Health Consultation

Dupont DeLisle Plant

(a/k/a DuPont E I De Nemours and Company, Incorporated)

Pass Christian, Harrison County, Mississippi

EPA FACILITY ID MSD096046792

Prepared by

U. S. Department of Health and Human Services

Agency for Toxic Substances and Disease Registry

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Background and Statement of Issues

A DeLisle, Mississippi, community member petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to investigate the DuPont DeLisle Titanium Dioxide plant. ATSDR has prepared this health consultation to address public health concerns about groundwater in the DeLisle community.

History and Demographics

The DuPont White Pigment and Mineral Products Plant, located in DeLisle, Mississippi, produces titanium dioxide. In operation since 1979, the plant is located on the north shore of the Bay of St. Louis, 15 miles west of Gulfport, Mississippi [1]. Although the plant site comprises 2400 acres, the plant itself only covers 200 acres (see site map, Figure 1, Appendix A). The town of Pass Christian is near the plant, directly across the Bay of St. Louis. DeLisle is an unincorporated community located due east of the DuPont facility. A daycare, a headstart school, and an elementary school are in the DeLisle community. Demographic statistics, based on 2000 U.S. Census data, are presented in Figure 1, Appendix A.

Petitioner and Community Concerns

ATSDR staff have visited the DeLisle community multiple times. They have discussed the site with the petitioner, with former plant workers, and with local physicians. The petitioner and the former workers expressed concerns about possible neurological symptoms related to the plant's operations. During July 2002, ATSDR staff held two public meetings, visited the Dupont site, met with the petitioner, and examined the surrounding area. During the public meeting and discussions with community members, ATSDR received the following comments and health concerns regarding the DuPont facility:

- elevated metals in hair samples from residents around the plant,
- possible contamination of the drinking water and St. Louis Bay by DuPont's underground injection wells,
- reported releases of dioxin congeners from the plant as reported from EPA's toxic release inventory report,
- cancer deaths in adults and children (different persons have expressed concerns about different types of cancer—breast, ovary, liver, kidney, gastrointestinal, childhood leukemia),
- fibromyalgias,
- neurologic/psychiatric problems (ALS, memory loss, depression, impotence),
- birth defects, and
- chronic sinusitis.

Some community members also expressed concerns that chemical releases, as reported on EPA's Toxic Release Inventory, from the DuPont plant could have contaminated the community's water and air. They did not, however, have any specific health complaints. One resident had undergone hair analysis and, because of manganese levels found in the hair, was chelated by a physician seven times. According to the petitioner, a number of residents have undergone hair analysis and believe that they have been exposed to metals through contaminated groundwater.

Environmental Data Submitted

ATSDR has obtained drinking water sampling data from several sources. These data sets provide information regarding the drinking water quality of the DeLisle area. The wells monitored vary in depth and represent a cross section of aquifers available for drinking water use in the DeLisle area.

Mississippi Department of Health

During the fall of 2000, the Mississippi Department of Health (MSDOH) tested DeLisle area groundwater, sampling nine area wells. Chains of custody were submitted with the samples, but without quality control information, detection limits, and analytic methods. Because the Mississippi Department of Health Laboratory routinely performs water quality analysis for the state under the Safe Drinking Water Act, ATSDR assumed appropriate quality assurance and control procedures were followed. The chemicals tested for and the results of the MSDOH testing are shown in Table 1, Appendix B.

DuPont Periodic Monitoring

As a requirement of its underground injection permit, DuPont collects groundwater samples quarterly from four plant wells and annually from six area community wells. The plant wells supply the process water for the plant and the drinking water for the workers. The community wells are DeLisle Elementary School (N286), Northwest corner of Market Street and North Street - Pass Christian (N327), 523 Bayview Avenue – Pass Christian (06), 126 St. Charles Street – Bay St. Louis (K4), Diamondhead (G153), and 106 Harvey Street – Bay St. Louis (K456). ATSDR obtained monitoring data from these tests from 1997 through 2002. DuPont specifically monitors for lead, cadmium, chromium, iron, mercury and vanadium. DuPont’s samples were analyzed internally at a DuPont laboratory. Samples were analyzed by atomic absorption using a modified method based on Standard Methods for Examination of Water and Waste; 18th Ed. Methods for Chemical Analysis of Water and Wastes; 03/83, ASTM, and EPA SW846. A summary of the DuPont testing results are shown on Table 2, Appendix B.

Sample Results submitted by a Resident

A resident submitted test results obtained at various locations in the DeLisle area. These samples were collected during the fall of 2000. Among the samples were spigot filter analytic results, surface water samples, hair analysis results, and tap water samples. Because of reasons further discussed in detail below, ATSDR did not consider the hair analysis results in this health consultation. ATSDR could not utilize the four spigot filter samples—a concentration could not be determined without knowing the volume of water that was filtered. Some samples submitted were of surface waters in the DeLisle area and were likewise not considered; this water is brackish and would not normally be consumed for drinking purposes. ATSDR reviewed the tap water testing results where complete chain of custody was submitted with the results and the method used to analyze the results was reported. The resident also reported to ATSDR that he used laboratory-supplied collection bottles and followed laboratory instructions regarding the collection and stabilization of the samples. Samples were analyzed at Environmental Science Corp. (Mt. Juliet, TN). ATSDR reviewed and used the results of 25 of 27 water samples submitted from this laboratory in this health consultation. A summary of these sample results are shown in Table 3. Table C-1 and response to Comment 1-4, Appendix C discusses the groundwater samples that ATSDR did not consider.

