Final Report

Metals Screening
Freeport, Brazoria County, Texas

January 14, 2013

TEXAS Department of State Health Services

Table of Contents

Executive Summary

The Texas Commission on Environmental Quality (TCEQ) asked the Texas Department of State Health Services (DSHS) to help investigate possible exposures to metals in Freeport, Texas. In response, DSHS collected urine samples from 353 residents living in the area of interest and tested them for cobalt, molybdenum, and nickel; metals reported to be in ambient air. Most people tested during this screening had urinary cobalt and molybdenum levels consistent with those seen in the United States (US) general population. Although there is no indication that the levels found will adversely affect the health of residents, a large number of people had urinary nickel levels higher than a reference value. The TCEQ and DSHS are collaborating to provide additional nickel testing for people identified with high nickel levels to determine if nickel levels continue to remain elevated.

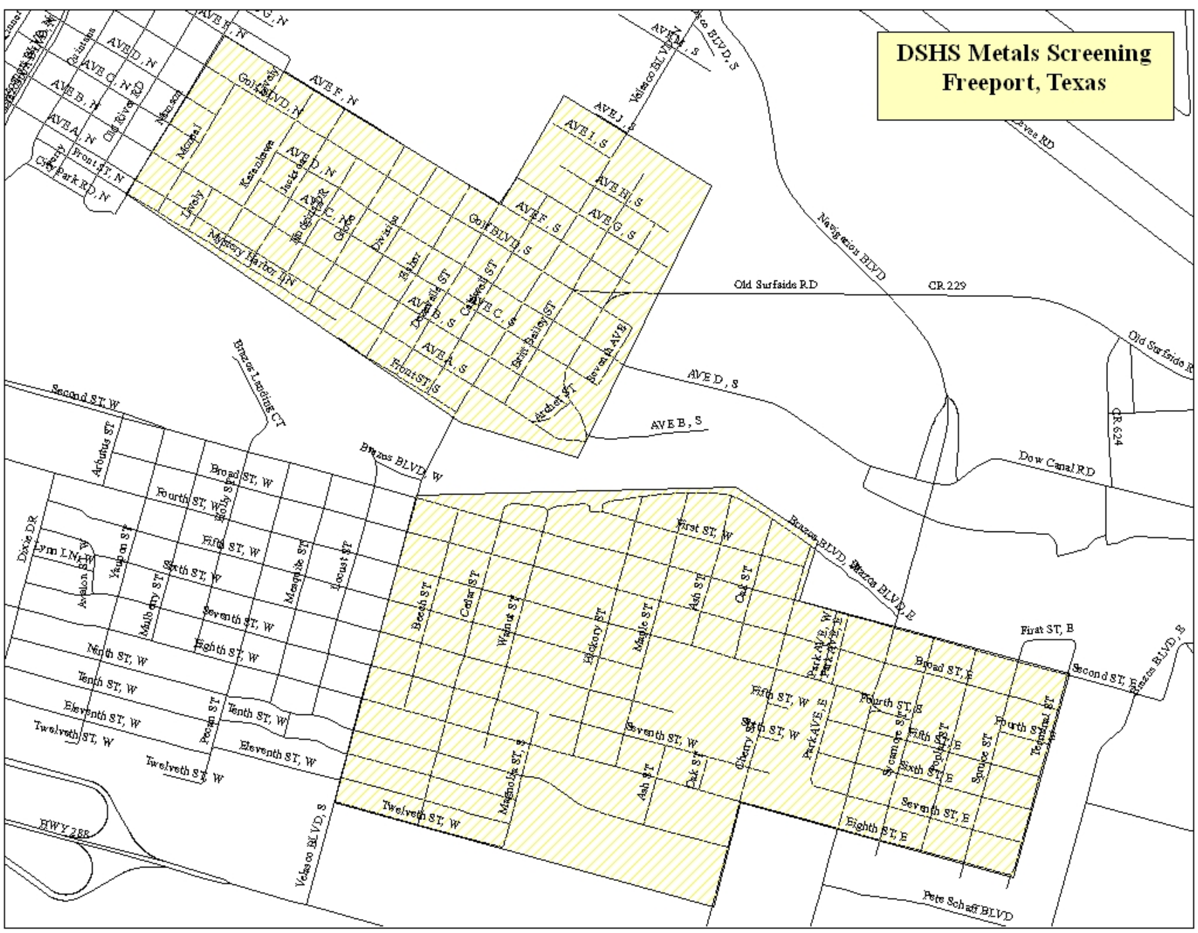
Purpose and Health Issues

The Texas Commission on Environmental Quality (TCEQ) asked the Texas Department of State Health Services (DSHS), Environmental and Injury Epidemiology and Toxicology Unit (EIET), to help investigate possible exposures to metals in Freeport, Texas. In response DSHS conducted urine metals screening for cobalt, molybdenum, and nickel: three contaminants of potential concern identified by the TCEQ. The results of the screening are presented in this report. A full list of the acronyms and abbreviations used in this report are included in Appendix A. More information about cobalt, molybdenum, and nickel is included in Appendix B.

Background

In response to TCEQ's request, DSHS collected urine from residents living in the area of interest in Freeport, Texas (Figure 1). Cobalt, molybdenum, and nickel were detected in soil and were elevated in ambient air samples collected by TCEQ during mobile monitoring trips. To determine how levels found in residents compared to those found in the United States (US) general population, urine samples were tested for these metals.

Figure 1. Area of interest in Freeport, Texas.



Biological Screening

On April 9 through 13, 2012, DSHS staff walked the neighborhoods in the area of interest (Figure 1), talked with local residents about the screening, and distributed a flyer with the dates, times, and location of the urine metals screening clinic. The screening clinic was held at the Freeport Historical Museum, May 3 through 6, 2012.

