HEALTH CONSULTATION

VERMICULITE NORTHWEST, INCORPORATED NORTH

SPOKANE, SPOKANE COUNTY, WASHINGTON

EPA FACILITY ID: WAN001002259

Prepared by:

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

Foreword: ATSDR's National Asbestos Exposure Review

Vermiculite was mined and processed in Libby, Montana, from the early 1920s until 1990. We now know that this vermiculite, which was shipped to many locations around the U.S. for processing, contained asbestos.

The National Asbestos Exposure Review (NAER) is a project of the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is working with other federal, state, and local environmental, and public health agencies to evaluate public health impacts at sites that processed Libby vermiculite.

The evaluations focus on the processing sites and on human health effects that might be associated with possible past or current exposures. They do not consider commercial or consumer use of the products of these facilities.

The sites that processed Libby vermiculite will be evaluated by (1) identifying ways people could have been exposed to asbestos in the past and ways that people could be exposed now and (2) determining whether the exposures represent a public health hazard. ATSDR will use the information gained from the site-specific investigations to recommend further public health actions as needed. Site evaluations are progressing in two phases:

Phase 1: ATSDR has selected 28 sites for the first phase of reviews on the basis of the following criteria:

The U.S. Environmental Protection Agency (EPA) mandated further action at the site based upon contamination in place

- or -

The site was an exfoliation facility that processed more than 100,000 tons of vermiculite ore from Libby mine. Exfoliation, a processing method in which ore is heated and "popped," is expected to have released more asbestos than other processing methods.

The following document is one of the site-specific health consultations ATSDR and its state health partners are developing for each of the 28 Phase I sites. A future report will summarize findings at the Phase 1sites and include recommendations for evaluating the more than 200 remaining sites nationwide that received Libby vermiculite.

Phase 2: ATSDR will continue to evaluate former Libby vermiculite processing sites in accordance with the findings and recommendations contained in the summary report. ATSDR will also identify further actions as necessary to protect public health.

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation with ATSDR. A part of the U.S. Department of Health and Human Services, ATSDR is the principal federal public health agency responsible for health issues related to hazardous waste. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. In general, health consultations focus on specific health issues so that DOH can respond to requests from concerned residents or agencies for health information on hazardous substances. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time of this health consultation, but they should not necessarily be relied on if land use or site conditions change in the future.

For additional information or questions regarding DOH or the contents of this health consultation, please call the health advisor who prepared this document:

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Glossary

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Ambient
Surrounding (for example, *ambient* air).

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Chronic
Occurring over a long time [compare with acute].

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or an injury that happens as a result of exposures that might have occurred in the past.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

EPA
United States Environmental Protection Agency.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Hazard
A source of potential harm from past, current, or future exposures.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Background and Statement of Issues

This health consultation evaluates the potential human health hazard posed by asbestos associated with vermiculite ore that was received from Libby, Montana, and processed at Vermiculite NW, Inc. (Vermiculite NW) in Spokane, Washington. DOH prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Vermiculite is a naturally occurring, flaky material with a variety of uses, including attic insulation, soil amendments, and fire-proofing material. Raw vermiculite contains water in its structure. When heated rapidly, the water flashes into steam, expanding the ore into accordion-like particles. This process, called *exfoliation*, expansion, or "popping," creates a lightweight material that is fire resistant, making it a useful home or building insulator.[1]

A series of reports, beginning November 1999 in the *Seattle Post-Intelligencer,* outlined the impacts of an asbestos contaminated vermiculite mine in Libby, Montana.[2] The Libby vermiculite mine operated from the early 1920s until 1990, and was last owned by the W.R. Grace Company. Unfortunately, the ore from Libby contained amphibole asbestos at levels as high as 26%.[3] Because mining and processing vermiculite is an extremely dusty task, miners and workers were exposed to high levels of asbestos-containing dust. Many of these workers developed asbestos-related lung diseases, including asbestosis, lung cancer, and mesothelioma.

ATSDR screened miners, mill workers, and people who had lived in Libby for at least six months prior to December 31, 1990. Results of the study indicated that 186 of the 365 (51%) former W.R Grace Company workers participating in medical tests and 1,186 of the 6,668 (18%) adult subjects who lived in the town had lung abnormalities.[4,5] The study determined that exposure to asbestos fibers was not restricted to the mine and processing facility, but also included people not employed by W.R. Grace.

