factors such as: finding comparable reference populations, estimating doses of chromium, statistical power, lifestyle and other variables affecting cancer/health problem occurrences.

Some studies that have found effects:

- A 1987 study of housewives exposed to a chemical plant's chromium contaminated slag used as fill in Tokyo, Japan, found a significantly higher number of cases of eczema and allergic contact dermatitis in summer months compared to a non-exposed control group. Contact with contaminants is probably greater in the summer and several studies have linked exposure to sunlight with more severe chromium-induced skin problems. The study also found the exposed women had more headaches, heaviness of head, chronic fatigue, dizziness, diarrhea, constipation, and blood and elevated protein in urine, which can be early signs of kidney disease.

- When a ferrochromium plant dumped their waste without containment, a Chinese population ended up exposed to up to 20 000 ug/L of Cr-VI in their drinking water, which turned yellow from the contamination. A number of studies analyzed this population and found: mouth sores, diarrhea, stomach pains, indigestion, vomiting, higher levels of white blood cells, and a higher number of deaths from all cancers combined, stomach cancer and lung cancer.

- A recent study in Greece analyzed the health of citizens exposed to 41 – 156 ug/L of Cr-VI in their drinking water for about twenty years due to dumping of numerous industrial wastes into the river. Compared to a nearby unexposed population, these people experienced more deaths from all cancers combined, leukemia and cancers of the: liver, lung, female kidney/genital/urinary, lip/oral cavity/pharynx, stomach, female colon, female breast and prostate.

- Waste from chromium ore processing and Cr-VI compound manufacturing was used as fill in Hudson County, New Jersey, exposing residents to unknown levels Cr-VI. A study found that people living closer to the contaminated sites had a higher risk of having lung cancer.

There are also studies which have found no health effects, such as a Swedish study in 1980 that found no difference between the number of lung cancers in communities with 50 to 100 times more chromium in their local air due to nearby ferrochromium facilities and in other unexposed communities. Some studies showing no effects have been conducted by researchers with ties to or funding from industry groups which would benefit from these findings, a fact that has created considerable debate within the scientific community about the findings.

What don't we know about the health risks of chromium?

Although chromium toxicity has been known for over 100 years, there is a lot that is unknown or unclear to scientists and regulators about the doses, mechanisms and effects of chromium on human health. Below are some questions currently without definitive answers:

1. Is there a threshold below which the body can detoxify ingested Cr-VI?
    - Although bodily fluids such as saliva and stomach acid can convert Cr-VI to the less toxic Cr-III, it is not proven that this is effective in preventing all chromium accumulation or effects.
2. Does Cr-VI inhalation cause any cancers other than lung and sinonasal?
    - Some links have been found to cancers such as stomach and bronchial.
3. Does Cr-VI inhalation cause gastrointestinal, kidney and liver damage?
    - Some evidence suggests this may be the case.
4. Does Cr-VI ingestion cause cancer in humans and if so, what cancers?
    - Some evidence from animal and human studies has linked Cr-VI in food or water to a variety of cancers.
5. Do any Cr-III compounds cause cancer?
    - Cr-III is not classifiable as a human carcinogen due to insufficient information.
6. Are there safe exposure levels to Cr-VI that do not cause allergic contact dermatitis and skin ulcers?
    - "No observed effect levels" have not been documented.
7. What are the reproductive and developmental effects of Cr-VI and Cr-III on humans and at what doses?
    - Animal studies have found that Cr-VI and Cr-III harm reproductive systems and that Cr-VI can cause mutations and development problems in offspring. There is inconclusive evidence for reproductive and develop ment effects of chromium in humans.

Does the government regulate chromium?

Both the Canadian and Ontario governments have regulations and/or guidelines for allowable chromium levels in water, air and soils to protect human health (Table 1). While Cr-VI is the most toxic form, some regulations specify limits for total chromium, (Cr-III + Cr-VI), based on assumptions about the proportion of total chromium that is Cr-VI. These assumptions may not apply to areas near chromite mines or smelters, where Cr-VI is actively produced. In recent years many governments have undertaken reviews to update some chromium regulations, many of which have resulted in stricter standards.