Each participant signed an informed consent outlining: the purpose of the testing; the procedures involved; the expected time commitment; any reasonably foreseeable risks or discomforts; potential benefits to the participant or to others; how their information would be kept confidential; and who they could contact with any questions or concerns regarding the consent form or the specimen collection procedures.

Individual urine test results and an explanation of those results were mailed to each participant.

Urine Sampling

Participants were provided a specimen collection cup with instructions to collect the first morning void urine sample and to bring the sample to the metals screening clinic. Urine samples were shipped to NMS Labs in Willow Grove, Pennsylvania, and analyzed for cobalt, molybdenum, and nickel using inductively coupled plasma mass spectrometry (ICP-MS). Urine test results were standardized based on individual creatinine levels and expressed as “urine test results per gram creatinine.”

Data Analysis Procedures

The purpose of this screening was to provide participants with information about how the levels of cobalt, molybdenum, and nickel in their bodies compared to those typically seen in the US general population.

For cobalt and molybdenum, individual test results were compared to those found in the US general population, as reported in the Centers for Disease Control and Prevention’s (CDC’s) National Health and Nutrition Examination Survey (NHANES) for survey years 2007-2008[1] [1]. NHANES provides information about the health, nutrition, and exposure status of children and adults across the US. Individual values were considered high if they were greater than the levels found in 95% of the people by age group (the 95th percentile, used as the “reference value” in this report). It is important to note that, on average, 5% of the people tested might be expected to have levels greater than the reference value. Reference values by age group for cobalt and molybdenum are presented in Tables 1 and 2, respectively.

[1] At the time this project was initiated, the 2007-2008 data tables [1] were the most recent data available for cobalt and molybdenum. Prior to completion of the Final Report, the 2009-2010 data [2] were released. However, because individual results compared to the 2007-2008 data had already been provided to participants, the 2007-2008 data [1] were used in this report. Although not presented, data collected in this screening were also compared to the 2009-2010 data [2] and there were no changes to the conclusions of this report.

Nickel is not tested as part of NHANES; therefore, reference values from the Mayo Clinic [3] were used to compare the nickel test results. According to the Mayo Clinic, urine levels up to 6 micrograms of nickel per gram creatinine (6 µg/g-cr) are normal for the general population and levels of 7 µg/g-cr or higher could suggest environmental and/or occupational exposures to nickel.