Vermiculite ore was transported from Libby by rail all over the country to facilities where it was expanded and bagged for regional distribution. One such facility, Vermiculite NW, was located at 1318 N. Maple Street in Spokane, Washington. It operated for more than three decades until it was closed in 1974 (Figure 1).[6,7,8]

Site Description

The former Vermiculite NW expansion plant site comprises approximately 1.5 acres in an area with a mix of commercial and residential land uses. In general, housing is present directly to the north and south of the facility, with commercial properties situated to the east and west. The nearest housing to the south of the plant is about 40 meters away. Houses to the north are situated on a steep, 25-foot-high bluff about 100 meters from the former plant. Historical aerial photographs show that little has changed since the 1950s with regard to land use in the area surrounding the former vermiculite expansion facility (Figure 2).

The site is currently owned by Spokane County, and a chain link fence around the perimeter restricts access. The building that housed the vermiculite expansion furnace was razed in the mid-1990s, and other warehouse buildings were demolished in November of 2002. The only remaining building from the Vermiculite NW facility is a small structure once used as office space. This building has been recently vacated and sits outside the fenced area.

Site Operations and History

The facility was equipped with a vermiculite furnace that expanded vermiculite ore (average density = 55 lbs/ft^3), producing a lightweight material (density ~7 lbs/ft^3) with a variety of uses.[9] According to a former employee who worked at Vermiculite NW in the 1960s, the process was a dusty one.

The facility received ore from Libby, Montana, in railcars via a railroad spur that ran parallel to the north side of the building. The ore from the railroad cars was unloaded into six storage bins, each with a capacity of 60 tons (~2200 ft^3), for a total storage capacity of 360 tons.[a, 10] Ore from the storage bins was transferred into a hopper before being directed to a conveyor belt that fed the furnace at a rate of about one ton per hour. The vermiculite ore stayed in the furnace for about eight seconds and was subjected to temperatures over 1000° F until it expanded ("popped"). Fans blew the expanded vermiculite through a chute, onto an elevator, and finally onto a vibrating screen that separated the expanded ore from unexpanded ore (commonly referred to as "stoner rock"). Expanded vermiculite was cooled, fed into a hopper, and funneled into open bags.

Workers held the bags at the end of the chute and pulled a tongue in the chute to allow vermiculite to fall into the bag. Once the bag was full, a worker pushed back the tongue, stopping the flow of vermiculite. The bag was then removed and sewn shut. Workers wore broad-brimmed hats to keep dust from falling on their faces. Dust accumulated on the floors, which were swept about every two hours. In general, workers did not wear respiratory protection.

Stoner rock and other by-products were piled on the south side of the facility (Figure 3) for disposal at undisclosed locations. A former worker reported that people carted this waste off for use in their yards. One employee transported the waste rock 15 miles north to his home in Chattaroy, Washington, for use as fill in his driveway, yard, and garden.

The facility also had a mixer on site, which combined expanded vermiculite with a variety of other materials, depending on the type of product being made. Other materials included sphagnum, fertilizers, gypsum, bentonite, wood pulp, and asbestos. Chrysotile asbestos was

[a] Records from WR Grace do not reveal the overall amount of ore the facility received from Libby over its operating life, but a rough estimate is possible on the basis of the amount of bagged vermiculite the facility produced. In 1972, 175,000 bags of vermiculite were produced, and each bag held 4 cubic feet of expanded vermiculite weighing approximately 28 lbs. This level of production would require at least 2450 tons of ore per year. This is an underestimate as it does not account for "stoner rock" and other inefficiencies in the process.

mixed with vermiculite to produce acoustic plaster, further contributing to the amount of asbestos dust associated with the facility.[11]