Discussion

Data Quality Evaluation

ATSDR received water samples from three sources. Water contamination concerns prompted both MSDOH and a resident to collect samples, and the DuPont groundwater monitoring data represent both wells on site and community wells surrounding the plant. DuPont reported that the instrument used to analyze the groundwater samples was calibrated according to the method specified in DuPont's underground injection control permit. This method uses a higher reference range for metals. This would result in imprecise (biased higher) determinations of metals in the ranges of the MCL (DuPont environmental consultant, personal communication, 2003). This would make the DuPont cadmium results higher than the actual groundwater concentration in the groundwater samples.

Hair Mineral Analysis, Fibromyalgia, Dioxin Like Compounds, and Chronic Sinusitis

Some community members believe that hair analysis results show that high manganese exposures occurred from drinking contaminated groundwater. As a result they have undergone chelation therapy. Valid methods exist for utilizing hair analysis for drugs of abuse, methyl mercury, and arsenic [2]. For most substances, however, insufficient data currently exist to allow the prediction of a health effect from a concentration of a substance (such as manganese) in hair [2,3]. Problems with hair analysis include unreliable results, lack of validation of analytic techniques, and external contaminants on the hair from shampoo, hair treatments and other products [2,3,4]. The ATSDR Hair Analysis Panel report discusses the state-of-the-art of hair analysis and its appropriate uses [2]. Given the above limitations, ATSDR is unable to use hair analysis to determine if adverse health effects are plausible from possibly contaminated groundwater.

Chelation therapy is the administration of a drug to draw toxic metals from the bloodstream, soft tissue (liver and or kidney), and bone, thus permitting excretion of these metals from the body. Because chelating agents are not substance-specific, they tend to deplete the organism of essential minerals (iron, calcium, copper, zinc) while ridding the body of poisonous chemicals. Chelating agents can also cause undesired secondary health effects, including but not limited to nausea and vomiting, fever, arthralgias, hypotension, headache, skin rashes, loss of protein in urine, blood in the urine, and cardiac arrhythmias [5,6,7]. In cases of suspected or proven environmental intoxications with heavy metals, the primary health care provider should consult a specialist in environmental-occupational medicine for guidance in the proper evaluation, diagnosis, and treatment of heavy metal poisoning. The Association of Occupational and Environmental Clinics specialize in this area of medicine. The AOEC may be contacted at 1-888-347-AOEC (-2632), or visit the AOEC Web site at http://www.aoec.org.

Fibromyalgia is characterized by achy pain and stiffness, including muscles, tendons (which attach muscles to bones), and ligaments (which attach bones to each other). Fibromyalgia does not have a known medical cause [8].

Chronic sinusitis was expressed to ATSDR as a health concern. Because, however, chemicals in the drinking water do not generally affect the respiratory system, ATSDR does not expect this sinusitis concern to be drinking-water related. A future ATSDR health consultation will evaluate exposure to airborne chemical releases from the plant, the chemicals' potential exposure pathways, and their relationship to the community's health concerns.

Some community members have expressed concerns about dioxin-like compounds, as reported on EPA's toxic chemical release inventory (TRI) for this facility. ATSDR is evaluating information regarding dioxin-like compounds and is preparing a health consultation that will address if there is a potential public health impact from dioxins at the DuPont DeLisle facility.

Pathway Analysis

An exposure pathway is the process by which an individual is exposed to contaminants originating from a contamination source. An exposure pathway consists of the following five elements:

1. a *source* of contamination,
2. a *media* 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 if all five elements are present and connected. If one of these elements are missing, the pathway is considered incomplete and human exposure is not possible. The complete and incomplete pathways analyzed in this health consultation are shown in Tables 4 and 5 in Appendix B.

Sources of Contamination

Underground Injection

Some residents expressed concern about the class I underground injection wells the DuPont facility operates to dispose of its iron chloride solution. Class I injection wells place liquid hazardous waste into the ground, below any sources of underground drinking water. Underground injection wells are required to comply with EPA's underground injection control regulations [9,10,11].

DuPont DeLisle's underground injection wells inject iron chloride solution into sand—at a depth of approximately 10,000 feet—in a geologic formation known as the Upper Washita-Fredericksburg Group [12]. Because of its corrosive nature and its metal (chromium and lead) content, the iron chloride solution is a characteristic EPA hazardous waste. DuPont DeLisle currently operates four such underground injection wells. According to EPA's Toxic Release Inventory (TRI), in 2000 DuPont estimated its underground injection of hazardous waste at this facility to be 12,557,081 pounds [13]. Table 6 in Appendix B contains the TRI listing of the hazardous waste injected for the year 2000.

Two barriers prevent the iron chloride solution injected into the Upper Washita-Fredricksbrug Group from migrating upward to underground drinking water. The first barrier is a confining zone, above the injection interval, of Selma Chalk (approximately 800 to 850 feet thick) and Midway Shale (approximately 1,150 feet thick) [12]. The second barrier is a number of saline aquifers separating the top of the confining zone and the lowest source of drinking water [12].

