Arbets- och miljömedicin | Uppsala

Rapport nr 1/2020

Miljömedicinsk bedömning av förorenad mark intill Bjäkenbackenskolan, Mora

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AKADEMISKA SJUKHUSET

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Sammanfattning

I februari 2020 fick Arbets- och miljömedicin i Uppsala en remiss från miljökontoret i Mora kommun med en begäran om att göra en miljömedicinsk riskbedömning av förorenad mark på ett område intill Bjäkenbackenskolan i Mora.

Analys av markprover insamlade av Projektengagemang AB visade att jorden i det aktuella området hade metallhalter som överstiger riktvärdet för känslig markanvändning (KM) för koppar, zink, bly och barium och även överskrider riktvärdet för mindre känslig markanvändning (MKM) när det gäller koppar. Inga förhöjda metallhalter har påvisats på själva skolgården. Enligt Naturvårdsverket utgår riktvärdet för dessa metaller, med undantag för bly, för att skydda markmiljön. För bly är istället riktvärdet satt utifrån risken för hälsopåverkan på människa. Fokus i den miljömedicinska bedömningen är att bedöma hälsorisken för eleverna på mellanstadieskolan Bjäkenbacken inklusive barnen på förskolan (6 – 12 år). Det dagliga intaget för högsta markkoncentrationen av metallerna beräknades med hjälp av Naturvårdsverkets beräkningsverktyg och jämfördes med respektive metalls tolerabla dagliga intag (TDI). Resultaten visade att kvoten mellan det beräknade dagliga intaget och TDI för koppar, zink, barium respektive kadmium var 0, medan kvoten för bly som visade att dagligt intag för de yngsta barn var nästan 3 gånger högre än det tolerabla dagliga intaget. Med ett sådant dagligt intag uppskattas det motsvara en högsta blyhalt i blod på 27 µg/L och kan innebära en förhöjd risk på gruppnivå för negativ påverkan på nervsystemets utveckling hos barn. Detta beräknade intaget av bly är en s.k. värsta fallberäkning det vill säga utgår från högsta markkoncentrationen av metallerna, att både biotillgängligheten och absorptionen i magtarmkanalen är 100 procent, utgår från små barn som har högsta dagliga intag av jord per kg kroppsvikt (5 år, 15 kg) som vistas i området 365 dagar per år enligt definitionen av KM. Det är viktigt att nämna att med tanke på skillnaden i beteende mellan olika åldrar av skolbarn

(6 – 12 år) inkluderade vi uppskattningarna av vuxenintag eftersom det bättre skulle representera de äldsta barnen.

Det förorenade området intill Bjäkenbackenskolan är för närvarande inhägnat på alla sidor varför barnen på skolan kan betraktas som oexponerade då de inte kan vistas på området. Ifall stängslet avlägsnas kan de yngsta barnen riskera en exponering med risk för långsiktiga negativa hälsokonsekvenser på gruppnivå till följd av blykontamineringen, dock försumbar på individnivå.

Inhalationsbidraget från förorenad mark är marginellt för samtliga metaller till följd av förväntade mycket låga koncentrationer av damm i inomhusmiljön från den förorenade marken då enbart ej övertäckt mark kan generera damm och denna enbart förekommer i skogsområdet på stort avstånd från där skolbarnen regelbundet vistas.

En beräkning har också gjorts för att bedöma risken för akut förgiftning vid ett högt engångsintag av jord och visade ingen risk av akut förgiftning av någon av metallerna.

1 Frågeställning

In February 2020, Arbets- och miljömedicin in Uppsala received a request from the Mora Municipality to do a risk assessment regarding the human health impact of a contaminated landsite within the limits of one of the larger schools in the municipality. The Mora Orsa Environmental Office contacted us because we have successfully collaborated on other cases related to metal land contamination. The Mora Orsa Environmental Office sought out our expertise to answer the following questions:

- Given the concentrations of metals present in the soil, if the area were open and children were to play in it, would there a risk to human health?

- If the part where the contaminants were found was to be sealed, would it still represent a danger to human health?

2 Background

The contaminated area in question is a former dumping site in the town Mora in the county of Dalarna.