Environmental Samples

Indoor air samples were taken from the facility on two separate occasions in the early 1970s. The first event consisted of three samples, all of which exceeded the permissible exposure limit (PEL) of 0.1 fiber per cubic centimeter (f/cc) with one sample exceeding the then-current PEL of 5 f/cc[12] This event prompted a follow-up inspection by the Washington State Department of Labor and Industries. The inspector noted a dusty work environment with inadequate ventilation. Air samples from within the facility revealed asbestos fiber concentrations that ranged from 6.1 to 50 f/cc.[13] All samples were above regulatory levels (Appendix B). One Vermiculite NW worker, himself diagnosed with asbestosis, spoke of other former workers who have died because of lung disease. Newspaper articles have also reported that Vermiculite NW workers may have developed respiratory disease, with one dying of mesothelioma 36 years after working at the Spokane plant for only 23 months.[14],[15]

No record of stack emission testing is available, so how much asbestos was emitted from the facility is uncertain. A former employee recalled a stack which, he estimated, rose 10 ft above the roof. He reported seeing dust coming from the stack and blowing in the direction of nearby homes. Some neighborhood residents also recalled dust blowing from the site. Others have claimed that dust came not from Vermiculite NW, but instead from the cement vault company located to the east of the site. Still others did not recall seeing any dust at all.

Eight soil and dust samples were collected from the site on April 27, 2000 (Figure 4). Six of these samples detected asbestos in concentrations ranging from trace amounts to 2%.[16] Two different methods, Polarized Light Microscopy (PLM) and Transmission Electron Microscopy (TEM), were used to analyze the samples with varying results. Follow-up samples were taken September 5, 2001.[17] Thirteen samples came from the site, 12 samples from nearby neighborhood yards, and 2 came from the previously-mentioned residence in Chattaroy, Washington, that reportedly had stoner rock from Vermiculite NW in the driveway and garden (Table B2). On-site sample results ranged from non-detect (ND)–3% asbestos. Off-site samples revealed a few locations with trace levels of asbestos in soil, including two samples from Chattaroy (Appendix B, Table B2).

It should be noted that much of the site is covered with loose gravel, asphalt, and fill while other areas of the site show accumulations of cement dust. Therefore, soil samples taken from the surface may not be representative of what lies a few inches below the surface: EPA investigators reported seeing layers of vermiculite 7–14 inches below the current ground surface.[18] Subsurface samples were not collected at this site.

Asbestos Analysis

Asbestos is the broad name given to a group of fibrous minerals that occur naturally in the environment. It is found in deposits or as contaminants in other minerals. The properties that make asbestos commercially viable are its high tensile strength, ability to be woven, heat resistance, and resistance to attack by acid or alkali. EPA banned most asbestos containing products in 1989 in response to public health concerns, but much of the rule was remanded by the U.S. Fifth Circuit Court of Appeals in 1991.[19] Current uses of asbestos include roofing products, gaskets, and friction products (brake linings, clutch facings).[20]

Asbestos occurs in two mineralogical forms: serpentine and amphibole. Chrysotile belongs to the serpentine family, and is the most common asbestiform used commercially. Chrysotile fibers are curved and flexible. Amphiboles are rod or needle shaped and very brittle, and some evidence indicates that they may be more toxic than serpentine forms. The fibers found in Libby vermiculite belong to the amphibole family.

Legally, asbestos *fibers* are defined as particles with a length-to-width ratio of ≥3:1 and which are longer than 5 μm. Concentrations in air are reported as fibers per cubic centimeter; asbestos content in bulk materials is reported as a percentage. Asbestos can be detected in air or bulk materials using light and electron microscopy.

The National Institute for Occupational Safety and Health's (NIOSH) method 7400 uses phase contrast microscopy (PCM) to determine airborne fibers in the workplace. This method cannot distinguish asbestos from fiberglass, cellulose or other fiber types. Therefore, it is useful only when the main source of dust is expected to be asbestos, and not in situations where asbestos fibers are mixed with other fiber types.[21] In addition, PCM may not detect very thin fibers. As a result of these limitations, a PCM count can be biased high if fibers other than asbestos are present, or low if thin asbestos fibers are present.

Polarized light microscopy (PLM) is the EPA accepted screening method for asbestos in bulk samples. The main purpose of the PLM analysis is to determine if asbestos exists in a medium. The limit of detection for this method is typically 0.25-1% asbestos. PLM uses polarized light to compare refractive indices of minerals and can distinguish between asbestos and non-asbestos fibers and between different types of asbestos. The method fails, however, in samples where asbestos fibers are fine or obscured by a tightly binding matrix.