Results

From May 3 through 6, 2012, DSHS collected urine samples from 353 participants; the results for 352 urine samples[2] are presented below.

Cobalt

Urinary cobalt results, adjusted for creatinine, are presented in Table 1 as micrograms of cobalt per gram creatinine (µg/g-cr). Of the 352 urine samples tested, 41 (12%) contained detectable levels of cobalt and 11 people (3%) had cobalt levels greater than the reference value for their respective age group[3].

Table 1. Summary of urinary cobalt results collected from 352 participants.

Age Group (years)	Number Tested	Range (µg/g-cr)[a]	Number of Detects	Reference Value (µg/g-cr)[b]	Number above Reference Value
1-5	19	ND[c]-1.4	<5[d]	1.39[e]	<5
6-11	36	ND-3.7	6	1.39	<5
12-19	40	ND-1.7	11	1.17	<5
20+	257	ND-1.9	22	1.19	5

[a] Standardizing the results per gram creatinine is a standard practice in medicine when presenting urine test results.
[b] The reference value is based upon the National Health and Nutrition Examination Survey (NHANES) conducted by the Centers for Disease Control and Prevention (CDC) for survey years 2007-2008 [1]. The reference value is the 95th percentile for each age group and represents the level at which 5% of the people in each age group tested in the US had values above. Having a result similar to or below the reference value indicates an exposure similar to what we would find in most individuals. Having a result higher than the reference value does not mean that people will get sick, it does however suggest a greater than normal exposure to the substance.
[c] ND indicates the contaminant was not detected. The detection limit for cobalt in urine was 1.0 microgram of cobalt per liter of urine (µg/L).
[d] Counts of 1 to 4 are expressed as <5 to protect confidentiality.
[e] NHANES does not contain information on metals in urine for children 1-5 years old. Information on children 6-11 years old was used as a comparison for this age group.

[2] One urine sample could not be analyzed because it did not meet clinical standards for laboratory analysis.
[3] NHANES does not contain information on metals in urine for children 1-5 years old. Information on children 6-11 years old was used as a comparison for this age group.

Molybdenum

Urinary molybdenum results, adjusted for creatinine, are presented in Table 2 as micrograms of molybdenum per gram creatinine (µg/g-cr). Of the 352 urine samples tested, 339 (96%) contained detectable levels of molybdenum and 8 people (2%) had molybdenum levels greater than the reference value for their respective age group [4].

Table 2. Summary of urinary molybdenum results collected from 352 participants.

Age Group (years)	Number Tested	Range (µg/g-cr)[a]	Number of Detects	Reference Value (µg/g-cr)[b]	Number above Reference Value
1-5	19	43-360	19	274[c]	<5[d]
6-11	36	ND[e]-450	35	274	<5
12-19	40	21-150	40	129	<5
20+	257	ND-190	245	122	<5

[a] Standardizing the results per gram creatinine is a standard practice in medicine when presenting urine test results.
[b] The reference value is based upon the National Health and Nutrition Examination Survey (NHANES) conducted by the Centers for Disease Control and Prevention (CDC) for survey years 2007-2008 [1]. The reference value is the 95th percentile for each age group and represents the level at which 5% of the people in each age group tested in the US had values above. Having a result similar to or below the reference value indicates an exposure similar to what we would find in most individuals. Having a result higher than the reference value does not mean that people will get sick, it does however suggest a greater than normal exposure to the substance.
[c] NHANES does not contain information on metals in urine for children 1-5 years old. Information on children 6-11 years old was used as a comparison for this age group.
[d] Counts of 1 to 4 are expressed as <5 to protect confidentiality.
[e] ND indicates the contaminant was not detected. The detection limit for molybdenum in urine was 11 micrograms of molybdenum per liter of urine (µg/L).

[4] NHANES does not contain information on metals in urine for children 1-5 years old. Information on children 6-11 years old was used as a comparison for this age group.