Mora is located in the vicinity of metalworking industries. It has previously been subject to risk assessments due to contamination by metals in different locations. This contamination is due to industrial dust deposition, as well as because of old dumping sites.

In the area, there has been a metalworking industry for over 100 years. Among other processing techniques, manufacturers carried out surface treatment of metal (chrome plating and nickel plating), smelting, and engineering industry.

The companies currently in the field are CW Lundberg Industri AB, FM Mattsson (crane manufacturer), Mora Armatur (sanitary fixture) and Morakniv AB. FM Mattsson and Mora Armatur are both part of FM Mattsson Mora Group AB.

Metal pollutants from the metalworking industry have been released into the air and thus spread over Mora. The casting is estimated to account for 97% of emissions to air. Mora Armatur, for example, carried out metalworking with surface treatment between 1927 and 2007. During this time, they processed brass (containing copper, zinc and lead) by casting, smearing and polishing. Emissions of copper, zinc and lead are estimated to have averaged 1.75 tons / year for 143 years (1). Furthermore, there has been at least one case of dumping of industrial waste which contributes to the increase of pollution in the area.

After suspecting a possible contamination in the Bjäkenbacken area, the municipality commissioned the company "Projektengagemang AB" (PE) to do a detailed soil survey of the affected land in accordance with the Naturvårdsverket guideline for känslig markanvänding (KM) (2). This was of particular importance as the space in question is next to a school that serves students from preschool to 6th grade.

3 Description of the area

Located in the Mora kommun, Bjäkenbackens School is one of the largest community schools. The property itself, around 19,277 m^2, is constituted by two large buildings linked together, two smaller houses, a number of small sheds, two soccer fields and one parking lot (Fig.1).

When commissioned, the PE company did a geological survey of different locations in the school area. The company did soil sampling at six specific locations which are represented by a group of 4 yellow squares in each. While five of the sample groups alongside the school plaza showed no sign of contamination, the sixth at the forest's edge brim was positive for metal contamination. A number of additional measurements, which are represented by the white squares, were taken to confirm the spread and contamination level of the polluted area (Fig. 1).

The ground areas within the school property can be divided into hardened surfaces (asphalt, concrete and artificial grass), graveled areas, and natural grass areas. The grazed surfaces are sometimes severely worn and consist of hard-packed soil or mud (in wooded areas) (2).

The largest open grass areas are the two football fields. Other open spaces consist of smaller green spaces and graveled areas inside the school yard.

This suggests that the risk for the inhalation of metal in soil dust does exist only because of worn out patches (naked soil) that will emit dust when disturbed by wind or anthropogenic activity. But it will likely not be one of the main intake routes due to the presence of trees, the low abundance of very fine loose sediment and the distance between indoor and contaminated spaces.

Figur 1. Provtagningsområden vid Bjäkenbackens skola. Gula rutor visar provtagningsplatser från första provtagningstillfället och vita rutor visar ungefärliga provtagningsplatser från det andra provtagningstillfället. Röda rutor visar det område som ströks från provtagningen då området stod under vatten (image taken from PE report 231451).

4 Risk Assessment

4.1 Exposure assessment and hazard identification

In the two areas where the soil sampling was done (i.e. the school's property and the forest's edge) only the second showed metals in high concentration on the soil (arsenic, barium, cadmium, cobalt, copper, chrome, nickel, lead, vanadium and zinc). The substances found in the area above the Naturvårdsverkets KM levels, included lead, cadmium, barium and zinc. Copper levels were even above the less restrictive Mindre Känslig Markanvänding (MKM) levels (Fig. 2). Arsenic, cobalt, chrome, nickel, vanadium where all far below the KM level and therefore not considered in the risk assessment as they presented no risk to human health at the measured concentrations.

Figure 2. Provtagningsområden vid Bjäkenbackens skola. Gula rutor visar provtagningsplatser från första provtagningstillfället och vita rutor visar ungefärliga provtagningsplatser från det andra provtagningstillfället (image taken from PE report 231451).

Given the situation presented, our first approach was to use the Naturvårdsverket beräkningsmodell to get land specific benchmark values for the environmental particularities of the area. Because the land usage was presented to us as KM by both the municipality and the sampling company, we perceived it as such in our model calculations (Table 1) (3).

