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ATTENTION: MR. R. BRENT MURPHY
PROJECT DIRECTOR, NWT/NUNAVUT

Dear Mr. Murphy

SUBJECT: HAZARD ASSESSMENT OF TOXIC METALS IN SOIL AT NANISIVIK TOWN SITE

The metal concentrations found in soil samples collected at the Nanisivik town site follow a pattern consistent with areas effected by zinc mining. The soils had very high concentrations of zinc and elevated concentrations of lead and cadmium. The concentration of these metals at this site are highly correlated as demonstrated in Figures 1 and 2, correlation plots of concentrations of these metals in soil. Two samples with extremely high concentrations of lead (430-01 and 530-01) which do not correlate with the concentrations of zinc and cadmium are not included in these plots. The concentrations of these metals are above some or all of the CCME Soil Guidelines in most of the samples analyzed.

CCME Soil Quality Guidelines

CCME Soil Quality Guidelines have been developed to protect specific sensitive ecological receptors and human health based on land use. They have been derived using reported toxicological data and estimates of exposure, to humans and to ecological receptors, based on land use. The lowest contaminant concentration required to protect human health, or sensitive ecological receptors, is used as the guideline. Generally guidelines for agricultural land use protect ecological receptors and guidelines for other land uses protect human health. Assumptions used in the estimation of human exposure to soil based on typical Canadian climates and lifestyles and are not applicable to the high arctic. It is not clear what adjustments should be made to apply these guidelines to the Nanivisik site. Table 1 lists the CCME Soil Quality Guidelines of metals found on the site by land use.

The surface soils at the Nanisivik site are toxic. Cadmium, lead and zinc are present in the soil at concentrations that suggest some hazard to the environment and to human health. The extent to which they will produce adverse effects to humans will be determined by exposure, and exposure will depend on the use of the site.

The concentration of zinc in 80% of the soil samples exceeded all CCME guidelines (Table 1). Only 8% of the samples were below CCME guidelines. The CCME lead guidelines for commercial land use was exceeded in 25% of the samples, and the CCME residential land use guidelines was exceeded in an additional 32% of the samples. The CCME cadmium guidelines for commercial land use was exceeded in 8.4 % of the samples, and the CCME residential land use guidelines was exceeded in an additional 13% of the samples. The mean Zn concentration at the site (average of all samples, 3200 mg/kg) exceeded all CCME guidelines. The average lead concentration at the site (220 mg/kg) but is marginally below (95% CI) the commercial land use guidelines. The mean Cd concentration at the site (average of all samples, 7.6 mg/kg) did not exceeds the CCME residential land use guidelines (>99.9% CI) but the cadmium soil concentration exceeded the CCME residential or commercial land use guidelines in about 21% of the samples analyzed.

In addition to these metals, soils with arsenic concentrations exceeding CCME guidelines were found. These samples were taken along a stream running through the site

The toxic effects of each of these metals must also be taken into account in assessing the actual hazard to human health. While the concentrations of zinc in the soil are very high and exceed all CCME guidelines, the human health effects are almost benign when contrasted with the toxic effects of lead and cadmium. Note that it is likely that zinc does pose a significant threat to the environment (the scope of this discussion has been limited to human health at the request of EBA Engineering Consultants Ltd).

Toxic Effects of Lead

The toxic effects of lead are summarized in Figure 3 which shows the toxic effect and the blood concentration of lead at which these effects start to occur. The toxic effects that result from an acute exposure are:

- Nausea, vomiting and abdominal pain
- Kidney damage (reversible)
- Damage to the central and peripheral nervous systems.

Chronic exposure to lead will result in additional permanent toxic effects

- Inhibition of hemoglobin synthesis (lead induced anemia)
- Irreversible damage to the central and peripheral nervous systems.
- Irreversible kidney damage (promotion of renal tumors in animals)
- Sterility in men and suppression of testicular endocrine functions
- Neonatal mortality
- Hypertension – increase in systolic blood pressure.