Transmission Electron Microscopy (TEM) can also analyze for asbestos in air and bulk samples. Light microscopy can detect particles only down to a diameter of about 0.3 µm. Many asbestos fibers have smaller diameters than this and are thus invisible to a light microscope. TEM uses electron diffraction and energy-dispersive x-ray methods, which give information on crystal structure and elemental composition, respectively. This information can help determine the elemental composition of the visualized fibers. One disadvantage of TEM is that it has difficulty determining asbestos concentration in soils and other bulk materials. Advantages of using TEM are that it can detect smaller fibers than PCM or PLM and can also determine the fiber type.[22]

When soil asbestos concentrations are low, the number of grids that are examined for a given sample can limit the accuracy of the TEM method. If the laboratory analyst does not count enough grids, the sample results will likely be inaccurate. In general the TEM approach is more tedious and time consuming – and therefore more costly – than PLM, but it provides the best approach for fiber identification and quantification at low sample concentrations.

Health Effects

The main concern with respect to asbestos exposure is the inhalation of asbestos fibers. Ingestion of asbestos poses little or no risk of non-cancer effects. However, some evidence shows that acute oral exposure might induce precursor lesions of colon cancer, and that chronic oral exposure might lead to an increased risk of gastrointestinal tumors. [22]

In general, inhaled asbestos fibers wider than 3 µm lodge in upper airways, and narrower ones can reach deeper into the lung and alveolar region. Exposure to long, thin, needle-like fibers is of the most concern because these fibers can reach the lower airways and become embedded in the lung tissue, where they may remain for the remainder of the person's life. Repeat exposure to asbestos in air has been shown to cause lung disease, including asbestosis, lung cancer, and mesothelioma.[23] Some reports have suggested that amphibole asbestos is more toxic than chrysotile asbestos, mainly because of physical characteristics of the fibers that allow chrysotile to be broken down and cleared from the lung, whereas amphibole is not removed and builds up to high levels in lung tissue. Some researchers believe that the resulting increased duration of exposure to amphibole asbestos significantly increases the risk of mesothelioma and, to a lesser extent, asbestosis and lung cancer. However, EPA's current risk models consider asbestos toxicity to be independent of size and mineralogy, and the Occupational Safety and Health Administration (OSHA) continues to regulate chrysotile and amphibole asbestos as one substance, as both types increase the risk of disease.

The lack of exposure information distinguishing the different fiber types limits evidence suggesting that the different types of asbestos fibers vary in carcinogenic potency. Other data indicate that differences in fiber-size distribution and other process differences can impact toxicity as much as, or more than, fiber type.[22]

Asbestosis

Asbestosis is caused by inhalation of asbestos fibers. Asbestos fibers in the lungs cause irritation and inflammation. The body attempts to neutralize these foreign fibers with phagocytes, a type of white blood cell that engulfs and absorbs waste material, harmful microorganisms, or other foreign bodies in the blood stream and tissues. The phagocytes are unable to remove all of the asbestos fibers, however, and instead actually help to inflame tissues. Eventually a scar tissue or fibrosis develops in the spaces around the small airways and alveoli. This thickening and scarring prevents oxygen and carbon dioxide moving to and from the blood, so breathing becomes much less efficient. The specific asbestos fiber type (amphibole or serpentine) to which the worker was exposed does not seem to be significant in the development of asbestosis, but some research suggests that longer fibers appear to be more potent than short fibers in causing asbestosis.[22] People with asbestosis are at additional high risk of developing lung cancer or mesothelioma.[22]

Other non-cancer effects include *pleural plaques*, localized or diffuse areas of thickening of the lung lining (pleura); *pleural thickening*, extensive thickening of the pleura, which restricts breathing; *pleural calcification*, the depositing of calcium in pleural areas, which is thickened by chronic inflammation and scarring; and *pleural effusions*, fluid buildup in the pleural space between the lungs and the chest cavity.[22]

Lung Cancer

Much evidence suggests that asbestos exposure contributes to lung cancer. The risk of developing lung cancer is much greater for those with significant exposure (usually at work) to asbestos, as compared to the general population. A long period of time—often as long as 30 years—can pass between asbestos exposure and the development of lung cancer. In addition, the combination of tobacco smoking and asbestos exposure further increases the risk of developing lung cancer far beyond the risk associated with separate exposures. In fact, the risk of lung cancer from combined exposure is greater than both factors added together.[22]

