LAW

Environmental Law Alliance Worldwide

MEMORANDUM: Environmental Aspects of Sterlite Industries (India) Limited copper smelting complex in Tuticorin (SIIL)

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I was requested to provide opinions about: 1) the extent of the area that a copper smelting facility may impact; and 2) whether there is evidence that the Sterlite Industries (India) Limited copper smelting complex in Tuticorin (SIIL) is endangering human health and the environment and contaminating water supplies.

What follows are my opinions regarding these two issues.

1. It is well established that copper smelting facilities have adverse environmental impacts that can extend for several tens of kilometers

For more than 100 years, it has been known that copper smelting facilities have adverse environmental impacts that can extend for several tens of kilometers. One hundred and three years ago, in 1907, the United States Supreme Court, in one its first ever environmental cases, issued a judgment. In this judgment, the United States Supreme Court stated:

> "This is a bill in equity filed in this Court by the State of Georgia ... to enjoin the defendant copper companies from discharging noxious gas from their works in Tennessee over the plaintiff's territory. It alleges that, in consequence of such discharge, a wholesale destruction of forests, orchards, and crops is going on, and other injuries are done and threatened in five counties of the state.
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> "It is a fair and reasonable demand on the part of a sovereign that the air over its territory should not be polluted on a great scale by sulphurous acid gas, that the forests on its mountains, be they better or worse, and whatever domestic destruction they have suffered, should not be further destroyed or threatened by the act of persons beyond its control, that the crops and orchards on its hills should not be endangered from the same source. ...
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> "The proof requires but a few words. It is not denied that the defendants generate in their works near the Georgia line large quantities of sulphur dioxide which becomes sulphurous acid by its mixture with the air. It hardly is denied, and cannot be denied with success, that this gas often is carried by the wind great distances and over great tracts of Georgia land. On the evidence, the pollution of the air and the magnitude of that pollution

are not open to dispute. Without any attempt to go into details immaterial to the suit, it is proper to add that we are satisfied, by a preponderance of evidence, that the sulphurous fumes cause and threaten damage on so considerable a scale to the forests and vegetable life, if not to health, within the plaintiff state, as to make out a case within the requirements of Missouri v. Illinois, 200 U. S. 496. Whether Georgia, by insisting upon this claim, is doing more harm than good to her own citizens is for her to determine. The possible disaster to those outside the state must be accepted as a consequence of her standing upon her extreme rights. ...

"Injunction to issue."[1]

In a more recent example (2004), scientists from Australia and Switzerland found elevated levels of arsenic and lead many kilometers from a copper smelter located in Port Kembla, Australia. The scientific study these scientists published stated:

"Heavy metal contamination in soils caused by atmospheric fallout of metal emissions from smelters is well known (Ragaini et al., 1977; Freedman and Hutchinson, 1980; Tyler, 1984; Løbersli and Steinnes, 1988; Dumontet et al., 1992; Barcan and Kovnatsky, 1998).

"Twenty-five topsoil samples were collected up to a distance of 24 km south and southwest of Port Kembla from the 12th to the 14th December 2000 and on the 15th February 2001 (Fig. 1).

"Overall, Port Kembla industries appear to have contaminated the surrounding soils to a distance of 1 to 13 km depending on the element, but most likely to [approximately] 4 km."[2]

2. Recent evidence conclusively demonstrates that the Sterlite Industries (India) Limited copper smelting complex in Tuticorin (SIIL) is endangering human health and the environment and contaminating water supplies

On 3 November 2010, I was provided with laboratory analysis reports of samples of slag, sediment and soil that were collected in the vicinity of Sterlite Industries (India) Limited (SIIL) in Tuticorin.

The sample of slag was described as: "From a roadside trader who had stored a portion of Sterlite's slag for packaging and sales as landfill material."

The sample of sediment was described as: "From the bed of an irrigation canal draining water from Sterlite's gypsum dump immediately after effluent from Sterlite was found running in the canal."

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1 *Georgia v. Tennessee Copper Co.*, 206 U.S. 230 (1907). http://supreme.justia.com/us/206/230/case.html

2 Martley, E., et al (2004) "Metal concentrations in soils around the copper smelter and surrounding industrial complex of Port Kembla, NSW, Australia." Science of the Total Environment 325:113–127. http://infolib.hua.edu.vn/Fulltext/ChuyenDe2009/CD237/47.pdf

The sample of soil was described as: "Yellowish white coloured soil taken from open land bordering Mr. Dharmaraj's house in Therku Veerapandiapuram."