The CCME Soil Quality Guidelines for lead are set to keep concentrations of lead in blood under 10 ug/dl – the concentration associated with adverse developmental effects in children (see Figure 3). This is likely to be a very conservative concentration, affording more protection than necessary, considering the intended land use of the site. Exposure of visitors to soil would be limited although concentrations of lead in blood of people working at the site should be monitored annually.

Toxic Effects of Cadmium

The toxic effects of cadmium occur at very low doses. EPA reference dose (RfD) for cadmium, the maximum safe daily intact is 0.005 mg/kg/day, for cadmium in water. The toxicity of cadmium is enhanced by its accumulation in kidneys and liver and its very long half life – as high as 30 years. Chronic exposure to cadmium will result in:

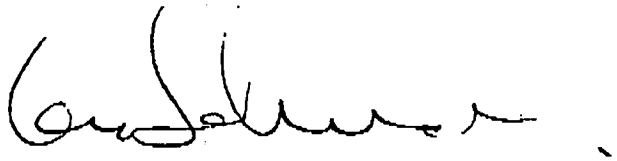
- Adverse effect to lungs including chronic obstructive pulmonary disease and emphysema.
- Kidney damage – chronic renal tubular disease resulting in proteinuria, aminoaciduria, glucosuria and decreased reabsorption of phosphate.
- Damage of skeletal system (Itia-Itia) resulting in osteomalacia and osteoporosis.
- Hypertension – increase in systolic blood pressure.
- Lung and prostrate cancer.

Human health related soil guidelines for cadmium are based on lifetime exposures. The limited exposure of visitors and workers at the site suggest that the soil guideline is extremely conservative. A risk assessment, or at least a comprehensive exposure assessment would be required to develop appropriate a soil concentration for protection of human health.

Toxic Effects of Zinc

Zinc is an essential nutrient with recommended daily allowances of 15 mg/day for men and 12 mg/day for women. Zinc is lethal at very high doses. In acute animal toxicity studies the LD 50 of zinc was over 200 mg/kg. Doses, well below this in man, will result in abdominal pain and nausea. Intense inhalation of zinc oxide will result in metal fume fever – characterized by elevated body temperature, nausea and headaches. High daily doses of zinc (1 mg/kg/day) over a 10-week period did result in a decrease in erythrocyte superoxide dismutase activity in healthy women. The EPA RfD of 0.3 mg/kg/day for zinc is based on this effect.

Yours sincerely



Ian Johnson Ph.D.
Manager, Ultra Trace Chemistries
Enviro-Test Laboratories

Table 1. CCME guidelines for metals in soil - by land use.

Metal	CCME Remediation Guidelines For Soil (mg/kg) by Land Use			
	Agricultural	Residential/ Parkland	Commercial	Industrial
Arsenic	12	12	12	12
Cadmium	1.4	10	22	22
Copper	63	63	91	91
Lead	70	140	260	600
Zinc	200	200	360	360

CCME Canadian Environmental Quality Guidelines 1999, Section 7.

Table 2. Number of soil samples from the Nanisivik site exceeding CCME guidelines (130 samples analyzed).

Metal	Number of Sample Exceeding CCME Guidelines		
	Residential/ Parkland[a]	Commercial	Total
Arsenic[b]		18	18
Cadmium	16	11	27
Copper	8	6	14
Lead	44	31	75
Zinc	16	104	120

[a]Includes only samples exceeding residential guidelines and less than commercial guidelines
[b]Commercial guidelines and residential guidelines are the same.