Pleural Mesothelioma

Pleural mesothelioma is a cancer of the cells that make up the pleura, or lining around the outside of the lungs and inside the ribs. It is an extremely rare disease with an incidence rate of one new case per 100,000 people per year, or about 2,000 to 3,000 new cases per year in the United States. The incidence rate of lung cancer in the United States, by comparison, is about 65 times greater. The primary factor associated with mesothelioma is previous exposure to asbestos fibers.[b] Amphibole fibers, such as those associated with Libby vermiculite, are thought to be more potent than serpentine fibers with regard to inducing mesothelioma.[22] Mesothelioma is a terminal disease. Fewer than half of the patients survive longer than seven months after diagnosis.

Discussion

The vermiculite originating from a mine in Libby, Montana, was contaminated with asbestos. Studies conducted in the Libby community indicate health impacts that are associated with asbestos exposure. The findings at Libby provided the impetus for investigating processing sites, including the Vermiculite NW site in Spokane, Washington, and other sites across the nation that received vermiculite from the Libby mine.

[b] In some cases, pleural mesothelioma has occurred in people with no known asbestos exposure. There is likely to be a baseline incidence of mesothelioma around the world that is not attributable to asbestos exposure, just as there may be other factors that contribute to inducing mesothelioma.

It is important to recognize, however, that the asbestos exposures documented in the Libby community are in many ways unique and will not necessarily be present at other sites that processed or handled Libby vermiculite. The site investigation at Vermiculite NW is part of a national effort to identify and evaluate potential asbestos exposures that may be expected at these other sites.

The exfoliation, or popping, of vermiculite ore at Vermiculite NW released significant amounts of asbestos fibers inside the facility and vented contaminated asbestos dust outside that may have been carried into the nearby neighborhood. On-site soil samples revealed detectable levels of asbestos, and off-site samples showed trace levels of asbestos. The following discussion will address past, current and future exposure pathways and health hazards associated with the asbestos released from Vermiculite NW.

An exposure pathway is the means by which an individual is exposed to contaminants. It consists of the following five elements: 1) a *source* of contamination; 2) a *medium,* such as air or soil, through which the contaminant is transported; 3) a *point of exposure* where people can contact the contaminant; 4) a *route of exposure* by which the contaminant enters or contacts the body; and 5) a *receptor population*. A pathway is considered complete only if all five elements are present and connected. A pathway is considered potential if the pathway elements are (or were) likely present, but insufficient information is available to confirm or characterize the pathway elements. A pathway may also be considered potential if it is currently missing one or more of the pathway elements, but the element(s) could easily be present at some point in time. An incomplete pathway is missing one or more of the pathway elements and it is likely that the elements were never present and not likely to be present at a later point in time. An eliminated pathway was a potential or completed pathway in the past, but has had one or more of the pathway elements removed to prevent present and future exposures.

On the basis of information from Libby and facilities that processed vermiculite ore from Libby, we have developed a list of possible exposure pathways for vermiculite processing facilities. All pathways have a common source—vermiculite from Libby contaminated with amphibole asbestos—and a common route of exposure—inhalation. Although asbestos ingestion and dermal exposure pathways could exist, health risks from these pathways will not be evaluated because they are minor compared to those resulting from inhalation exposure to asbestos.

The exposure pathways considered for the Vermiculite NW site are listed in Appendix A, Table A1. Not every pathway identified for the Vermiculite NW site is a significant source of exposure. In general, the main pathways are past inhalation of fibers by former workers and nearby residents and current and future inhalation of fibers from re-suspended dust and soil by residents and on-site workers. Table A2 shows the pathways that are evaluated in the following paragraphs.