The laboratory report is dated 29 October 2010 and it indicates that it received the above samples on 19 October 2010. The laboratory report indicates that it used only methods approved by the United States Environmental Protection Agency[3] for the measurement of metals in the above samples, providing me with assurance that the reported results are valid and accurate.

Copper ore typically contains as much iron as copper. According to the U.S. EPA: "Copper is mined from a variety of ores, often containing less than one percent copper. This copper is typically in the form of mineral compounds with sulfur, iron, arsenic, and tin."[4] Therefore, iron-bearing wastes are unavoidable, high-volume by-products of copper smelting facilities.

Consistent with this fact, iron is a predominant component of the sample of slag. The sample of slag was found to contain 94,069 milligrams per kilogram (mg/kg) of iron, which is equivalent to 9.4% iron. Iron in the sediment sample is very elevated: 28,643 mg/kg, which is equivalent to 2.9%. Iron in the soil sample is extremely elevated, at 335,602 mg/kg, which is equivalent to 33.5%. These are orders of magnitude greater than naturally occurring levels of iron in sediment and soil. SIIL is the only possible source of these elevated levels of iron.

Although iron is an essential nutrient, iron can also be a very toxic substance. According to a recent, peer-reviewed scholarly publication:

> "Iron is the most abundant trace mineral in the body and is an essential element in most biological systems. It is likely that iron was essential for developing aerobic life on Earth. But iron is toxic to cells in excessive amounts. Acute iron poisoning is common and potentially lethal in dogs, cats, and many other animals. Iron is also a leading cause of unintentional poisoning deaths in children less than 6 years old. ....
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> "Iron exerts its most profound effects on the cardiovascular system. Excessive iron can cause fatty necrosis of the myocardium, postarteriolar dilatation, increased capillary permeability, and reduced cardiac output. Free iron stimulates serotonin and histamine release as well as systemic metabolic acidosis caused by lactic acid accumulation. All these mechanisms lead to shock. Excessive iron also interferes with clotting mechanisms, augmenting hemorrhagic processes. Excessive iron also has been reported to cause thrombocytopenia. ...
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> "When the amount of elemental iron ingested is greater than 60 mg/kg, serious clinical signs can develop. In all animals, oral doses between 100 and 200 mg/kg are potentially lethal."[5]

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[3] U.S. EPA "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods." http://www.epa.gov/osw/hazard/testmethods/sw846/

[4] U.S. EPA "Compilation of Air Pollutant Emission Factors: Section 12.3 Primary Copper Smelting." http://www.epa.gov/ttnchie1/ap42/ch12/bgdocs/b12s03.pdf

[5] Albertson, J. (February 2006) "The toxicity of iron, an essential element." Veterinary Medicine, 82:86 http://www.aspcapro.org/mydocuments/zn-vetm0206_082-090.pdf

According to information I received, the canal from which the sediment was taken has killed many a goat that has come there to drink water, including on 9 October 2010, about 4 days before the date on which the sample was taken.

A reasonable probability is that these goats were killed by ingestion of excess iron from SIIL. A typical goat weighs about 35 kilograms. Therefore, a dose of 2100 (35 x 60) mg of iron would cause serious clinical signs in a goat, and a dose of 3500 to 7000 (35 x 100-200) mg of would be potentially lethal. The sediment sample contains 28,643 mg/kg of iron. It would only take a goat to ingest 73 grams of this sediment to develop serious clinical symptoms of iron poisoning - not taking into account any iron that is dissolved in the water in the canal that a goat would also ingest. The soil sample contains 335,602 mg/kg of iron. It would only take a goat to ingest 6 grams (less than an quarter of an ounce) of the contaminated soil to develop serious clinical symptoms of iron poisoning

Iron is especially toxic to children. According to the Poison Control Center of the Children's Hospital of Philadelphia:

> "Ingestions of less than 20 mg/kg of elemental iron are considered non-toxic, ingestions of 20-60 mg/kg produce mild to moderate toxicity, and ingestions of greater than 60 mg/kg.of elemental iron have the potential to produce serious toxicity.
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> "Acute iron poisoning produces gastrointestinal, cardiovascular, metabolic, hepatic, and central nervous system effects secondary to both the direct caustic effect of iron on the GI mucosa and to the presence of free unbound iron in the circulation. Symptoms seen as a result of iron's corrosive action on the GI mucosa range from abdominal pain, vomiting and diarrhea1 to intestinal necrosis, perforation and peritonitis."[6]

The level of iron detected in the soil sample from the open land bordering Mr. Dharmaraj's house in Therku Veerapandiapuram, 3,35,602 mg/kg, indicates a serious risk to children caused by SIIL. A small child may weigh only 20 kg. Accidental ingestion of only 3.5 grams of soil from this location would have the potential to produce serious toxicity in a small child.