When calculating the scenario specific riktvärden, this model generates guideline values based on the lowest of three calculated partial guideline values for (a) health effects, (b) environmental effects in the area and (c) effects on natural resources such as drinking water aquifers or surface water bodies and free-range pollution (4).

Table 1. Scenario specific Riktvärde for KM

Ämne	Halt i mark (µg/kg TS)	Riktvärde (µg/kg)	Styrande för riktvärde
Bly	170000	80000	Intag av jord
Koppar	460000	80000	Skydd av markmiljö
Kadmium	850	4000	Skydd av markmiljö
Zink	250000	250000	Skydd av markmiljö
Barium	220000	200000	Skydd av markmiljö

More important than the benchmark values themselves, the model tells us what these values are meant to protect against. From analyzing the table, we can see that only the riktvärde of lead is meant for the protection of human health. The other scenario specific riktvärden are for the protection of the environment in the area (4) (bilaga 1).

4.2 Assessment of intake, dose and human health effects

The second step in the risk assessment was then to focus on the human health effects. To do this, the first action was to estimate the daily intake from the contaminated soil given Naturvårdverkets parameters (5,6). The intake parameters by Naturvårdsverket assume a daily soil intake of 120 mg for children and 50 mg for adults. Furthermore, it assumes an average weight of 70 kg for and adult and 15 kg for a child and a gastrointestinal absorption rate of 100% of the chemicals (this is not realistic but allows us to be as conservative as possible given

biological differences, dietary behavior and other genetic or environmental factors). Given the concentration of metals in the most contaminated soils (µg/kg TS) the daily intake of the different metals was calculated and compared to the respective World Health Organization's (WHO) tolerable daily intake[1] (TDI). We use TDI because for these natural elements there is always a small background intake from minerals in food, water or soil.

Table 2. Comparison between calculated daily intake from highest metal content in soil and TDI (7-11)

Metaller	**Dagligt intag TS (µg/kg kv dag)**		**TDI (µg/kg kv dag)**		**Kvot av Dagligt intag till TDI**	
	Barn	**Vuxen**	**Barn**	**Vuxen**	**Barn**	**Vuxen**
Bly	1,36	0,12	0,5[1]	0,5[A]	2,7	0,2
Koppar	3,68	0,33	500[2]	500[2]	<0,1	<0,1
Zink	3,6	0,32	300[3]	400[3]	<0,1	<0,1
Kadmium	0,0068	0,0006	0,36[1]	0,36[1]	<0,1	<0,1
Barium	1,76	0,16	200[4]	200[4]	<0,1	<0,1

1 - Miljöhälsorapport 2017 - Folkhälsomyndigheten. (n.d.). Retrieved May 15, 2020, from https://www.folkhalsomyndigheten.se/publicerat-material/publikationsarkiv/m/miljohalsorapport-2017/

A - lead TDI for adults was not available for it is usually not the population of concern for this substance, so we used the children TDI.

2 - Datablad för koppar". Kemakta Konsult AB Institutet för Miljömedicin. Naturvårdsverket, Juni 2016. https://www.naturvardsverket.se/upload/stod-i-miljoarbetet/vagledning/fororenade-omraden/koppar.pdf

3 - "Datablad för zink". Kemakta Konsult AB Institutet för Miljömedicin. Naturvårdsverket, Juni 2016. https://www.naturvardsverket.se/upload/stod-i-miljoarbetet/vagledning/fororenade-omraden/zink.pdf

4 - Scientific Committee on Health and Environmental Risks (2012, March 22). Assessment of the Tolerable Daily Intake of Barium. Retrieved from https://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_161.pdf

Comparing the daily intake from soil to the TDI of the present metal contaminants in the soil, only lead presents a health concern for the children, with a maximum daily intake almost three

[1] Tolerable daily intake (TDI) refers to the daily amount of a chemical that has been assessed safe for human being on long-term basis (usually whole lifetime).

times larger than that of the TDI. When comparing the adult intake to that of the TDI we see that to the adult population lead is not of concern to human health. This is very important due to the age difference and behavior in our population. This means that the 12-year-old will have exposures more similar to the adults and the 6-year-old more similar to the children's exposure.