Nickel

We identified a possible issue with the method the laboratory used to test for nickel. There was a possible interference with calcium oxide when running urine samples for nickel using ICP-MS that could potentially overestimate nickel test results. To evaluate this issue, on August 6 through 8, 2012, a second urine sample was collected from 43[5] of the original 352 participants. Each sample was split into two portions with one portion sent to the original laboratory (NMS Labs) and the other portion sent to the National Center for Environmental Health (NCEH) laboratory at the CDC in Atlanta, Georgia. The CDC laboratory used a different method, one that avoided the potential interference possible with the original method, to test the samples. The results from the two laboratories indicated that the results obtained with the original method in May were representative of the amount of nickel present in participants' urine at that time.

Urinary nickel results for the May testing, adjusted for creatinine, are presented in Table 3 as micrograms of nickel per gram creatinine (µg/g-cr). Of the 352 urine samples tested, 345 (98%) contained detectable levels of nickel and 111 people (32%) had nickel levels greater than the reference value from the Mayo Clinic.

Table 3. Summary of urinary nickel results collected from 352 participants (May 2012).

Age Group (years)	Number Tested	Range (µg/g-cr)[a]	Number of Detects	Reference Value (µg/g-cr)[b]	Number above Reference Value
1-5	19	2.2-18	19	0.0-6.0	11
6-11	36	1.7-15	36	0.0-6.0	10
12-19	40	ND[c]-8.1	39	0.0-6.0	<5[d]
20+	257	ND-35	251	0.0-6.0	87

[a] Standardizing the results per gram creatinine is a standard practice in medicine when presenting urine test results.
[b] The reference value for nickel in urine is based upon information provided by the Mayo Clinic and applies to all ages [3].
[c] ND indicates the contaminant was not detected. The detection limit for nickel in urine was 1.0 microgram of nickel per liter of urine (µg/L).
[d] Counts of 1 to 4 are expressed as <5 to protect confidentiality.

[5] The follow up nickel testing was offered to those participants with the highest nickel levels, as well as randomly selected participants with lower nickel levels.

Urinary nickel results for the August follow-up testing, adjusted for creatinine, are presented in Table 4 as micrograms of nickel per gram creatinine (µg/g-cr). Based upon the CDC test results, of the 43 urine samples tested, 41 (95%) contained detectable levels of nickel and less than 5 people[6] (less than 12%) had nickel levels greater than reference value from the Mayo Clinic.

Table 4. Summary of urinary nickel sample results collected from 43 participants (August 2012).

Age Group (years)	Number Tested	Original Laboratory			CDC Laboratory		
		Range (µg/g-cr)[a]	Number Detected	Number above Reference Value[b]	Range (µg/g-cr)[a]	Number Detected	Number above Reference Value[b]
1-5	<5[c]	1.9-5.3	<5	0	1.42-2.25	<5	0
6-11	<5	2.7-7.5	<5	<5	1.36-6.34	<5	<5
12-19	<5	1.4-19	<5	<5	0.84-17.85	<5	<5
20+	32	1.1-9.3	32	5	ND[d]-6.83	30	<5

[a] Standardizing the results per gram creatinine is a standard practice in medicine when presenting urine test results.
[b] The reference value for nickel in urine (0-6 µg/g-cr) is based upon information provided by the Mayo Clinic and applies to all ages [3].
[c] Counts of 1 to 4 are expressed as <5 to protect confidentiality.
[d] ND indicates the contaminant was not detected. The detection limit for nickel in urine was 1.0 microgram of nickel per liter of urine (µg/L) for the original laboratory and 0.337 micrograms of nickel per liter of urine (µg/L) for the CDC laboratory.

[6] Counts of 1 to 4 are expressed as <5 to protect confidentiality.

Discussion

Introduction

In addition to normal dietary exposure, people can be exposed to chemicals by breathing, eating, drinking, or coming into contact with contaminated media. Cobalt, molybdenum, and nickel were detected in soil and elevated in ambient air samples collected by TCEQ during mobile monitoring trips. The degree to which people may be exposed to these contaminants depends on the concentrations in the air, the amount of time people spend in the area, and the amount of air they breathe, which can be influenced by the amount of time they spend outdoors and the degree of physical exertion while outdoors.