Other substances in the soil sample also indicate a serious risk to the health of residents of the area.

Arsenic is a human toxin. In developing Soil Guideline Values for inorganic arsenic in residential soil and allotments[7] of 32 mg/kg and 43 mg/kg, respectively, the United Kingdom Environment Agency has stated:

> "Anthropogenic activity has resulted in the widespread atmospheric deposition of arsenic from the burning of coal and the smelting of non-ferrous metals including copper (O'Neil, 1995).

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6 http://www.chop.edu/service/poison-control-center/tox-talk/iron-poisoning.html

7 In the United Kingdom, an allotment is land, which can be rented by an individual for growing fruit and vegetables, for personal and family use. http://www.farmgarden.org.uk/ari/documents/plotholdersguide.pdf

> Inorganic arsenic is carcinogenic in humans (Environment Agency, 2009d). Long-term exposure produces lung tumours via inhalation and a range of cancers via the oral route (most clearly cancer of the skin, bladder and lung)."[8]

The level of arsenic found in the soil sample from the open land bordering Mr. Dharmaraj's house in Therku Veerapandiapuram is 532 mg/kg, which is more than ten times higher than the Soil Guideline Values for inorganic arsenic in residential soil and allotments in the United Kingdom. It is more than fifty times the mean background level of arsenic of 10 mg/kg. Therefore, the level of arsenic detected in the soil sample from the open land bordering Mr. Dharmaraj's house in Therku Veerapandiapuram indicates a serious risk to public health caused by SIIL.

Cadmium is also a human toxin. In developing Soil Guideline Values for cadmium in residential soil and allotments of 10 mg/kg and 1.8 mg/kg, respectively, the United Kingdom Environment Agency has stated:

> "Following long-term exposure to cadmium, the main health concerns are its toxicity to the kidney and bones, arising via ingestion and inhalation, and its lung carcinogenicity seen in exposed workers following inhalation."[9]

The level of cadmium found in the soil sample from the open land bordering Mr. Dharmaraj's house in Therku Veerapandiapuram is 20.1 mg/kg, which is more than two times higher than the Soil Guideline Values for inorganic cadmium in residential soil, and more than ten times the Soil Guideline Value for cadmium in allotments. It is more than twenty times the mean background level of cadmium of less than 1 mg/kg. Therefore, the level of cadmium detected in the soil sample from the open land bordering Mr. Dharmaraj's house in Therku Veerapandiapuram indicates a serious risk to public health caused by SIIL.

Nickel is also a human toxin. In developing a Soil Guideline Value for nickel in residential soil of 130 mg/kg, the United Kingdom Environment Agency has stated:

> "Nickel is a potent skin sensitiser (that is, able to cause allergic reaction in humans) and as many as 1 – 4 per cent of men and 8 – 20 per cent of women in the general population may be nickel-sensitive (Environment Agency, 2009d). Ingestion of nickel can cause skin reactions in previously sensitised individuals. The other main concern for oral exposure to nickel is its developmental toxicity potential, which has been observed in experimental animal studies (Environment Agency, 2009d).
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> "Soluble nickel salts and the mixture of nickel sulphides and oxides present in refinery dust are carcinogenic to the lung and nasal tissues in humans (Environment Agency, 2009d). Other toxic effects of nickel observed following inhalation exposure include chronic bronchitis, emphysema, reduced vital capacity and asthma."[10]

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8 http://www.netregs.gov.uk/static/documents/Research/SCHO0409BPVY-e-e.pdf

9 http://www.environment-agency.gov.uk/static/documents/Research/SCHO0709BQRO-e-e.pdf

10 http://www.environment-agency.gov.uk/static/documents/Research/SCHO0409BPWB-e-e.pdf

The level of nickel found in the soil sample from the open land bordering Mr. Dharmaraj's house in Therku Veerapandiapuram is 187 mg/kg, which is more than 40% higher than the Soil Guideline Value for nickel in residential soil in the United Kingdom. It is more than the mean background level of nickel of around 30 mg/kg. Therefore, the level of nickel detected in the soil sample from the open land bordering Mr. Dharmaraj's house in Therku Veerapandiapuram indicates a serious risk to public health caused by SIIL.