Contamination from Waste Storage, Accidental Releases from Plant Processes

The 1995 RCRA facility investigation and subsequent confirmatory sampling discovered the groundwater contamination [14]. It was associated with waste storage areas and past accidental waste releases [14]. DuPont completed Phase I and Phase II RCRA facility investigations and determined that the groundwater contamination had not migrated beyond the site's property line. [15,16]. DuPont also determined that the predominant groundwater flow is toward St. Louis Bay, away from residential wells located beyond DuPont's property (Figures 2 and 3 Appendix A) [15]. Contaminants found in the shallow groundwater monitoring wells below the DuPont facility are listed in Appendix B, Table 7. Appendix B, Table 8 discusses the specific waste processes that released the contamination.

To date, DuPont has collected over 119 soil samples and conducted 2,750 analytical tests on these soil samples. DuPont has also collected over 168 groundwater samples and conducted 2,874 analytical tests on these groundwater samples. All of this information has been carefully reviewed by both EPA and Mississippi Department of Environmental Quality (MSDEQ) project managers (Lael Butler, U.S. Environmental Protection Agency, personal communication). No drinking water wells are located in the area of contamination. EPA is working with DuPont on corrective actions for the impacted areas. Figures 2 and 3, Appendix A shows the DuPont site's potentiometric surface, the areas impacted beneath the plant, and the location of the monitoring wells currently in operation.

Media -Drinking Water Sources

Aquifers are underground geological formations containing useable amounts of water. The Citronelle and the Miocene aquifer systems supply underground drinking water to the DeLisle area [17]. The Citronelle aquifer is a formation of sand and gravel with a thickness range of 0 to 300 feet. The Miocene aquifer system consists of multiple layers of sand separated by beds of clay. The thickness of the Miocene aquifer ranges from 1000 to 4000 feet [17]. The Miocene system encompasses the Graham Ferry Formation, the Pascagoula Formation, the Hattiesburg Formation, and Catahoula Sandstone. A U.S. Geological Survey study of the groundwater in Harrison County found that aquifers deeper than 500 feet were artesian [18]. In an artesian well, the water is pressurized and will rise toward the well's top. Well pressure is the result of layers of clay that overlay the groundwater. Before extensive pumping in the region reduced the pressure in these aquifers, water in some wells flowed freely, without pumping [18]. The U.S. Geological survey reported that the individual sand beds are hydraulically connected—but not sufficiently connected to result in stabilized pressure common to all the aquifers [18]. The main recharges to these aquifers are probably located outside Harrison County [18].

The major source of domestic water for the DeLisle area is through private residential wells. Although not all-inclusive, the state of Mississippi geographic information data warehouse has data on approximately 714 privately owned wells and 15 public wells within a 5-mile radius of the DuPont DeLisle site [19]. Appendix A, Figure 3 contains a map showing the location of wells near the site's boundaries. The average well depth for the residential wells is 454 feet below ground surface (bgs) with a maximum depth of 2413 feet bgs. The average depth of the public wells is 949 feet bgs. The deepest public well in the 5-mile radius of the plant is 1210 feet bgs.

Route and Point of Exposure

There is no indication that persons are currently exposed to contaminants from the plant via groundwater. If a completed exposure pathway were to exist, ingestion of contaminated drinking water would be the primary route of exposure. Because metals are poorly absorbed through the skin, other uses of water (e.g. bathing or recreational) would not contribute significantly to this exposure pathway.

Receptor Population

As a result of regulatory oversight and of significant geologic barriers to contaminant migration, it does not appear these wells are currently impacting the drinking water supply for the DeLisle community. Contamination is present in the shallow aquifer under the DuPont facility. This contamination will not impact DeLisle's drinking water supply because the direction of the groundwater flow is away from DeLisle (see Figures 2 and 3). A completed exposure pathway from either the underground injection wells or from the plant does not exist. Nevertheless, some of the groundwater testing results submitted to ATSDR exceeded the EPA drinking water guidelines. The metals detected in these water samples are most likely the result of the geology of the aquifers (i.e. naturally occurring metals) or are the result of plumbing leaching metals into the household's domestic water supply.

Public Health Implications

Tables 1, 2, and 3 summarize the data ATSDR reviewed to date concerning groundwater in the DeLisle area. For reference, the applicable Maximum Contamination Levels (MCLs) or Secondary Maximum Contaminant Level (SMCL) are provided. A MCL is the EPA's legally enforceable standard for drinking water within public water supply systems. A SMCL is established as a guideline. It assists public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. If water samples are at or above the SMCL, contaminants do not necessarily pose a risk to human health [20]. Chemicals exceeding their guidelines, or for which no guidelines exist, are discussed in further detail below.

Aluminum

Aluminum was detected in 12 of 34 water samples. Four aluminum levels exceeded the secondary maximum contaminant level (SMCL) of 0.05 mg/L. Aluminum's SMCL is based upon discoloration of water. The maximum level of aluminum detected is 0.34 mg/L. Because no MCL exists for aluminum, ATSDR compared these levels to the EPA's Preliminary Remediation Goals (PRGs). PRGs are concentrations in air, soil, or water which, under default conditions of exposure, would yield doses equivalent to levels of chronic exposure that EPA has established as safe in humans. The PRG for aluminum is 36 mg/L [21]. This is more than 100 times higher than the highest level detected at this site. Therefore, even the highest level of aluminum detected in drinking water at this site would not pose any hazard to public health.

Antimony

Antimony was detected in 8 out of 24 samples. Only the highest sample (0.0065 mg/L) exceeded EPA's MCL of 0.006 mg/L [22]. The latter concentration represents an excess (<8%) over an MCL based on an EPA Reference Dose with a safety factor of 1000. Therefore, even the highest concentration of antimony detected in drinking water at this site would not likely pose any hazard to human health.