It is difficult to predict adverse health effects based upon a urinary test result for these metals. The purpose of this screening was to determine if unusual exposures to these metals were occurring in Freeport. We compared the test results from this screening to reference values for the US general population. Cobalt and molybdenum test results were compared to a reference value obtained from NHANES. Having a result greater than the reference value does not mean that the people with these levels will experience harmful effects; it only suggests their exposure was likely higher than 95% of the people tested in their age group throughout the US. As nickel is not tested as a part of NHANES, we used reference values from the Mayo Clinic. These reference values also are not indicative of the potential for health effects; however, the Mayo Clinic specifies that levels above 50 µg/g-cr are levels of concern and indicate excess exposure to nickel [3].

No Unusual Exposures to Cobalt

Only 12% of the people tested had detectable levels of cobalt in their urine. It is not unusual for people to have some cobalt in their body; most people are exposed to cobalt through the food they eat and vitamin B_{12}, a cobalt containing compound, is an essential nutrient. Because of how the reference value was derived, we would expect to find at least 5% of the people we tested to have levels above the reference value. Since only 3% of the people tested had levels of cobalt that exceeded the reference value (Table 1), it does not appear that people in this community are having unusual exposures to cobalt.

No Unusual Exposure to Molybdenum

Molybdenum was detected in 96% of the people tested in this screening. Molybdenum is an essential nutrient and is commonly found in legumes (beans, peas, and lentils), nuts, grains, leafy vegetables, and liver. Most people take in more than twice the recommended daily intake; therefore, it is not unusual for people to have molybdenum in their body. Because of how the reference value was derived, we would expect to find at least 5% of the people we tested to have levels above the reference value. Since only 2% of the people tested had levels of molybdenum that exceeded the reference value (Table 2), it does not appear that people in this community are having unusual exposures to molybdenum.

Some Unusual Exposures to Nickel

From the original testing done in May, nickel was detected in 98% of the people tested. For the August follow-up testing, nickel was detected in 95% of the people tested. Nickel is commonly found in foods such as chocolate, soybeans, nuts, and oatmeal so it is not unusual for people to have some nickel in their body. From the August follow-up testing, less than five people had levels of nickel that exceeded the level the Mayo Clinic considers typical for the US general population (Table 4). However, from the original screening, 32% of the people tested had nickel levels higher than those considered typical for the US general population (Table 3). Although this suggests that people had a higher-than-normal exposure, none of the levels approached the 50 µg/g-cr level identified by the Mayo Clinic as indicating excessive exposure [3].

Since the body eliminates nickel fairly rapidly, the amount of nickel in urine will vary over time; TCEQ and DSHS are collaborating to provide additional nickel testing for people who had urinary nickel levels higher than the US general population to determine whether exposures are ongoing.

Limitations

This report reflects the results of the current screening effort which alone cannot be used to determine the source of cobalt, molybdenum, or nickel in any specific individual.

This was a one-time sampling event, and the cobalt, molybdenum, and nickel urinary test results only represent the levels of these metals in the body at the time the sample was collected.

The urine testing was limited to residents currently living in the area of interest (Figure 1). These data are representative only of those people who came in to be tested, it was not a random sample and may not be representative of all residents who live or have lived in the area of interest. This screening analysis was not designed to be a comprehensive epidemiological study and should not be interpreted as such.

Urine samples were analyzed only for cobalt, molybdenum, and nickel. Therefore, participants are cautioned not to attempt to draw any conclusions about other general health issues or concerns on the basis of these results. A normal test result does not necessarily imply that the participant's health status is good; likewise, an elevated test result does not necessarily imply any increased risk for adverse effects or that existing health issues are connected to potential exposure to these contaminants.

For cobalt and molybdenum we used the 95th percentile from NHANES as a reference value. Since NHANES does not test metals in urine for children in the 1 to 5 years age group we used the 95th percentile from the 6 to 11 years age group for the reference value. We do not know if data for the 6 to 11 years age group are representative of the 1 to 5 years age group.

Nickel is not one of the substances tested under NHANES so reference values provided by the Mayo Clinic were used for interpreting the urinary nickel results in this screening. The Mayo Clinic reference values were similar to reference values found in other published sources.