Past Exposures

On-Site Occupational Exposure

The conditions inside the operating vermiculite facility were extremely dusty, and workers were exposed to asbestos in air that exceeded current occupational standards. All indoor air samples taken in 1972 and 1973 exceeded the current OSHA PEL by 4 to 500 times. Furthermore, news articles and anecdotal information from former employees make it clear that employees were exposed to asbestos fibers and that some developed disease later in life. A case study of a worker in a California vermiculite expansion plant provides additional evidence of the severity of conditions in facilities like Vermiculite NW. The worker developed fatal asbestosis 50 years after working in the plant for only two summers.[23]

Waste Piles

Determining past non-occupational exposures is difficult because no air samples were taken outside the facility. Neighbors who lived near the site before the plant closed in 1974 report that children would jump from the roof into piles of vermiculite ore on the north side of the facility. Air samples near piles of stoner rock taken for a study in Minnesota revealed asbestos fiber concentrations in air to be 13.5 f/cc.[24] If the asbestos levels were similar at the Spokane plant, these children were potentially exposed to high levels of asbestos in air.

Residential Indoor and Outdoor

Although anecdotal evidence from a former worker suggests stoner rock from the Spokane site was used by some community members in the past, the extent of this practice is not known. Stoner rock that was transported off-site for community use may have resulted in asbestos exposures in the yard, and perhaps in the home through inhalation of dust tracked indoors. Some yards near Western Mineral Products vermiculite expansion facility in Minnesota, where stoner rock was used as fill, had asbestos levels in soil as high as 10%.[24] The stoner rock was also commonly used in gardens and as a surfacing material for driveways.

Emissions from the facility could have deposited asbestos in nearby yards or homes, further exposing residents through inhalation of re-suspended dust. No information on levels of contamination in house dust exists to eliminate or confirm this possibility, but trace levels of asbestos detected in off-site soil indicate that asbestos fibers traveled off-site by some means.

Household contact

One Vermiculite NW worker who lived near the facility stated that his clothes were so dusty after work that he would beat the dust off his clothing as he walked home. This example demonstrates how workers could have inadvertently brought asbestos containing dust home in their clothing or hair, potentially exposing their family members or other household contacts. Case studies of asbestos workers and their household contacts have shown that this pathway is potentially significant. ATSDR investigations in Libby, Montana, have also demonstrated a higher risk for worker's household contacts than for the general population.

Ambient Air

Because the facility operated before the implementation of strict air pollution control regulations, it did not have sophisticated pollution control devices. The vent system on the vermiculite expansion furnace used a low-velocity cyclone as its primary pollution control device and a high-velocity cyclone as its secondary control device.[9] A former worker reported that an exhaust duct with a width of about 12-16 inches protruded 10 ft from the roof, but no emission testing was conducted during plant operation. The lack of stack or ambient air testing complicates any estimation of asbestos exposure to residents living near the facility. Asbestos emitted in air from the facility could, however, have impacted nearby residents, and air dispersion modeling can estimate asbestos concentrations in air in the adjacent neighborhood. Because of the lack of testing, more data is needed from W.R. Grace records or former worker contacts before ambient exposures can be estimated through modeling.

Current and Future Exposures

On-site Soil

The vermiculite expansion facility ceased operation in 1974, but detectable amounts of asbestos remain in on-site and nearby soils. Asbestos fibers do not easily break down in the environment and will remain in soil for many years. Wind, vehicle traffic, construction, or other activities may cause renewed or continued exposure by disturbing soil and re-suspend asbestos particles. This potential prompted EPA researchers to conduct experiments with on-site soil in order to determine if asbestos could be re-suspended in significant quantities.

Researchers conducted the initial experiments in a laboratory setting with the soil from the site placed in a small glove box. The glove box was used to prevent dust from and asbestos from being spread through out the laboratory, while providing researchers the ability to agitate the soil. Bulk soil asbestos levels were not measured before the samples were placed in the box, but samples from earlier sampling events showed asbestos levels that ranged from non-detect to 3%. Researchers collected air samples while the soil was manipulated to mimic activities that might re-suspend asbestos fibers. Using TEM, researchers found asbestos fibers at levels as high as 9.4 f/cc.[25] In addition, they also found winchite fibers (an unregulated amphibole type) at levels as high as 4.4 f/cc. In comparison, background asbestos levels in air range from 0.00001 f/cc in rural air samples to 0.0001 f/cc in urban air. As noted, the current occupational PEL for asbestos is 0.1 f/cc. The results of the glove box experiments suggested that asbestos fibers could potentially be re-suspended at levels that are of health concern. Because these experiments occurred in a laboratory setting, however, whether normal activities could create a similar exposure scenario remains unclear.