Also on 3 November 2010, I was provided with laboratory analysis reports of two ground water samples (one from an open well and one from a handpump) that were collected in the vicinity of Sterlite Industries (India) Limited (SIIL) in Tuticorin.

The first water report of sample collected from open well was described as: "well water near the slag dump at factory on the border of Kumareddiyapuram and Therikuveerapandiapuram villages."

The second groundwater Sample was described as: "water from hand pump from the Therikuveerapandiapuram village."

The laboratory report is dated 2 November 2010 and it indicates that it received the above samples on 19 October 2010. The laboratory report indicates that it used only methods contained in the 21st edition (2005) of Standard Methods for the Examination of Water and Wastewater, a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), for the measurement of substances in the above well water samples, providing me with assurance that the reported results are valid and accurate.

High levels of **sulfate** in water can impart an intolerable taste to water and cause gastrointestinal effects, including diarrhea. The World Health Organization has stated:

> "The 1958 WHO *International Standards for Drinking-water* suggested that concentrations of sulfate greater than 400 mg/litre would markedly impair the potability of the water. The 1963 and 1971 International Standards retained this value as a maximum allowable or permissible concentration. The first two editions of the International Standards also suggested that concentrations of magnesium plus sodium sulfate in excess of 1000 mg/litre would markedly impair drinking-water potability. In the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, a guideline value of 400 mg/litre for sulfate was established, based on taste considerations. No health-based guideline value for sulfate was proposed in the 1993 Guidelines. However, because of the gastrointestinal effects resulting from ingestion of drinking-water containing high sulfate levels, it was recommended that health authorities be notified of sources of drinking-water that contain sulfate concentrations in excess of 500 mg/litre. The presence of sulfate in drinking-water may also cause noticeable taste at concentrations above 250 mg/litre and may contribute to the corrosion of distribution systems."

The levels of sulfate found in the well water near the slag dump at factory on the border of Kumareddiyapuram and Therikuveerapandiapuram villages, and in the water from hand pump from the Therikuveerapandiapuram village, contain very high levels of sulfate: 4200 milligrams

per liter (mg/L) and 2050 mg/L, respectively. These are levels of sulfate that are associated with gastrointestinal effects and objectionable taste.

The levels of **calcium** in the well water near the slag dump at factory on the border of Kumareddiyapuram and Therikuveerapandiapuram villages, and in the water from hand pump from the Therikuveerapandiapuram village are also very high: 562 mg/L and 414 mg/L, respectively.

Calcium is the counter ion in the chemical substance **calcium sulfate dihydrate** ($Ca_2SO_4:H_2O$), which is better known as gypsum. It is well known that SIIL discards enormous quantities of gypsum, a by-product waste of copper smelting, in the vicinity of its smelter complex in Tuticorin.

In my opinion, the co-presence of high levels of calcium and high levels of sulfate in these well waters constitutes proof that SIIL has contaminated local water supplies.

Further mention must be made of the fact that the well waters near SIIL (e.g near the slag dump at factory on the border of Kumareddiyapuram and Therikuveerapandiapuram villages, and in the water from hand pump from the Therikuveerapandiapuram village) are completely unsuitable for use in irrigation because of the unusually high **salinity** of these samples. The United Nations Food and Agriculture publication "Water quality for Agriculture"[11] establishes guidelines for interpreting the effects of irrigation water on crops depending on the salinity of irrigation water. This publication, like most others about this topic, explains that irrigation water that has an Electrical Conductivity (ECw) of greater than 3 micromhos/cm, or a total dissolved solid (TDS) concentration of 2000 mg/L, will cause severe damage to crops and is thus unsuitable for use as irrigation water.[12] The well water near the slag dump at factory on the border of Kumareddiyapuram and Therikuveerapandiapuram villages has an ECw of 11,550 micromhos/cm and a total dissolved solid content of 7854 mg/L. The water from the hand pump from Therikuveerapandiapuram village has an ECw of 6920 micromhos/cm and a total dissolved solid content of 4706 mg/L. Therefore, use of these waters for irrigation water would cause severe damage to crops.

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11 http://www.fao.org/docrep/003/t0234e/t0234e00.htm;

12 http://www.fao.org/docrep/003/t0234e/T0234E01.htm#tab1