Health Consultation

Barium Health Concern

COX ROAD DUMP SITE
DAYTON, LIBERTY COUNTY, TEXAS

EPA FACILITY ID: TXD987987179

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Prepared by

Texas Department of State Health Services
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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Purpose and Statement of Issues

On April 26, 2006, a concerned citizen contacted the Texas Commission on Environmental Quality (TCEQ) to inform them that her daughter and mother had barium present in their blood and that they were exhibiting "classic symptoms" of barium toxicity [1]. The citizen expressed a concern that the barium was related to barium in her drinking water [2] and might be related to the Cox Road Dump Site located near her residence. In response, the TCEQ sampled soil and drinking water from the citizen's home and from the public water supply system supplying the home. The TCEQ then contacted the Texas Department of State Health Services (DSHS) to request assistance addressing the citizen's health concerns (Note: Appendix A lists abbreviations and acronyms used in this report).

Background

Site Description and History

The Cox Road Dump Site (also known as Liberty Waste Disposal Landfill [3]) is an 80-acre, abandoned industrial waste dump/landfill located in Liberty County southwest of Dayton, Texas that was capped during the early 1980s [4]. The property is one mile north of Farm to Market Road (FM) 1413 along the west side of Cox Road. A county ditch which cuts north-south through the site carries runoff southward away from the site to the "Big Ditch" along FM 1413. The runoff is eventually carried east-southeast to the west prong of the Old River, a distance of approximately 2 miles [5]. The site has limited public access; a gate and warning signs have been installed on the east side of the property along Cox Road, however, people still can walk onto the site. Additional fencing around the site will be installed to further restrict access.

A health consultation for the Cox Road Dump Site was completed earlier this year [6]. The consultation, which included a full history of the site, concluded that the site posed no apparent public health hazard [6]. Contaminants found in residential surface soil were below detection or within ranges of levels that would be expected for this area of the United States and it was not likely that children or adults would consume ditch sediment and surface water at levels that would result in adverse health effects. Additionally, community members would not have sufficient exposures to on-site source waste to result in adverse health effects. Shallow groundwater did have elevated levels of some contaminants; however, there were no known uses of shallow groundwater in the area [6].

Health Concerns

The serum barium tests were conducted by the citizen's doctor because they live close to a hazardous waste dump site and because the daughter has "classical symptoms" of barium poisoning [2]. Tests results indicated 331 µg/L and 251 µg/L of barium in the citizen's mother's blood and daughter's blood, respectively [1]. On talking further with the citizen, her mother had a recent emergency colostomy for an obstruction in her sigmoid colon. We were unable to get a clear diagnosis with regard to the cause of the obstruction other than it was reportedly not due to a primary cancer or a metastasis [2]. Her daughter, who was 4 ½ years old, has had a persistent

problem with cramps and abdominal/stomach pains and frequent semi-formed to loose bowel movements, five or more times per day. She also indicated that one or both of them have had numbness in the legs [2].

The child is reportedly a finicky eater but eats a lot of chicken and pasta plus cooked vegetables such as green beans, corn, and peas [2]. The child has been drinking mostly bottled water for the past six months, but drinks some Kool-Aid and eats food prepared with tap water. Additionally, for several years the child has been restricted to indoor activities (very limited soil exposure) due to concern over the Cox Road Site. The citizen only allows her daughter to walk to/from the car. The mother of the citizen also does no outdoor activities, and they do not have a garden [2].

Environmental Sampling

As a part of the investigation into the citizen's health concern, soil and drinking water samples were collected from the citizen's residence and from the public water supply that supplies water to the residence [7, 8]. Two surface soil and one drinking water sample were collected from the residence and analyzed for metals. Four samples were collected from the public water supply systems and analyzed for metals, polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), and volatile organic compounds (VOCs).

For this consultation, DSHS relied on the information provided in the referenced documents and assumed adequate quality assurance/quality control (QA/QC) procedures were followed with regard to data collection, chain-of-custody, laboratory procedures, and data reporting.

Discussion

To assess the potential health risks that may be associated with the contaminants found in the residential soil and drinking water, we compared each contaminant detected with its respective health-based assessment comparison (HAC) value for non-cancer and cancer endpoints. These values are guidelines that specify levels of chemicals in specific environmental media (soil, air, and water) that are considered safe for human contact with respect to identified human endpoints. Non-cancer screening values are generally based on The Agency for Toxic Substances and Disease Registry's (ATSDR's) minimal risk levels (MRLs)[1] and EPA's reference doses (RfDs)[2]. Both of these are based on the assumption that there is an identifiable exposure threshold (both for the individual and for populations) below which there are no observable adverse effects. Thus, MRLs and RfDs are estimates of daily exposures to contaminants that are unlikely to cause adverse non-cancer health effects even if exposure occurs for a lifetime. The cancer risk comparison values used in this consultation are based on EPA's

[1] An MRL is a contaminant specific exposure dose below those which might cause adverse health effects in the people most sensitive to such chemical-induced effects. MRLs generally are based on the most sensitive chemical-induced end point considered to be of relevance to humans.