Regarding the contaminant intake from different sources, other than soil consumption, the only other potential source would be respirable dust. But given the distance between the contaminated site and the school indoor and the small quantity of naked earth present, the amount of lead in the dust in the indoor classroom is assumed to be so small that we neglected it in our calculations.

When looking at the relevance of the possibility of an acute intoxication, the intake of soil necessary was unrealistically high as all these substances have very high acute intoxication thresholds via soil uptake. The lowest one would be barium, and still it would require the ingestion of 1 kg of soil on a single intake before starting to exhibit symptoms of acute intoxication (8, 9, 13, 14, 15).

4.3 Risk Characterization

After analyzing the ratio between substance intake and TDI we can see that other than lead, all the other metals present on the soil are not a threat to human health in the present quantity and form (TS).

Because lead is the only substance whose exposure exceeds that of the guideline values and its intake can be near 3 times above that of the TDI, it became the focus of the risk assessment. To be able to determine the magnitude of the risk from the daily intake of lead in soil from the area, this needed to be translated into blood levels and compared to health risks in the toxicologic literature. The USA Environmental Protection Agency through the IEUBK

(Integrated Exposure Uptake Biokinetic) model for lead in children allows to estimate blood lead level (BLL) in the body from ingestion.

The IEUBK Model for lead is designed to facilitate: (a) rapid delineation of the relationship between environmental lead and blood lead in children 6 months to 7 years old.; and (b) calculation of the risk of elevated blood lead (i.e., the probability of a given child or a group of children having blood lead concentrations exceeding a specified level of concern). Like most other models biokinetic models, this one assumes a steady state of lead concentration in the environment and between the environment and the medias in the body (blood and bone) (bilaga 2) (15,16).

With an estimated BLL of 27 µg/L, we see when compared to the TDI equivalent in BLL 12 µg/L for children, that we are two times above what is considered a low risk level (12). Furthermore, if compared with an historic registry of BLL in Sweden we can see not only that these levels correspond to those of 1993, but also that they more than three times to that of the average Swedish child currently (12).

When compared to the lead-related health effects, we can see that at a concentration 27 µg/L, effect in cognition is the main concern. But as all recent literature has been pointing to, there is no such thing as a safe lead level exposure to children, so at a blood lead level of 27 µg/L we can see systemic symptoms other than just at the cognition level (13,14,18). It is important to stress again that we have used a worst case scenario approach where we assumed highest soil concentrations, 100% absorption and a lack of the limit threshold, therefore the health concerns present are of theoretical nature, meaning although the risk does exist, it is unlikely to that we will see it on this population.

5 Conclusion

This calculation was done taking in account the worst-case scenario. Under these parameters we see that the level of lead has the potential to affect only the younger of school children, in particular if we have in account that there is no safe daily intake of lead for children.

Given that the area where contaminated soil was found is currently closed, soil consumption, which was the predominant intake route, is now improbable. The remaining route of exposure is then dust inhalation. However, due to terrain and geographical conditions, this exposure is negligible. By rerunning the Naturvårdsverket riktvärden beräkningsmodell only using inhalation of lead in dust we see that the KM for land use increased to 600000 µg/kg TS, which include both chronic and short-term health risks.

Given this, it is safe to say that if the given scenario applies, the intake of soil from the contaminated land in this report, should not be a perceivable risk to children's health in the school area.