Boron

Boron is a naturally occurring element found mainly as an inorganic compound in rocks. As boron-containing rocks weather, boron releases naturally into the environment. The levels seen in these water samples are too low to pose any hazard to public health. They are consistent with background levels of boron detected in nationwide surveys of water quality [23].

Cadmium

Cadmium was detected in 22 of 120 samples. Ten samples from DuPont wells during 2000–2001 sampling, together with one from a single community well in 1999, contained cadmium at levels in excess of EPA's 0.005 mg/L MCL. The cadmium levels in these samples ranged from 0.006 mg/L in the community well to 0.22 mg/L in a DuPont well. The DuPont wells are the plant wells that provide both drinking and process water to the plant. Subsequent tests in these wells did not detect any cadmium. As discussed in the data quality section of this health consultation, the monitoring performed by DuPont as part of its UIC permit requirements utilizes a different analytical range from the monitoring that is normally performed to determine compliance with EPA's MCLs. Therefore, the data obtained using this analytical methodology should not be used for health assessment purposes. Routine monitoring of the DuPont drinking water supply by MSDOH has not discovered levels of cadmium exceeding the MCL (DuPont environmental consultant, personal communication, 2003).

Using analytical methodology appropriate for drinking water analyses, the maximum concentration of cadmium detected in a drinking water sample was 0.0002 mg/L, which is well below the EPA's MCL. The MCL for cadmium is protective of damage to the kidneys from long-term exposure to cadmium, as well as for other adverse health effects.

The relationship between occupational exposure to cadmium and an increased risk of cancer (specifically, lung and prostate cancer) has been explored in a number of epidemiologic studies. For inhalation exposures, the results are conflicting for epidemiological studies that evaluated cadmium's effects on increased lung cancer [24]. No human studies found any occupational or environmental exposures that associated an increase in cancer with oral exposure to cadmium in humans [24].

Moreover, neurological effects have not generally been associated with cadmium. In general, however, there is little available human evidence to indicate that cadmium adversely affects the human nervous system at exposures even up to levels that result in renal toxicity [24]

Because detected levels of cadmium were near or below a human NOAEL for minimal effects, and because subsequent tests did not indicate elevated levels of cadmium in any of the these wells, cadmium in drinking water at this site is not likely to pose a public health hazard to residents.

Calcium

Calcium, an essential nutrient, was detected in 23 of 25 samples. The maximum detection was 14 mg/L. Assuming that a person drinks 2 liters of water a day, water containing calcium at 14 mg /L would provide only 28 mg calcium/day. The Recommended Daily Allowance for calcium is 400-1200 mg/day, depending on age [25]. The calcium exposure from groundwater is within the

RDA and well below levels expected to cause health effects. Therefore, calcium in drinking water is not a public health concern in the DeLisle community.

Copper

Copper was detected in 27 of 34 samples. The maximum concentration of 3.2 mg/L was detected in one residential well and was the only sample that exceeded exposure standards. EPA has not established an MCL for copper, but does list a Technical Treatment Action Level of 1.3 mg/L. Some reports refer to persons experiencing gastrointestinal distress after drinking copper-contaminated water in excess of 3 mg/L for 1–2 weeks [26]. Copper is, however, an essential nutrient; and toxic reactions to copper in drinking water are uncommon. As discussed in the pathway section of the document, available data indicate sources of groundwater contamination for the DuPont DeLisle site appear not to be affecting area drinking water sources. Other metals associated with the plant (*e.g.* manganese or vanadium which are injected in higher volumes than copper) were not detected in this sample. However, excess copper in drinking water are commonly a result of corrosion of water pipes or natural weathering of rock [27]. Follow-up testing at this home is necessary to confirm the result and to identify the contamination source.

Iron

Iron was detected in 66 of 111 samples. Although EPA has established no primary MCL for iron in drinking water, 12 samples did exceed EPA's secondary MCL (SMCL) of 0.3 mg/L. The maximum detection was 12 mg/L. Water high in iron can have an unpleasant taste for some people, and materials washed in water with high iron concentrations could stain. Iron is an essential nutrient required by proteins involved in oxygen transport (hemoglobin) and energy metabolism (cytochromes). The RDA of iron ranges from 10–18 or more mg/day, depending on age and pregnancy status, and intakes of 25–75 mg/day are not expected to be harmful to healthy individuals [25,28]. As discussed in the pathway section of the document, available data indicate sources of groundwater contamination for the DuPont DeLisle site appear not to be affecting area drinking water sources. Therefore, iron in drinking water at in the DeLisle community is not likely to pose any hazard to public health.

Lead

Lead was detected in 17 of 120 samples. Three water samples exceeded the Technical Treatment Action Level of 0.015 mg/L, including the highest concentration of 0.026 mg/L. It is prudent public health policy to minimize exposures to lead. However, drinking water from the well with the maximum concentration of lead (0.026 mg/L) would not be expected to result in a blood lead level of health concern in either children or adults [29]. As discussed in the pathway section of the document, available data indicate sources of groundwater contamination for the DuPont DeLisle site appear not to be affecting area drinking water sources. Levels of lead in drinking water usually indicate corrosion of household plumbing systems rather than lead pollution of the aquifer [30]. To confirm the detected levels—and to identify the source of the contamination in the three households in which lead was detected in excess of EPA's action level—residents should retest those wells. In the meantime, before drinking any water from these three wells, these residents might want to let the water run long enough to evacuate standing water from the pipes.