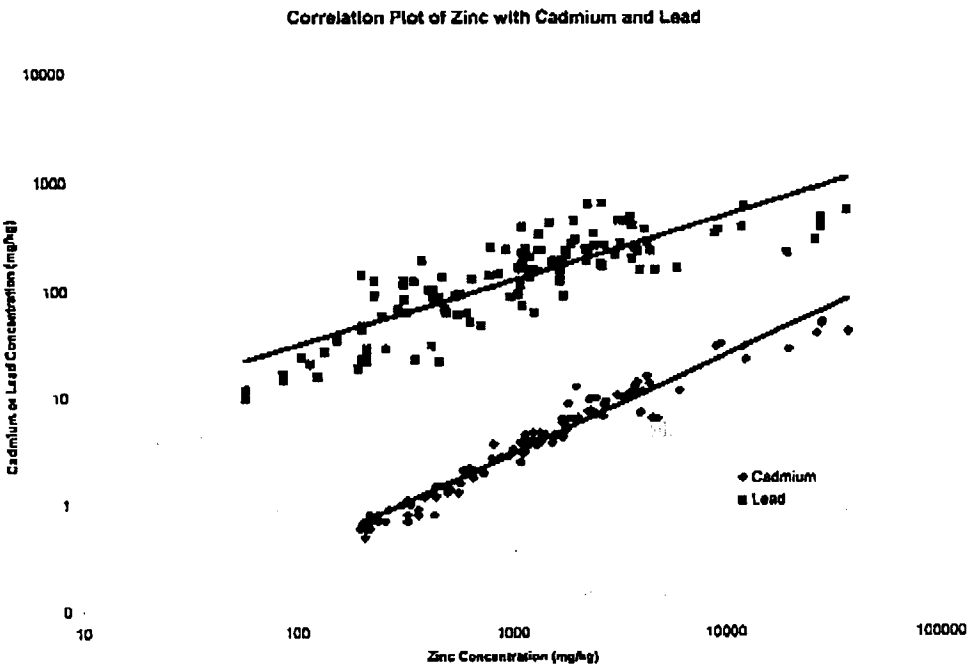
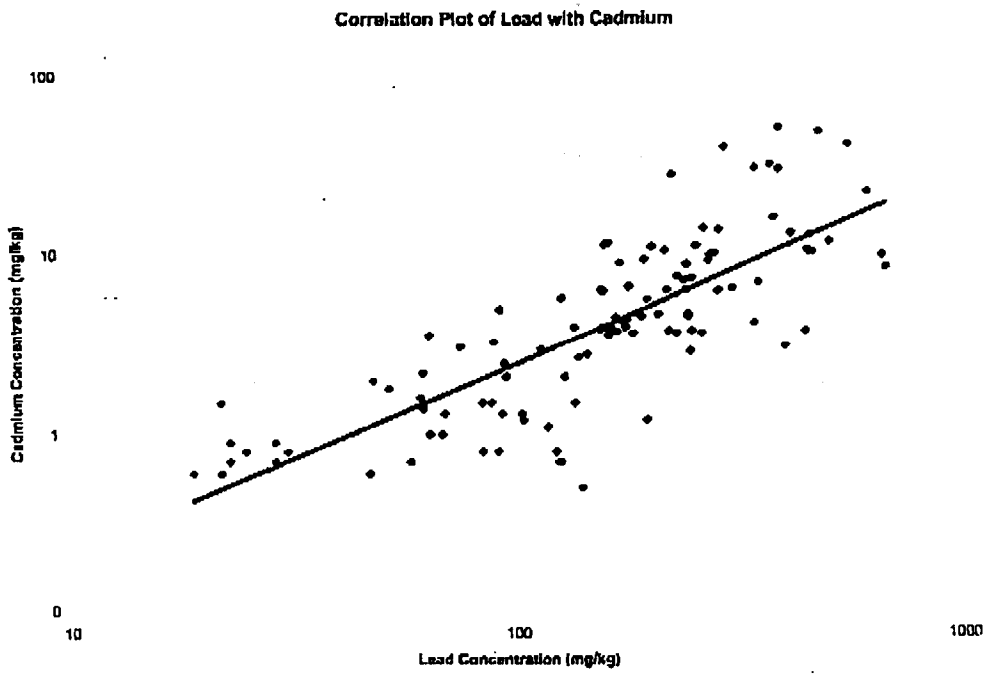


Figure 1. Correlation plots of zinc with cadmium and lead.