The Canadian and Ontario standards for chromium in drinking water are set for total chromium (50 ug/L), unlike the state of California which recently set a target for Cr-VI, which is a much lower value (0.02 ug/L).

Canadian soil total chromium and Cr-VI guidelines for the protection of human health allow less chromium than standards in the United States and a number of other countries. The upper range of typical Ontario chromium concentrations in uncontaminated soils is slightly higher than the Canadian guidelines, so the Ontario Site Condition Soil Standards have set some limits which allow more chromium.

The Ontario environmental air standards set in 2011 (effective 2016) are much stricter than the Ontario Ministry of Labour's standards for workplace air.

The federal Metal Mine Effluent Regulations do not set a limit for chromium in effluent being discharged into the environment. Under hazardous waste guidelines, Canadian and Ontario standards require that waste leach no more than 5 000 ug/L total chromium, a limit which is less stringent than a number of other countries.

Table 1 Canadian and Ontario Regulations and Guidelines for chromium.

CAN is Canada. ON is Ontario. PM_{10} is particulate matter <10um in diameter. TSP is total suspended particulate size fraction. ug = microgram = 1 000 000 grams. na is not applicable.

Limit			
Drinking Water (ug/L)*1 2*	**Total Cr**	**Cr-III**	**Cr-VI**
CAN: Maximum Acceptable Concentration ON: Quality Standard	50	-	-
ON: potable groundwater standard	50	-	25
Soils (mg/kg)*3 4*			
CAN: Guideline for protection of environmental and human health for agricultural, residential/parklands	64	-	0.4
CAN: Guideline for the protection of environmental and human health for industrial and commercial lands	87	-	1.4
ON: All land uses, Soil Standard for contaminated sites	160	-	-
ON: All land uses: medium to fine, coarse textured Soil Standard for contaminated sites	-	-	10, 8
ON: Residential/Parkland/Institutional/Industrial/Commercial/ Community property use Soil Standard for contaminated sites within 30m of water body	70	-	0.66
ON: Agricultural or Other property use Soil Standard for contaminated sites within 30m of water body, potable groundwater condition	67	-	0.66
Environmental Air (ug/m^3)*5*	**Cr-0, II , III**	**Cr-VI PM_{10}**	**Cr-VI TSP**
ON: 24-hr average Ambient Air Quality Criterion set in 1982 (Cr-II, III)	1.5	-	-
ON: 0.5-hr average Standard based on Cr-III respiratory effects, effective 2016	1.5	na	na
ON: 24-hour average Air Standard and Ambient Air Quality Criterion based on Cr-III respiratory effects, effective 2016	0.5	na	na
ON: 24-hr average Ambient Air Quality Criterion, based on Cr-VI carcinogenicity, effective 2016	na	0.00035	0.0007
ON: annual Ambient Air Quality Criterion, based on Cr-VI carcinogenicity, effective 2016	na	0.00007	0.00014
ON: 0.5-hr average Air Standard, based on Cr-VI carcinogenicity, effective 2016	na	-	0.002
ON: annual Air Standard, based on Cr-VI carcinogenicity, effective 2016	na	-	0.00014
Occupational Air (ug/m^3)*6*	**Cr-0, III**	**Cr-VI**	

Ma G and Garbers-Craig AM. 2006. Cr(VI) containing electric furnace dusts and filter cake from a stainless steel waste treatment plant Part 1 - Characteristics and microstructure. Ironmaking and Steelmaking. 33(3), 229-237.

[3] http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2010-sum_guide-res_recom/index-eng.php#a3
[4] http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_030169_e.htm
[5] http://ceqg-rcqe.ccme.ca/
[6] http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_086518.pdf
[7] http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2011/010-6353.pdf
[8] http://www.labour.gov.on.ca/english/hs/pubs/oel_table.php