Lead has only been associated with cancer in some occupationally exposed groups of workers, such as lead smelter workers. The information available on the carcinogenicity of lead in occupationally exposed humans is limited in its usefulness—the lead compound(s), the route(s) of exposure, and the levels of exposure were not always reported. Furthermore, concurrent exposure to other chemicals (including arsenic, particularly in lead smelters) and confounding variables, such as smoking, were often not evaluated [30]. Therefore, the data currently available do not support an assessment of the potential carcinogenic risk of lead in humans. The available data on the carcinogenicity of lead following ingestion by laboratory animals indicate that lead is carcinogenic and that the most common tumors are renal [30]. The extremely high cumulative doses of lead used in these studies are difficult to extrapolate to low-level exposure in humans. In addition, it is possible that the high doses required to induce renal tumors could also have produced a carcinogenic effect resulting from nonspecific tissue damage, independent of any direct effect of lead [30]. Furthermore, any relationship between chemically induced male rat kidney tumors and potential human carcinogenicity has been questioned [30].

Lead is also neurotoxic [30]. Adults can have overt neurological signs and symptoms and impairment on neurobehavioral tests at blood-lead levels as low as 40–60 µg/dL [30]. These blood-lead levels are comparable to those at which other symptoms of lead poisoning, such as gastrointestinal symptoms, occur [30]. Therefore, lead is not expected to be associated with community members' CNS complaints.

In children, there are scientific data supporting the association of lowered Intelligence Quotient (IQ) and mental retardation with lead exposure and contamination [29]. Blood-lead levels of 40–60 µg/dL are considered to be markedly elevated in children, and neurobehavioral effects are distinct [29]. There are no clear definitions of what constitutes low versus moderate blood-lead levels, and effects observed at the lower levels (particularly <15 µg/dL), have proven more difficult to separate from socioeconomic and other variables [29]. There are also some neurobehavioral parameters—such as aggressiveness and antisocial behavior—that have been associated with lead exposure in the very young [29]. The U.S. Centers for Disease Control and Prevention (CDC) determined in 1991 that blood-lead levels greater than10 µg/dL in children were to be considered elevated [31].

Evidence from human studies examining congenital anomalies as an end point indicate no association between prenatal exposure to low levels of lead and the occurrence of major birth defects. This conclusion is further supported by developmental toxicity studies conducted in rats and mice; these studies provide no evidence that lead compounds (acetate or nitrate) are teratogenic when exposure is by natural routes (i.e., inhalation, oral, or dermal) [30].

Magnesium

Magnesium was detected in 25 of 25 samples. Assuming consumption of 2 L/day, the highest concentration detected in drinking water at DeLisle (3.8 mg/L) would provide one with only 7.6 mg of magnesium per day. The recommended daily allowance for this essential nutrient ranges from 40 milligrams to 400 milligrams [25,32]. Therefore, magnesium in drinking water in the DeLisle area poses no hazard to public health.

Manganese

Manganese was detected in 28 of 34 samples, with the maximum detection at 0.22 mg/L. Manganese is a very common element in nature, as described in the Merck Index:

> "Widely distributed, abundant element; constitutes 0.085% of earth's crust. Occurs in the minerals pyrolusite, hausmannite, manganite, braunite (3Mn2O3.MnSiO3), manganosite (MnO), and in several others; occurs in minute quantities in water, plants and animals" [33].

In 1993 manganese was encountered in a county-wide survey of groundwater conducted by the U.S. Geological Survey (USGS). Groundwater from 25 wells revealed manganese in all 25 samples, with a maximal reading of 250 µg/L (0.250 mg/L) in a well completed in the Graham Ferry Formation [34]. The well with the maximal reading in the USGS survey was located approximately 24 miles east of the DuPont site. Because the maximum manganese concentration detected in drinking water sample from DeLisle is 0.22 mg/L, ATSDR believes manganese detected in the samples submitted occurred naturally in the aquifers underlying Harrison County.

Some local residents have stated that they believe manganese is responsible for the neurological problems in their community. These residents are probably basing their conclusions on the health effects caused by chronic inhalation of excessive amounts of manganese (e.g., by miners). These health effects include a neurological condition (manganism) similar to, but distinct from, Parkinsonism. However, manganese is an essential nutrient—oral intake is not known to produce toxicity in humans, even at relatively high doses. A 70-kg adult who daily drinks 2 liters of water containing 0.22 mg/L of manganese (the maximum level detected) would ingest only 0.44 mg manganese/day. The Food and Nutrition Board of the National Research Council designates 2.0 to 5.0 mg/day as an "estimated safe and adequate daily intake" of manganese for adults and the World Health Organization (WHO) describes 8 - 9 mg/day as "perfectly safe." A normal diet might contain well over 10 mg manganese/day. Adding 0.44 mg/day from drinking water would be of no consequence, because the human body normally absorbs only what it needs and excretes any excess [32]. Guidelines have been derived using the Recommended Daily Allowance (RDA) for manganese as a starting point. Both EPA and the World Health Organization (WHO) have developed guidance levels for manganese in drinking water. The World Health Organization has a guidance value of 0.5 mg/l for drinking water [35]. To help evaluate manganese in drinking water, EPA developed a health-related benchmark—called a Health Reference Level (HRL)—of 300 µg/L (0.3 mg/L) [36].