[2] An RfD is an estimate (with uncertainty spanning an order of magnitude) of a daily exposure to the human population (including sensitive groups) that is likely to be without appreciable risk of deleterious effects during a lifetime.

chemical-specific cancer slope factors (CSFs)[3]. Where available we also compared contaminants found in the drinking water to EPA's maximum contaminant levels (MCLs). The MCL is the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system.

Exceeding either a non-cancer or a cancer screening value does not necessarily mean that the contaminant will cause harm; however, it does suggest that potential exposure to the contaminant warrants further consideration. Factors that influence whether exposure to a contaminant could or would result in adverse health effects include: how much of the contaminant an individual is exposed to, how often and how long they are exposed, and the manner in which the contaminant enters or contacts the body. Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status all may influence how well the individual absorbs, distributes, metabolizes, and excretes the contaminant.

Public Health Implications

The only contaminant that exceeded a HAC value was arsenic which exceeded its Cancer Risk Evaluation Guide (CREG) both in soil samples and in one of the drinking water samples from the public water supply (Appendix B, Tables 1-3). It is important to note that the maximum concentration of arsenic detected in the water system was approximately five (5) times lower than the MCL for this contaminant and would not be expected to result in adverse health effects. Additionally, soil arsenic concentrations were within the range of normal background concentrations of arsenic for the area [9]. Due to the concern expressed about barium a brief review of barium toxicology is included below.

Barium

Barium is a naturally occurring element that is relatively abundant in the earth's crust and is found in most soils at concentrations ranging from about 15 to 3,500 mg/kg with mean values ranging between 265 and 835 mg/kg [10]. Barium also is present in a wide variety of food items including breads, peanut butter, cereals, pasta, fruits, vegetables, eggs, dairy products, and to a lesser extent meats, poultry, and fish at levels from 0.01 mg/kg up to 3 mg/kg [10]. The highest concentrations of barium in food have been noted in peanut butter and peanuts (2.9 mg/kg) and Brazil nuts (3-4 mg/kg) [10]. It also is present in many public drinking water supplies at an average level of 30 µg/L, but can be as high as 300 µg/L in some regions of the United Sates [10].

On-site source area samples obtained from the Cox Road Dump were found to contain an average barium level of 259 mg/kg (range 70.3-555 mg/kg) [6]. Drainage ditches within about a mile of the site were found to have an average barium level in sediment of 176 mg/kg (range 54.7-389 mg/kg) [6]. Residential soil samples from the neighborhoods near the site had an average barium level of 592 mg/kg (range: 62.9-5,080 mg/kg) [6]. However, elimination of the single outlier value of 5,080 mg/kg brings the average residential barium level down to 184

[3] A CSF is an estimate of excess lifetime risk of one cancer in one million (1×10^{-6}) exposed people and an exposure period of 70 years.

mg/kg (range 62.9-493 mg/kg) which is quite comparable to both on-site soil samples and off-site sediment samples [6]. Together, these data tend to imply that both the on-site and off-site barium measurements originate from normal background levels of this element in native soils in the area and not from dumping activities at the site.

We do not know how the single sample with 5,080 mg/kg came to be so much higher than all the other on- and off-site samples, but it could have come from any number of man-made sources. Barite (a mineral composed primarily of barium sulfate with occasional traces of strontium and calcium) is used extensively in the oil industry as a constituent in drilling muds [10, 11]. Barium also is used as a filler in many paints and other industrial coatings, plastics, rubber products, brake linings, and in some sealants and adhesives [10, 11]. Barium carbonate often is used as a rodenticide [10]. Barium sulfate is used extensively in the medical field as a contrast medium for diagnosing problems in the upper and lower GI tract [11]. In this setting, it is often ingested in quantities of 400 grams or more. Since barium sulfate is virtually insoluble (only approximately 2.46 mg will dissolve in a liter of water at 25 ºC [10]) it generally causes no problems on ingestion (except for occasional constipation) [10, 11]. However, some of the more soluble forms of barium, such as barium acetate, barium chloride, barium oxide, barium hydroxide, and barium carbonate can be very poisonous on ingestion [10].