In order to better understand how re-suspension of dust could cause exposure, EPA conducted another round of sampling on the site in October 2002 during activities such as leaf blowing and trench digging. Although this sampling event was limited in scope, results indicated that asbestos fibers on site were re-suspended, however, at much lower levels than found during the glove box experiments. PCM analysis detected asbestos at a maximum of 0.25 f/cc which exceeds the occupational PEL of 0.1 f/cc, while TEM results did not exceed 0.045 f/cc. In general, asbestos fiber counts were higher at on-site locations versus those on top of the bluff off-site. Furthermore, asbestos fibers were either not detected, or were detected at much lower levels when TEM was used to corroborate the PCM analysis. This difference illustrates that PCM analysis of a re-suspended soil medium may produce results that are higher than reality.

Also of note is that more dust and asbestos may have been re-suspended had the experiment been conducted in the middle of summer versus the fall, when wetter soil may prevent dust re-suspension. At the time of the air sampling, the soil was moist a few inches below the surface Furthermore, redevelopment of the site is likely to expose a larger area of bare soil, which may also contribute to higher levels of re-suspended dust and asbestos through wind and vehicle traffic.

Spokane County took precautions to minimize re-suspension of dust on the site during demolition of on-site warehouse buildings in the fall of 2002.[26] The site itself was covered, and the building materials were covered with a slurry that kept the dust down. A large HEPA (high-efficiency particulate air) vacuum mounted on a truck vacuumed the ground beneath the structures. The land is now vacant, so current land use is not likely to disturb soil. Access is also restricted by a perimeter fence, thereby limiting the possibility of current exposures.

Future land use at the site could uncover buried or covered asbestos hot spots on the site. Spokane County, the current owner of the property, has recently demolished the remaining structures on the site, and eventually plans to sell it or convert it to a useful piece of land. The potential for disturbing unknown quantities of asbestos in on-site soil would exist if redevelopment does occur. EPA investigators have stated that some evidence exists that fill dirt has been placed on the site since 1974. Asphalt has also been placed over some areas on the site, including the area where former workers reported that waste rock was piled. Disturbing these top layers of soil or destroying asphalt and concrete on the site may uncover more highly contaminated soils and cause asbestos fibers in the soil to become airborne. Workers in these situations will be in close contact with the soil and possibly exposed to hazardous levels of asbestos in air.

Spokane County has agreed to clean the site through the Washington State Department of Ecology's (Ecology) voluntary cleanup program. This program allows the landowner to clean up the site with input and oversight from Ecology. In a recent letter from EPA to Spokane County, EPA reported that they "will seek to assure protection of public health and the environment through the elimination of any pathways for the release or threatened release of asbestos into the environment. In order to minimize potential exposure to asbestos in soil, there will likely be a combination of protection measures such as soil excavation and replacement, physical barriers, and land use controls".[27] Proper oversight from EPA and Ecology can effectively minimize future worker and nearby resident's asbestos exposures related to the site.

Residential Outdoor and Indoor

Residential soil showed trace levels of asbestos, so it appears that asbestos fibers can be re-suspended in residential areas near the site, or tracked into the home to be re-suspended with house dust. The levels of asbestos in air remain uncertain, but levels would likely be less than what was found in EPA sampling through actively disturbing on-site soil. Asbestos levels in soil are less in the neighborhood than on-site; furthermore, most yards have grass and vegetation, which minimizes disturbance of the soil.

Child Health Considerations

DOH and ATSDR recognize that infants and children are often more vulnerable to exposures than adults in communities faced with environmental contamination. Because children depend completely on adults for risk identification and management decisions, DOH and ATSDR are committed to evaluating children's special interests at the site.

The effects of asbestos on children are thought to be similar to the effects on adults. However, children could be especially vulnerable to asbestos exposures because they are more likely to disturb fiber-laden soils or indoor dust while playing. Children also breathe air that is closer to the ground and may thus be more likely to inhale airborne fibers from contaminated soils or dust.

Furthermore, children who are exposed could be more at risk of actually developing asbestos-related disease than people exposed later in life because of the long latency period between exposure and onset of asbestos-related respiratory disease.