Information on the carcinogenic potential of manganese is limited, and the results are equivocal. Only a small number of rodent studies have shown a weak, non-dose related cancer effect. Overall, there is a paucity of evidence from other species and from human data suggest that the potential for cancer in humans is low [37]. Manganese is classified by EPA as a group D carcinogen (Not classifiable as a human carcinogen).

Very little information is available on birth defects in humans because of drinking manganese. The incidences of neurological disorders and the incidences of birth defects and stillbirths were elevated in a small population of people living on an island where there were rich manganese deposits [37]. Still, the lack of exposure data, the small sample sizes, and the absence of a suitable control group preclude ascribing these effects to manganese [37]. The route of exposure was assumed to be primarily oral, but inhalation exposure was not ruled out.

Molybdenum

Molybdenum was detected in 25 out of 34 drinking water samples that analyzed for this metal. The highest detection was 0.0062 mg/L. Molybdenum is found naturally in rocks. The average concentration of molybdenum in rocks is 1 to 1.5 parts per million [33]. No MCL exists for molybedeum. ATSDR's Reference Media Evaluation Guide (RMEG) for chronic exposure to molybdenum in drinking water is 0.05 mg/L for children and 0.2 mg/L for adults. An RMEG is a concentration in air, soil, or water below which non-cancer health effects are not expected to occur. RMEGs are derived from EPAs Reference Dose or Reference Concentration, and are for chronic exposures. All of the levels of molybdinum seen in drinking water at this site were well below ATSDR's comparison values of 0.05 mg/L and 0.2 mg/L.

Nickel

Nickel was detected in 10 out of 34 samples. The highest detection was 0.019 mg/L. Nickel is a naturally occurring element in the earth's crust, which is composed of an average of 99 parts per million of nickel [33]. EPA does not have a MCL for nickel. ATSDR has an RMEG of 0.2 mg/L for children and 0.7 mg/L. The highest level of nickel is below the RMEG for both children and adults.

Nickel refinery dust, believed to have been mostly nickel subsulfide, has been classified as a class A human carcinogen by EPA [38]. Although the evidence is sufficient to consider less-soluble nickel compounds carcinogens following inhalation exposure, how environmental exposure to nickel affects cancer risk is not clear. Nickel levels in the environment are much lower than those that were associated with cancer in workers. In the environment, nickel is also more likely to be in the form of a mineral lattice rather than the more active nickel refinery dust which contains nickel subsulfide, the form of nickel most consistently associated with cancer [38].

Potassium

Potassium, another essential nutrient, was detected in 23 out of 25 samples. Assuming consumption of 2 L/day, the highest level of potassium detected in water in the DeLisle area (4.1 mg/L) would correspond to an intake of only 8.2 mg potassium/day. The Food and Nutrition Board for the National Research Council has, however, determined that the minimum requirement for potassium ranges from 1,600 to 2,200 milligrams per day [25]. There is considerable evidence that increasing the amount of potassium ingested to 3,500 milligrams per day would be beneficial [25]. Compared to the large amount of potassium needed daily by the human body, no amount that could be obtained from drinking water in the DeLisle area would be of any biological significance.

Sodium

Sodium was detected in 25 out of 25 samples. The maximum detection was 150 mg/L. Sodium is another essential nutrient needed in large amounts every day. The Food and Nutrition Board for the National Research Council designates 120 to 500 milligrams per day as a *minimum* requirement for sodium [25]. The FDA has identified 2400 mg/day as a safe *upper* intake level [39]. That would be equivalent to about 6 grams of table salt. (Salt or sodium chloride is 39% sodium by weight.). Although much of it remains controversial, there is evidence that "excessive" amounts of sodium over a long period of time can lead to high blood pressure [27]. That said, consumption of well water containing the even highest concentration of sodium detected in the DeLisle area should not make the difference between a non-toxic and a toxic daily intake of sodium. The levels of sodium in well water in the DeLisle area are generally low. In a 1993 Harrison County survey, sodium levels in groundwater ranged from 0.031 mg/L to 0.4 mg/L[34]. Secondly, drinking water contributes only a small proportion of one's total daily intake (which could be several *grams* per day in adults). Therefore, if there is a concern about potential for hypertension, those in the DeLisle area whose drinking water contains elevated levels of sodium can most easily compensate for the additional sodium intake by simply using less table salt. ATSDR does not consider sodium levels in drinking water at this site constitute a public health problem.

Tin

Tin was detected in 2 out of 25 drinking water samples. Tin is found naturally in the earth's crust, which has an average of 0.0006 percent (or 6 parts per million) [33]. Therefore, ATSDR compared the levels at this site to EPA's Preliminary Remediation Goals (PRGs), concentrations which, under default conditions of exposure, would correspond to conservatively safe chronic, lifetime exposures. All of the levels of tin seen in drinking water at this site were below EPA's PRG of 22 mg/L [21].

Titanium

Titanium was detected in 1 out of 25 drinking water samples. Titanium is the ninth most abundant metal in the earth's crust, comprising an average of 0.63 percent [33]. The maximum drinking water result is 0.012 mg/L. Titanium does not have a PRG. The EPA Risk-Based Concentration (RBC) for titanium in drinking water is 150 mg/L [40]. RBCs are calculated using a similar method as the PRGs, and also represent safe levels for chronic lifetime exposures.