At present, we do not know what specific compounds of barium are in the single neighborhood sample containing 5,080 mg/kg. In all probability, any remaining barium compounds would be very nearly insoluble since any soluble forms would have dissolved and been carried away long ago by the frequent rainfall and periodic flooding events characteristic to the area. Regardless, assuming that it is one of the more soluble forms of barium a 16 kg child ingesting 200 mg of soil per day, every day, would absorb a maximum of 0.06 mg/kg/day, a dose well below EPA's chronic oral RfD of 0.2 mg/kg/day. If the drinking water supply were found to contain barium at a well-above-average level of 100 µg/L, a 16 kg child drinking 1 liter of water per day would absorb an additional dose of approximately 0.006 mg/kg/day. Together with an average dietary contribution of 0.025 mg/kg/day for a 4-year old child and an average inhalation intake of 0.002 mg/kg/day, the a total intake is still less than half the RfD. With the child spending minimal time outdoors, exposure to soils from the single sample containing 5,080 mg/kg is unlikely. Also, with the child drinking limited amounts of water from the public water supply system, exposure to significant quantities of barium from this potential (but unverified) source also is unlikely.

The reported serum barium levels in the child and her grandmother of 251 and 331 µg/L respectively are both above what is considered by some to be the "normal range" of 30-200 µg/L [12, 13]. However, other sources have reported the "normal range" to be 30-290 µg/L [16] and 80-400 µg/L [14, 15]. Furthermore, while the reported levels may be somewhat above the "normal range," they are 4 to 15 times lower than the range that would be expected to produce significant clinical signs or symptoms of barium poisoning [12, 16].

Obstruction in the sigmoid colon is a rare complication of barium contrast studies in which several hundred grams of barium sulfate are administered by mouth or by enema and the barium is not fully expelled but instead forms a concretion in the gut causing an obstruction [17]. No history of such a contrast study was obtained for either the child or her grandmother. Crampy

abdominal pains and diarrhea are among the signs and symptoms reported in barium poisoning cases [10], but there are numerous infectious, systemic, and metabolic causes for these signs and symptoms (e.g., giardiasis, cryptosporidiosis, irritable bowel syndrome, gluten intolerance, lactose intolerance, ulcerative colitis, to name a few) and these should be evaluated by a well qualified pediatrician. Furthermore, the child's blood levels should have been much higher if there had been a one-time, point-source exposure (i.e., in the range of 1,500-3,000 µg/L) [12, 16] unless there was a delay of several weeks between the last reported symptoms and the drawing of the blood sample. In the case of this child, the symptoms are on-going, therefore the exposure would have to be on-going (at significantly higher levels than we can account for), and the blood levels should have remained above the 1,000 µg/L level. We are left with routine dietary and drinking water sources to explain this barium exposure with a slight possibility of an as-yet-undiscovered source of barium coming from within the house (for example, paints, sealants, adhesives, or rat poison).

Subsequent to the preceding exposure and risk estimates, samples were obtained from the citizen's residence and from the public drinking water supply. Results from these tests have shown that barium levels are well below the HAC values for both soil and water, and consequently, these media have been eliminated as significant sources of barium exposure for this family.

Child Health Considerations

In communities faced with air, water, or food contamination, children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. Sufficient exposure levels during critical growth stages can sustain permanent damage to the developing body systems of children. Children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

Previously, we evaluated the likelihood for children living in the vicinity of the Cox Road Dump Site to be exposed to site contaminants at levels of health concern. Currently, children are not likely to be exposed to contaminants from the site both because of its distance from residential areas as well as its limited access to the public. The drainage ditch, debris, and other materials hidden by tall vegetation could pose a physical hazard to small children if they were to trespass on the site; however, the likelihood of this occurring seems low.

Conclusions

1. Drinking water has been eliminated as a significant source of barium exposure for this family.
2. Samples from within the household did not show a significant barium exposure potential.
3. Except for a single neighborhood sample, on-site soil and off-site sediment barium levels appear to be in the normal background range.
4. Serum barium levels in this child and her grandmother vary from the "upper range of normal" up to "slightly elevated," depending on the chosen comparison population norms.
5. The serum barium levels reported are not high enough to expect clinical signs or symptoms of barium toxicity.
6. The borderline-elevated serum barium levels in this family most likely come from natural dietary sources; therefore, there is no apparent public health hazard from the Cox Road site.

Recommendations

1. The child should be on a well-balanced diet, high in fresh vegetables, fruits, whole grain products, lean meats, chicken, and fish and low in "fast food meals," fat, saturated fat, and cholesterol. Sugar, fruit juices, sugar-sweetened soft drinks, and cakes, cookies, and candy should be used in moderation.
2. If the child is still symptomatic, she should have a thorough work-up by a pediatrician to rule out infectious, systemic, and metabolic causes for her signs and symptoms.
3. Limiting outdoor activities does not seem warranted on the basis of the residential samples obtained, and children should have at least 30 minutes of out-door play activities daily (weather conditions permitting).
4. If the family still has concerns about their health, we would recommend having the child and grandmother retested to rule out laboratory error in blood test results.