Conclusions

While we found detectable levels of cobalt, molybdenum, and nickel in participants, finding low levels of these metals in people is not unusual. Most people tested during this screening had urinary cobalt and molybdenum levels consistent with those seen in the US general population. For cobalt and molybdenum, the results are not consistent with unusual exposures to these metals. However, there was a large number of people with nickel levels higher than what is considered normal by the Mayo Clinic. While it is not possible to determine the source of these exposures, there is no indication that the levels found will adversely affect the health of residents. The TCEQ and DSHS are collaborating to provide additional nickel testing for those people with urinary nickel levels higher than the level considered normal by the Mayo Clinic.

Recommendations

People with urinary nickel levels higher than the US general population should participate in the next round of testing to help determine if ongoing exposure to nickel is occurring. Individuals with health concerns should consult their personal physician. Although exposure to metals through dietary sources is normal, people concerned about environmental exposure should follow standard precautions for reducing exposure, such as washing hands after contacting soils outside and before eating. More information about reducing exposure to metals can be found at http://www.dshs.state.tx.us/epitox/education.shtm.

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Appendix A: Acronyms and Abbreviations

CDC	Centers for Disease Control and Prevention
DHHS	Department of Health and Human Services
DSHS	Texas Department of State Health Services
EIET	Environmental and Injury Epidemiology and Toxicology
EPA	Environmental Protection Agency
IARC	International Agency for Research on Cancer
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
µg	micrograms
µg/g-cr	micrograms per gram creatinine
µg/L	micrograms per liter
NCEH	National Center for Environmental Health
ND	not detected
NHANES	National Health and Nutrition Examination Survey
TCEQ	Texas Commission on Environmental Quality
US	United States

Appendix B: Metals Information

Cobalt

Cobalt is a naturally occurring element that is a hard, silvery-grey metal. In the environment cobalt is usually combined with other elements such as oxygen, sulfur, and arsenic to make cobalt compounds. These cobalt compounds are commonly found in small amounts in rocks, soil, water, plants, and animals. One of these cobalt compounds, cyanocobalamin or vitamin B_{12}, is an essential nutrient for humans and animals [4].

Cobalt is no longer mined in the US, but is obtained from imported materials or by recycling scrap metal that contains cobalt. Cobalt is mixed with other metals to form alloys. These alloys are harder, more resistant to wear and corrosion, and are used for military and industrial applications. Cobalt is used in aircraft engines, magnets, grinding and cutting tools, and artificial hip and knee joints [4].

Cobalt is also used as a colorant in glass, ceramics, and paints. Although not all cobalt compounds are blue, cobalt colorants have a characteristic blue color. Cobalt compounds can be used as catalysts, paint driers, and as an additive in agriculture and medicine. Cobalt also exists in radioactive forms. Radioactive cobalt is used for sterilizing medical equipment and consumer products, radiation therapy for treating cancer, manufacturing plastics, and for scientific and medical research. Radioactive cobalt can also be used to irradiate food in order to destroy harmful bacteria, viruses, fungi, or insects that might promote spoilage or cause human disease [4].

Cobalt enters the environment from natural sources, including rainwater runoff, windblown dust, and seawater spray. Human activities such as coal-fired power plants and incinerators, vehicular exhaust, industrial activities related to the mining and processing of cobalt-containing ores, and the production and use of cobalt alloys and chemicals also contribute to cobalt in the environment. Cobalt attached to large particles of dust in the air settle to the ground quickly. Cobalt attached to smaller particles can remain in the air for many days. Plants can accumulate cobalt from the soil, especially fruit, grain, and seeds. However, the levels of cobalt normally found in the environment do not result in excessive amounts of cobalt in food or water [4].

Although people can be exposed to cobalt through breathing air, drinking water, or skin contact with substances containing cobalt, food is the largest source of exposure to cobalt for most people. As an essential nutrient, the recommended daily intake of vitamin B_{12} is 6 micrograms (µg). The average person consumes about 11 µg of cobalt every day in their diet. People who do not have enough iron in their body may absorb more cobalt from food than other people [4].