Figure 2. Correlation plot of lead with cadmium



Lead - Toxic Effects

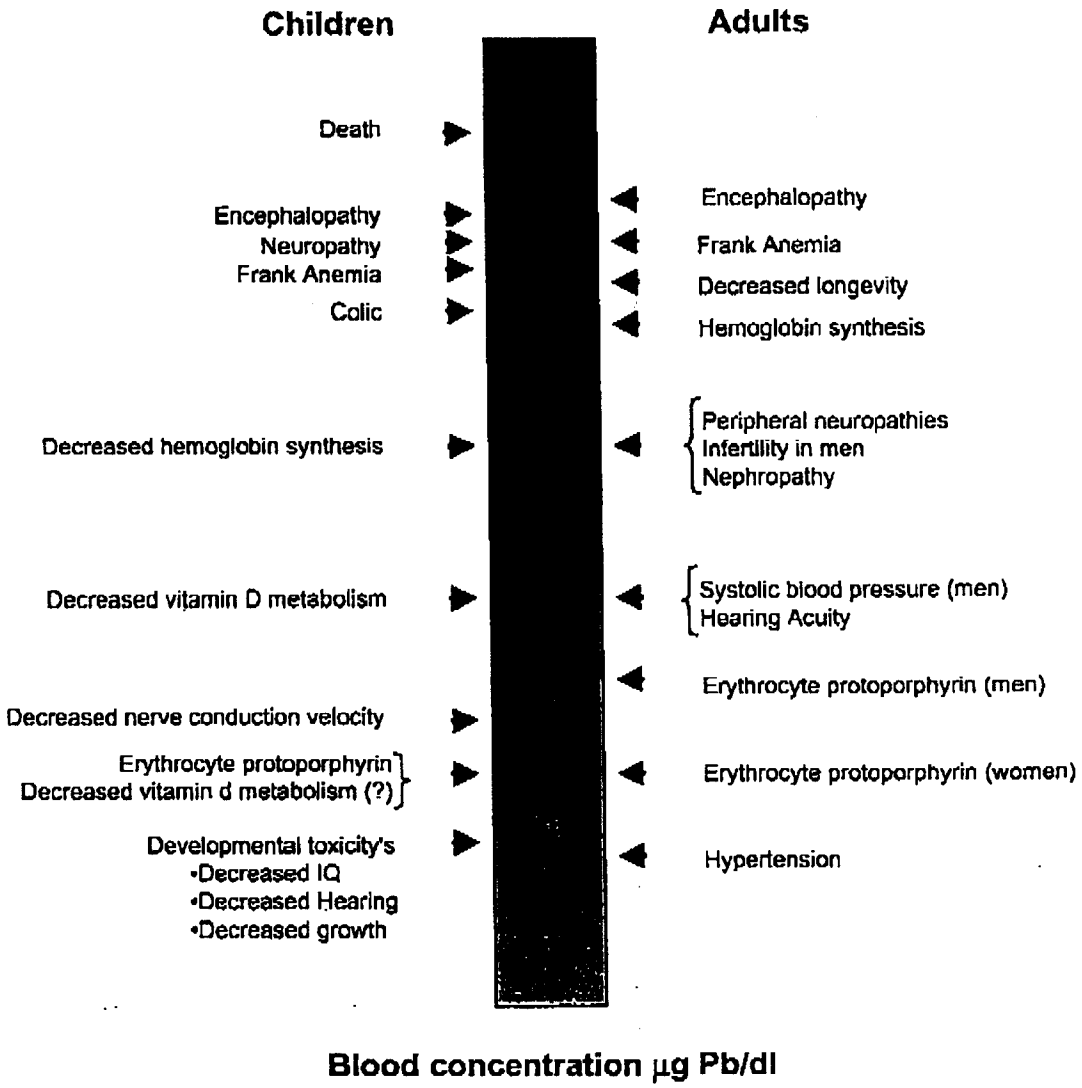


Figure 3. Toxic effects of lead with associated lead concentrations in blood.