Vanadium

Vanadium was detected in 14 out of 120 samples. The maximum detection in water was 0.165 mg/L. Vanadium is a metallic element that occurs naturally in air, soil and groundwater [41]. No MCL exists for vanadium, and ATSDR has no comparison values for chronic exposure to vanadium. Therefore, ATSDR compared the levels at this site to PRGs, concentrations which, under default conditions of exposure, would correspond to conservatively safe chronic, lifetime exposures. All of the levels of vanadium seen in drinking water at this site were below EPA's PRG of 0.26 mg/L [21].

Child Health Considerations

ATSDR's Child Health Initiative recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities concerned about air contamination. Children are at greater risk than adults from certain kinds of exposures to hazardous substances released into their environment. Children may be more likely to be exposed to outdoor air contaminants when playing outdoors. Because children are smaller than adults, exposure may result in higher dose per body weight. Also, children's developing body systems can sustain damage if toxic exposures occur during critical growth stages. Consequently, ATSDR evaluated the sampling data to assess the potential health effects on children in the community. In the homes with lead and copper concentrations that were greater than the EPA technical treatment action level, the recommendations given below for retesting of these sources would be appropriate.

Conclusions

The concentrations of metals detected in drinking water were not at levels that would be expected to cause adverse health effects. Available data indicate that contamination from the

DuPont DeLisle plant is not affecting underground drinking water sources in the community. Therefore, ATSDR has categorized the site as **No Public Health Hazard** to underground drinking water. Hair mineral analysis results do not provide reliable indication of either environmental exposures or the need for treatment (i.e., chelation therapy) for environmental disease.

Public Comment

ATSDR received three public comments during the public comment period for this health consultation, which ended on 7/9/2003. ATSDR addresses these comments in Appendix C.

Recommendations

Conduct further sampling to identify the source (plumbing or aquifer) in homes where water samples exceeded the technical treatment action level for lead and copper.

Provide physician and community environmental health education to the DeLisle community.

Public Health Action Plan

The Public Health Action Plan for the site contains a description of actions that have been or will be taken by ATSDR or other government agencies at the site, individually or in combination. The purpose of the Public Health Action Plan is to ensure that this public health consultation not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR to follow up on this plan to ensure its implementation.

Actions completed:

- ATSDR conducted a site visit to verify site conditions and gather pertinent information and data for the site.
- ATSDR has completed a public comment health consultation concerning groundwater concerns in the DeLisle area.
- ATSDR held a public meeting to discuss this health consultation with the community on June 5, 2003.
- ATSDR has responded to comments received during the public comment period for this document.

Actions ongoing:

- MSDOH has agreed to provide further groundwater testing for those residents who have lead and copper results greater than the applicable guidelines, if requested by the residents.
- ATSDR is developing a health consultation evaluating the DeLisle area’s exposure to air emissions from the DuPont DeLisle plant and its potential for public health impact.
- ATSDR is developing a health consultation regarding the DuPont DeLisle plant’s dioxin-congener contaminated waste and its potential for public health impact.

Actions planned:

- ATSDR is planning to provide community and physician environmental health education concerning issues such as hair analysis and appropriate recognition, diagnosis and treatment of diseases related to environmental exposures.
- ATSDR will reevaluate and expand this plan when needed. New environmental, toxicological, or health outcome data or the results of implementing the above proposed actions could determine the need for additional actions at this site.

Authors, Technical Advisors

Principal Authors

James T. Durant M.S.P.H., C.I.H.

Environmental Health Scientist
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry
1600 Clifton Road (E-29)
Atlanta, GA 30333

Frank Schnell Ph.D., D.A.B.T.

Toxicologist
Exposure Investigations and Consultations Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Lourdes Rosales-Guevara M.D.

Medical Officer
Exposure Investigations and Consultations Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Reviewed by:

Don Joe P.E.

Chief, Petition Response Section
Exposure Investigations and Consultations Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

John E. Abraham, Ph.D. M.P.H.

Chief, Exposure Investigation and Consultations Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

References

1. US Environmental Protection Agency. RCRA Facility Assessment of DuPont DeLisle Plant, DeLisle, Mississippi. Atlanta, GA: ID No MSD096046792 RCRA Facility; 1996.

2. Agency for Toxic Substances and Disease Registry. Hair analysis panel discussion: exploring the state of the science. Atlanta: US Department of Health and Human Services; 2001 June 12-13.

3. Frish M and Schwartz BS. The pitfalls of hair analysis for toxicants in clinical practice: Three case reports. Environ Health Perspect 2002;110 (4):433–36.

4. Seidel S, Kreutzner R, Smith D. McNeel S, Gilliss D. Assessment of commerical laboratories performing hair mineral analysis. J Am Med Assoc 2001;285(1):67–72.

5. Guldager B, Jorgersen PJ, Grandjean P. Metal excretion and magnesium retention in patients with intermittent claudication treated with intravenous disodium EDTA. Clin Chem 1996; 42(12): 1938–42.

6. Grandjean P, Guldager B, Jorgersen P, Holmstrup P. Placebo response in environmental disease: chelation therapy of patients with symptoms attributed to amalgam fillings. J Occup Med 1997;39(8):707–14.

7. Kosnett, M.J. Unanswered questions in metal chelation. Clin Toxicol 1992; 30(4):529–547.

8. Berkow, R. Beers, M.H. Fletcher, M.B., Bogin, R.M., editors. Merck Manual – Home Edition. Internet Edition Provided By Medical Services, USMEDSA, USHH Barbara Amelia Nace, Site Designer and HTML Author. Daniel E. Moy, Programmer. Available at: http://www.merck.com/mrkshared/mmanual_home2/home.jsp . Last accessed May 2004.