Although some cobalt that is taken into the body leaves the body quickly through feces, the rest is absorbed into the blood and distributed throughout the body, mainly into the liver, kidney, and bones. Cobalt absorbed by the body leaves the body slowly through urine [4].

In addition to being an essential nutrient, cobalt is also beneficial to the body because it increases red blood cell production and can be used as a treatment for anemia. However, too much cobalt in the body can lead to harmful effects. Workers exposed to extremely high levels of cobalt had difficulty breathing and other effects such as asthma, pneumonia, and wheezing. Although heart problems have been noted in people exposed to cobalt when it was used as an additive to beer, these people drank excessive amounts of beer and the effects on the heart may have been due to protein-poor diets and possible heart damage from alcohol abuse. Heart effects have not been seen in people, including pregnant women, who used cobalt to treat anemia. However, effects on the thyroid have been seen in people exposed to cobalt at similar levels. Exposure to radioactive cobalt can cause a reduction in white blood cells (lowering resistance to infection), blisters or burns, loss of hair, damage to cells in the reproductive system, nausea, vomiting, diarrhea, bleeding, coma, and death [4].

In animals, long-term exposure to cobalt in air caused lung damage and an increase in red blood cells. Similar exposures to cobalt in food and drinking water caused effects on the blood, liver, kidneys, heart, testes, and behavior. Changes in the fetus were seen in animals exposed to radioactive cobalt. Other health effects from exposure to radioactive cobalt include temporary or permanent sterility, changes in the lungs resulting in difficulty breathing, lower numbers of red and white blood cells, genetic damage to cells, cancer, and death [4].

Although effects on the developing fetus have been noted in animals exposed to high levels of cobalt, birth defects have not been seen in children born to mothers exposed to cobalt to treat anemia during pregnancy. The amount of cobalt used in the animal studies was much higher than that to which people are normally exposed [4].

Cobalt has not been found to cause cancer in humans or animals after exposure through food or water. However, animals that breathed cobalt or had cobalt placed directly under the skin or into the muscle developed cancer. Based on these animal studies, the International Agency for Research on Cancer (IARC) classifies cobalt as possibly carcinogenic to humans [4].

Children can be exposed to cobalt in the same way as adults. Children can also be exposed before they are born if the mother is exposed to cobalt while she is pregnant. Cobalt can also be passed to the child through breast milk; however, the benefits of breastfeeding far outweigh this risk. Health effects in children exposed to cobalt are similar to those in adults, but animal studies indicate children absorb more cobalt from food than adults [4].

Molybdenum

Molybdenum does not occur in nature as a free metal; instead, it is found in combination with other elements in various minerals. In its purified form, it is a silvery-grey metal. Small amounts are found in natural waters, with levels higher in ground and surface water near mining operations and ore deposits [5].

Molybdenum is added to metal alloys to add strength and hardness and to slow down corrosion. Molybdenum compounds are used as pigments for ceramics, inks, and paint and have also been used as corrosion inhibitors and lubricants. Semiconductor and battery industries have also begun to use molybdenum [5].

Most people are exposed to molybdenum through the food they eat, such as legumes (beans, peas, and lentils), nuts, grains, leafy vegetables, and liver. As an essential nutrient, the recommended daily intake of molybdenum is 45 µg, although most people take in more than twice that amount daily [5].

Molybdenum that is ingested is absorbed by the body. Molybdenum taken into the body goes to the bloodstream and to other organs in the body, mainly the kidneys, liver, and bones. Molybdenum is quickly eliminated by the body through urine [5].

While not much is known about human health effects from low levels of exposure to molybdenum, it is considered to be of low human toxicity. Long-term exposure to very high levels of molybdenum can cause higher serum uric acid levels and a gout-like illness [5]. Inhalation of molybdenum can cause lung irritation [6].

Effects from excessive exposure to molybdenum can cause symptoms similar to copper deficiency, and treatment with a copper supplement can reverse these symptoms. Wilson's disease, a condition in which the body stores excess amounts of copper, can also be treated with molybdenum to reduce the copper burden on the body. Molybdenum can also be used to treat other conditions associated with excessive copper [6].