In the case of Vermiculite NW, children were likely to have been exposed to asbestos in the past in air while playing on piles of ore, inhaling ambient air, and inhaling re-suspended asbestos fibers in soil or house dust. These exposure pathways, however, cannot be quantitatively evaluated. Current exposures to children are probably not significant because access at the site is restricted, but the amount of residual asbestos fibers in household soil and dust near the facility is unknown. Very low levels of asbestos in yard soils near the former facility are likely, but the level to which children are exposed is likely to be less than the levels generated by EPA investigators using equipment to disturb soil on the site.

Conclusions

1. Vermiculite NW received and processed amphibole asbestos-contaminated vermiculite ore from Libby, Montana from the 1940s until 1974. Air samples from the interior of the facility while it was operating showed high levels of asbestos fibers in air. Recent soil samples revealed residual asbestos fibers on site and trace amounts in the yards of some nearby residences.

2. A *public health hazard* existed for former workers in the Vermiculite NW facility. Asbestos concentrations in air were measured as high as 500 times the current occupational PEL. Some workers from the facility have since been diagnosed with asbestos related lung disease.

3. An *indeterminate health hazard* existed for household contacts of workers who might have brought asbestos contaminated dust into their homes. ATSDR investigations of various populations exposed to asbestos contaminated vermiculite in Libby, Montana indicate increased risk for workers' household contacts compared to those exposed through non-occupational scenarios or to background levels.

4. An *indeterminate health hazard* existed for children who may have played on ore and stoner rock piles in the past. It is not known how long or how frequently children played on these piles. Air samples taken near similar piles in Minnesota revealed high levels of asbestos.

5. An *indeterminate health hazard* existed for people that lived near the facility while vermiculite was processed there (estimate 1940s to 1974). The community around the site could have been exposed to asbestos fibers from plant emissions, from waste rock brought home for personal use, or from indoor household dust that contained asbestos from one or more outside sources. Insufficient information is available to determine if these exposures occurred, how often they may have occurred, or what concentrations of airborne asbestos may have been present during potential exposures. This information may never be available.

6. The Vermiculite NW facility no longer processes vermiculite at the site and no evidence of onsite waste piles were observed during a recent site visit. The pathways for current or future community exposure to airborne Libby asbestos from facility emissions and to onsite waste piles have been eliminated and pose *no public health hazard*.

   Individuals within the community could be exposed to asbestos from vermiculite waste rock used as fill material, for gardening, or for paving driveways. This current and future exposure pathway is *an indeterminate public health hazard* because insufficient information is available to determine if waste material from the facility was used within the community.

7. An *indeterminate health hazard* exists for current and future on-site workers involved in site remediation or redevelopment. On-site air samples taken while soil was being disturbed revealed that some asbestos fibers can become airborne. The amount of fibers in the air, though low, may be at levels of concern under other conditions that involve both excavation and disturbance.

Recommendations/Action Plan

1. DOH and ATSDR will evaluate the feasibility of identifying former workers and their household contacts. Follow-up activities may include evaluating health effects, providing educational materials, and interviewing community members to obtain additional site-related information pertaining to waste disposal practices, industrial hygiene practices, and other facility operations relevant to past exposure pathway analysis.

2. DOH and ATSDR are conducting a screening level health statistics review in order to determine the incidence of asbestos-related disease in the Spokane area.

3. DOH and ATSDR will develop health educational materials for exposed populations, including information that encourages smoking cessation and annual influenza vaccinations.

4. DOH and ATSDR will develop educational materials that target health care providers to promote an awareness of the potential exposure pathways, potentially exposed populations, and symptoms of diseases associated with Libby asbestos. The agencies will disseminate information through professional organizations as well as local and community healthcare networks.

5. DOH will evaluate the feasibility of obtaining historical information from W.R Grace records regarding the facility's operating specifications to obtain parameters for an air dispersion model.

6. DOH will ensure that information concerning the history of the site is available to local health officials and other city/county officials and property development authorities to increase awareness for future land use changes and/or redevelopment activities.

7. EPA, Ecology, Spokane County and DOH will develop plans to limit worker and resident exposures that may result from land use changes or redevelopment at the site. Spokane County is currently working with EPA and Ecology to clean the site and minimize workers' and nearby residents' exposure to asbestos during the cleanup process.

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