Public Health Action Plan

Actions Completed

1. Staff from DSHS and TCEQ talked with the concerned citizen about the barium blood levels in her mother and daughter.
2. The TCEQ sampled soil and drinking water from the concerned citizen's residence and drinking water from the public water supply system that supplies the community where she lives.
3. The TCEQ and DSHS independently evaluated results from the soil and drinking water sampling and barium toxicology.

Actions Planned

1. The DSHS and ATSDR will continue to work with environmental agencies to address community concerns.
2. A copy of this document will be provided to the concerned citizen.

Authors, Technical Advisors, and Organizations

Report Prepared by
Carrie M. Bradford, MS, PhD
Toxicologist
DSHS Health Assessment & Toxicology Program

Richard Beauchamp, MD
Senior Medical Toxicologist
DSHS Health Assessment & Toxicology Program

Susan Prosperie, MS, RS
Manager
DSHS Exposure Assessment & Surveillance Group

John F. Villanacci, PhD, NREMT-1
Principal Investigator/Manager
DSHS Environmental & Injury Epidemiology and Toxicology Branch

Jennifer Lyke
Regional Representative
ATSDR Region 6

George Pettigrew, PE
Senior Regional Representative
ATSDR Region 6

Jeffrey Kellam
Environmental Health Scientist
Division of Health Assessment and Consultation
Superfund and Program Assessment Branch

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Certification

This public health consultation on Cox Road Dump Site, Barium Health Concern in Dayton, Liberty County, Texas was prepared by the Texas Department of State Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methods and procedures existing when the time the public health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, CAT, SPAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with its findings.

Team Lead, CAT, SPAB, DHAC, ATSDR

Appendix A: Acronyms and Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CREG	Cancer Risk Evaluation Guide
CSF	Cancer Slope Factor
DSHS	Texas Department of State Health Services
EMEG	Environmental Media Evaluation Guide
EPA	Environmental Protection Agency
FM	Farm to Market
HAC	Health-based Assessment Comparison
kg	kilograms
mg	milligrams
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
MCL	Maximum Contaminant Level
MRL	Minimal Risk Level
ND	Not Detected
µg/L	micrograms per liter
PCB	Polychlorinated Biphenyl
QA/QC	Quality Assurance/Quality Control
RfD	Reference Dose
RMEG	Reference Dose Media Evaluation Guide
SVOC	Semivolatile Organic Compound
TCEQ	Texas Commission on Environmental Quality
VOC	Volatile Organic Compound

Appendix B: Tables

Table 1. Concentrations of metals in soil samples collected at concerned citizen's residence [7]. All other contaminants were at levels below the detection limit.

Contaminant	Concentration (mg/kg)	# Detected/ # Samples Collected	# Samples that exceed HAC value	HAC value (mg/kg) *
Arsenic	1.39; 1.67	2/2	2	0.5 (CREG)
Barium	76; 83.5	2/2	0	10,000 (child RMEG)
Cadmium	ND; 0.04	1/2	0	10 (child chronic EMEG)
Chromium	5.57; 6.38	2/2	0	200 (child RMEG)
Lead	8.87; 10.2	2/2	0	400 (EPA action level)
Mercury	0.011; 0.015	2/2	0	20 (child chromic EMEG)
Selenium	0.80; 0.82	2/2	0	300 (child chronic EMEG)

Table 2. Concentrations of metals in water sample collected at concerned citizen's residence [7]. All other contaminants were at levels below the detection limit.

Contaminant	Concentration (µg/L)	# Detected/ # Samples Collected	# Samples that exceed HAC value	HAC value (µg/L) *
Barium	86.6	1/1	0	2,000 (child RMEG)
Cadmium	0.29	1/1	0	2 (child chronic EMEG)
Chromium	0.58	1/1	0	30 (child RMEG)
Lead	0.72	1/1	0	15 (EPA action level)

Table 3. Concentrations of metals in water samples collected from public water supply systems [8]. All other contaminants were at levels below the detection limit.

Contaminant	Concentration Range (µg/L)	# Detected/ # Samples Collected	# Samples that exceed HAC value	HAC value (µg/L) *
Arsenic	ND - 1.82	1/4	1	0.02 (CREG)
Barium	31.4 - 94.7	4/4	0	2,000 (child RMEG)
Cadmium	ND - 0.19	1/4	0	2 (child chronic EMEG)
Lead	0.32 - 2.92	4/4	0	15 (EPA action level)

* Most conservative HAC value
CREG – Cancer Risk Evaluation Guide
RMEG – Reference Dose Media Evaluation Guide
EMEG – Environmental Media Evaluation Guide
ND – Not Detected