7 References

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Bilaga 1

Riktvärden — Naturvårdsverket, version 2.0.1

	Envägskoncentrationer (mg/kg)						Riktvärde	Justeringar (mg/kg)		Hälsorisk-	Skydd av	Spridning (mg/kg)			Riktvärde	Bakgrunds-	**Avrundat**
Ämne	Intag av jord	Hudkontakt jord/damm	Inandning damm	Inandning ånga	Intag av dricksvatten	Intag av växter	för hälsa, långtidseff.	Korttids-exponering	Akut-toxicitet	baserat riktvärde	markmiljö (mg/kg)	Skydd mot fri fas	Skydd av grundvatten	Skydd av ytvatten	hälsa, miljö, spridning	halt (mg/kg)	**riktvärde** (mg/kg)
Bly	**88**	3200	5300	beaktas ej	beaktas ej	beaktas ej	**84**	600	data saknas	**84**	200	beaktas ej	beaktas ej	3600	84	beaktas ej	**80**
Kadmium	9	3300	53	beaktas ej	beaktas ej	beaktas ej	7,7	250	data saknas	7,7	**4**	beaktas ej	beaktas ej	16	4	beaktas ej	**4,0**
Barium	1300	46000	27000	beaktas ej	beaktas ej	beaktas ej	1200	data saknas	data saknas	1200	**200**	beaktas ej	beaktas ej	48000	200	beaktas ej	**200**
Koppar	31000	ej begr.	27000	beaktas ej	beaktas ej	beaktas ej	14000	data saknas	data saknas	14000	**80**	beaktas ej	beaktas ej	2400	80	beaktas ej	**80**
Zink	19000	680000	ej begr.	beaktas ej	beaktas ej	beaktas ej	18000	data saknas	data saknas	18000	**250**	beaktas ej	beaktas ej	9600	250	beaktas ej	**250**

Gråmarkerade celler indikerar att detta värde är styrande för riktvärdet.
Eventuell gul/orange cell indikerar att riktvärdet justerats till bakgrundshalten.

Eget scenario: **--- namnlöst ---**
Generellt scenario: **KM**

Avvikelser mellan eget scenario och generellt scenario redovisas på kalkylblad "Uttagsrapport".

Uttagsrapport

Generellt scenario: **KM**
Eget scenario: **--- namnlöst ---**

Naturvårdsverket, version 2.0.1

Beskrivning
Standardscenario för känslig markanvändning, enligt Naturvårdsverkets generella riktvärden för förorenad mark.

Beräknade riktvärden

Ämne	**Riktvärde**		**Styrande för riktvärde**	**Kommentarer (obl = obligatorisk, frv = frivillig)**
Bly	80	mg/kg	Intag av jord	
Kadmium	4,0	mg/kg	Skydd av markmiljö	
Barium	200	mg/kg	Skydd av markmiljö	
Koppar	80	mg/kg	Skydd av markmiljö	
Zink	250	mg/kg	Skydd av markmiljö	

Avvikelser i scenarioparametrar	**Eget scenario**	**Generellt scenario**	Kommentarer till scenarioparametrar (frv)
	--- namnlöst ---	**KM**	
Inandning av ånga	beaktas ej	beaktas	Kommentar saknas!
Intag av dricksvatten	beaktas ej	beaktas	Kommentar saknas!
Intag av växter	beaktas ej	beaktas	Kommentar saknas!
Skydd av grundvatten	utförs ej	utförs	Kommentar saknas!
Justering för bakgrundshalt	utförs ej	utförs	Kommentar saknas!

Avvikelser i modellparametrar	**Eget värde**	**Standardvärde**	Kommentarer till modellparametrar (frv)
Inga avvikelser i modellparametrar.	-	-	

Egendefinierade ämnen
Inga egendefinierade ämnen används.

Avvikelser ämnesdata

Eget scenario: --- **namnlöst** ---

Naturvårdsverket, version 2.0.1

Eget ämne: Koppar-mod

Fördefinierat ämne: Koppar

Radera kommentare

Avvikelser	**Eget ämne**	**Fördefinierat ämne**		**Egna kommentarer**
Inga avvikelser finns. De två ämnena är identiska.				TDI från Naturvårdsverket database

Eget ämne: Bly-mod

Fördefinierat ämne: Bly

Radera kommentare

Avvikelser	**Eget ämne**	**Fördefinierat ämne**		**Egna kommentarer**
	Bly-mod	**Bly**		
Tolerabelt dagligt intag, TDI	0,0005	0,0035	mg/(kg,dag)	TDI från Miljöhälsorapport 2017 <<

Eget ämne: Barium-mod

Fördefinierat ämne: Barium

Radera kommentare

Avvikelser	**Eget ämne**	**Fördefinierat ämne**		**Egna kommentarer**
	Barium-mod	**Barium**		
Tolerabelt dagligt intag, TDI	0,2	0,02	mg/(kg,dag)	TDI från Scientific Committee on Health and Environmental Risks <<