Although molybdenum does not appear to cross the human placenta [6], animal studies have found adverse reproductive outcomes [5]. Although the IARC and the Environmental Protection Agency (EPA) have not yet classified molybdenum with respect to its ability to cause cancer, a study in mice found some evidence that molybdenum causes cancer. A study in workers exposed to molybdenum found a possible link with lung cancer, though there was little epidemiological data available [5].

Nickel

Nickel is a hard, silvery-white metal. It is naturally found in the environment combined with oxygen or sulfur as oxides or sulfides. Nickel is found in all soils and on the ocean floor and is emitted from volcanoes [7].

Most nickel is used for making stainless steel. Nickel is commonly combined with other metals such as iron, copper, chromium, and zinc to form alloys. These alloys are used in industrial processes to make valves and heat exchangers. They are also used for making metal coins and jewelry. Nickel compounds can also be used for nickel plating, to color ceramics, to make batteries, and as catalysts to increase the rate of chemical reactions [7].

Nickel is not mined in the US, but is obtained from recycling nickel-containing alloys or is imported from other countries. Nickel is released to the environment by industries that make or use nickel, nickel alloys, or nickel compounds. It is also released by oil-burning power plants, coal-burning power plants, and trash incinerators [7].

Nickel released into the air can stay in the air for several days. If it is attached to small particles, it can stay in the air for over a month. As it settles to the soil, it attaches to particles containing iron or manganese. Plants can take up and accumulate nickel, but it does not appear to accumulate in fish or small animals [7].

Most people are exposed to nickel through the foods they eat. Chocolate, soybeans, nuts, and oatmeal are naturally high in nickel. People can also be exposed to nickel by breathing air, drinking water, smoking tobacco, or coming into contact with substances containing nickel. Nickel can pass from a pregnant mother to her unborn child. It can also be passed from mother to child in breast milk; however, the benefits of breastfeeding far outweigh this risk [7].

The body absorbs more nickel from drinking water than from eating food containing the same amount of nickel. Nickel that gets into the body goes mainly to the kidneys, but can also go to other organs. Most of the nickel taken into the body in food is not absorbed and is eliminated quickly in the feces. The rest goes to the bloodstream and is eliminated in urine [7].

The most common health effect associated with exposure to nickel is an allergic reaction. About 10-20% of people are sensitive to metallic nickel, a condition that happens after direct and prolonged skin contact with nickel, such as by wearing jewelry containing nickel. After a person is sensitized to nickel, further contact with nickel may produce a skin rash at the contact site or at other parts of the body. People sensitized to nickel can also have a reaction after eating food, drinking water, or inhaling dust that contains nickel [7].

People that are not sensitive to nickel have to be exposed to large amounts of nickel for adverse health effects to occur. People who drank water containing 100,000 times more nickel than is typically found in water had stomach aches, increased red blood cells, and increased protein in the urine. Health effects reported in people working in nickel refineries or nickel-processing plants and breathing dust containing nickel compounds include chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus. People working in these types of facilities are typically exposed to much higher levels of nickel in the air than what is found in the environment [7].

The US Department of Health and Human Services (DHHS) has determined that nickel by itself may reasonably be considered to be a carcinogen and that nickel compounds are classified as known human carcinogens. The IARC has classified nickel in the same way in that nickel by itself may possibly be carcinogenic and some nickel compounds are carcinogenic. The EPA has determined that nickel containing refinery dust is a human carcinogen [7].

Animals exposed to nickel compounds had lung inflammation and damage to the nasal cavity. Animals that ate food or drank water that contained extremely high levels of nickel had lung disease and affected the stomach, blood, liver, kidneys, immune system, reproduction, and development [7].

Health effects in children exposed to nickel are expected to be similar to those seen in adults; however, we do not know if children are more susceptible to nickel. Although animal studies have shown increases in newborn deaths and decreases in newborn weight after exposure to high levels of nickel, human studies to determine if nickel harms the developing fetus are inconclusive [7].