Eget ämne: Kadmium-mod

Fördefinierat ämne: Kadmium

Radera kommentare

Avvikelser	**Eget ämne**	**Fördefinierat ämne**		**Egna kommentarer**
Inga avvikelser finns. De två ämnena är identiska.				TDI från Miljöhälsorapport 2017

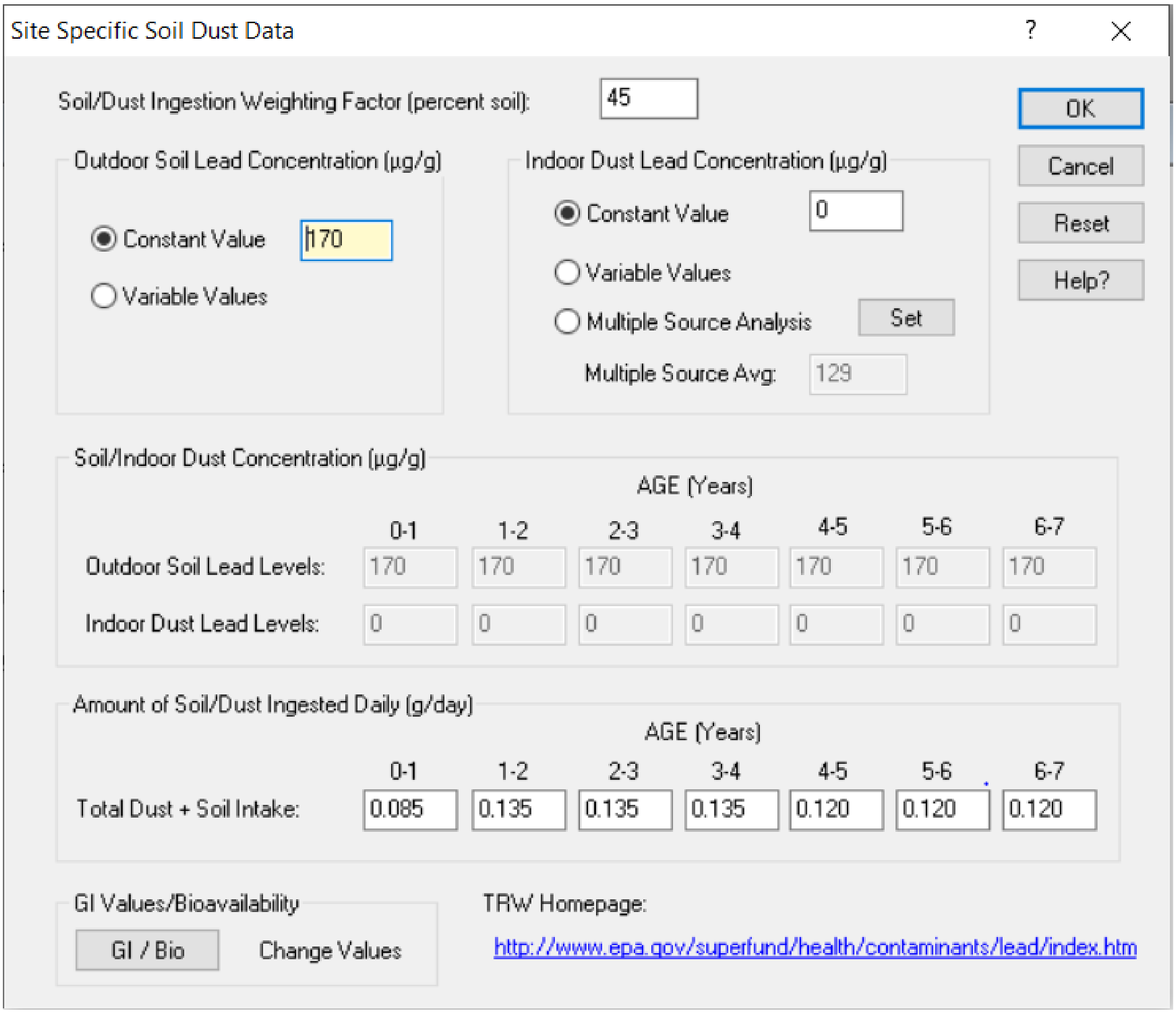
Eget ämne: Zink-mod

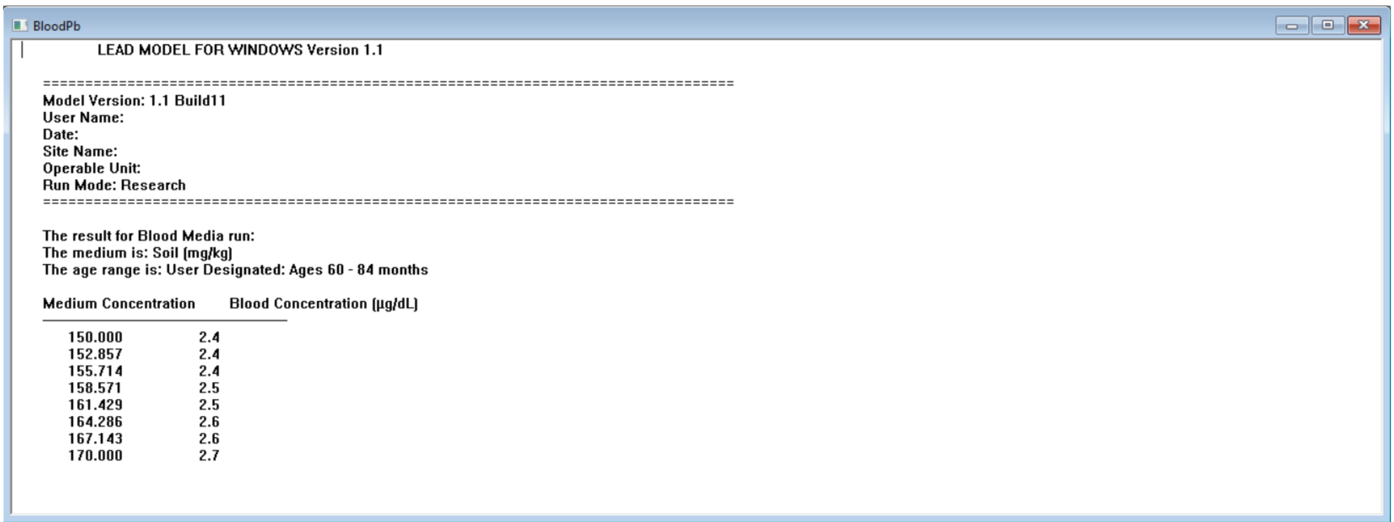
Fördefinierat ämne: Zink

Radera kommentare

Avvikelser	**Eget ämne**	**Fördefinierat ämne**		**Egna kommentarer**
Inga avvikelser finns. De två ämnena är identiska.				TDI från Naturvårdsverket database

Bilaga 2


Site Specific Soil Dust Data
Soil/Dust Ingestion Weighting Factor (percent soil): 45
OK
Cancel
Reset
Help?
Outdoor Soil Lead Concentration (µg/g)
Constant Value 170
Variable Values
Indoor Dust Lead Concentration (µg/g)
Constant Value 0
Variable Values
Multiple Source Analysis
Set
Multiple Source Avg: 129
Soil/Indoor Dust Concentration (µg/g)
AGE (Years)
0-1 1-2 2-3 3-4 4-5 5-6 6-7
Outdoor Soil Lead Levels: 170 170 170 170 170 170 170
Indoor Dust Lead Levels: 0 0 0 0 0 0 0
Amount of Soil/Dust Ingested Daily (g/day)
AGE (Years)
0-1 1-2 2-3 3-4 4-5 5-6 6-7
Total Dust + Soil Intake: 0.085 0.135 0.135 0.135 0.120 0.120 0.120
GI Values/Bioavailability
GI / Bio
Change Values
TRW Homepage:
http://www.epa.gov/superfund/health/contaminants/lead/index.htm


BloodPb
LEAD MODEL FOR WINDOWS Version 1.1
Model Version: 1.1 Build11
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
The result for Blood Media run:
The medium is: Soil (mg/kg)
The age range is: User Designated: Ages 60 - 84 months
Medium Concentration Blood Concentration (µg/dL)
150.000 2.4
152.857 2.4
155.714 2.4
158.571 2.5
161.429 2.5
164.286 2.6
167.143 2.6
170.000 2.7