9. US Environmental Protection Agency. Office of Water. Class I underground injection control program: Study of risks associated with class I injection wells. Washington, DC: EPA 816-R-01-007; March 2001.

10. Committee on Government Operations, US House of Representatives. Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee: Control over injection

well disposal operations protect drinking water. Washington, DC: US General Accounting Office GAU/RCED-87-170; August 1987.

11. US Environmental Protection Agency. Office of Ground Water and Drinking Water. Protecting drinking water through underground injection control. Drinking water pocket guide #2. Washington, DC: EPA 816-K-02-001; January 2002.

12. DuPont Environmental Remediation Services. EPA no-migration and non-endangerment petition demonstration, DuPont DeLisle Plant, Pass Christian, Mississippi. June 27, 1995.

13. Toxic inventory report for DuPont DeLisle plant. Washington DC: Environmental Protection Agency. 1999. Available at: http://www.epa.gov/enviro/html/tris/tris_query.html. Last accessed January 10, 2003.

14. DuPont Corporate Remediation Group. Confirmatory sampling groundwater investigation report, DuPont DeLisle Plant, Pass Christian, Mississippi. June 30, 1998.

15. DuPont Corporate Remediation Group. RCRA Facility investigation report. prepared for DuPont DeLisle Plant, 7685 Kiln DeLisle Road, Pass Christian, MS 39571. December 7, 1999.

16. DuPont Corporate Remediation Group. RCRA Facility investigation report Phase2 report, DuPont DeLisle Plant. October 22, 2001.

17. Wasson BE. Sources of water supplies in Mississippi. A cooperative study sponsored by the US Geological Survey and the Mississippi Research and Development Center, Jackson, MS. 1986.

18. Newcombe R Jr, Shattes DE, Humphres CP Jr. Water for the growing needs of Harrison County, Mississippi. Geological Survey Water-Supply Paper 1856. Washington, DC: United States Printing Office; 1968.

19. Mississippi Automated Resource Information System. Available at: http://www.maris.state.ms.us/index.html. Last accessed January 10, 2003.

20. Secondary Drinking Water Regulations: Guidance for Nuisance Chemicals. United States Environmental Protection Agency. Available at: http://www.epa.gov/safewater/consumer/2ndstandards.html Last accessed March 3, 2003.

21. U.S. Environmental Protection Agency Region IX. Preliminary Remediation Goals. Available at: http://www.epa.gov/region09/waste/sfund/prg/index.htm. Last accessed March 3, 2003.

22. Agency for Toxic Substances and Disease Registry. Toxicological profile for antimony. Atlanta: US Department of Health and Human Services; 1992 September.

23. Agency for Toxic Substances and Disease Registry. Toxicological profile for boron. Atlanta: US Department of Health and Human Services; 1992 July.

24. Agency for Toxic Substances and Disease Registry. Toxicological profile for cadmium. Atlanta: US Department of Health and Human Services; 1999 July.

25. National Research Council (US). Subcommittee on the Tenth Edition of the RDAs. Recommended dietary allowances. 10^{th} ed. Washington, DC: National Academy Press; 1989.

26. Agency for Toxic Substances and Disease Registry. Toxicological profile for copper—draft for public comment. Atlanta: US Department of Health and Human Services; 2002 September.

27. US Environmental Protection Agency. Office of Water. Preparing your drinking water consumer confidence report: Revised guidance for water suppliers. Working draft for public review. Washington, DC: EPA Publication 816-R-01-003; 2001 January.

28. Tenenbein M. Iron. In: Ford MD et al eds. Clinical toxicology. Philidelphia: W.B. Saunders Company; 2001. p. 305–09.

29. Agency for Toxic Substances and Disease Registry. A Framework to Guide Public Health Assessment Decisions at Lead Sites. Appendix D, Toxicological profile for lead. Atlanta: US Department of Health and Human Services; July 1999.

30. Agency for Toxic Substances and Disease Registry. Toxicological profile for lead. Atlanta: US Department of Health and Human Services; July 1999.

31. CDC. 1991. Preventing lead poisoning in young children. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention.

32. Goyer R and Clarkson TW. Toxic effects of metals. In: Klaasen CD et al eds. Casarett and Doull's toxicology: The basic science of poisons. 6th ed. New York: McGraw-Hill; 2001. p. 811–67.

33. The Merck Index, Thirteenth edition (electronic version by Cambridgesoft.com). Merck & Co. Whitehouse Station, NJ. 2001.

34. Slack LJ, Oakley WT, O'Hara CG, Cooper LM. Quality of ground water in Harrison County, Mississippi, June-July 1993. USGS Open-File Report 94-125. Jackson, Mississippi: US Geological Survey; 1994.

35. World Health Organization. Guidelines for drinking-water quality, 2nd ed. Vol. 2. Health criteria and other supporting information. Geneva, World Health Organization, 1996. pp. 276-284. Available at: http://www.who.int/docstore/water_sanitation_health/GDWQ/Chemicals/manganesefull.htm#guideline. Last accessed May 2004.

36. Health Effects Support Document for Manganese. EPA 822-R-03-003 U.S. Environmental Protection Agency Office of Water (4304T) Washington, DC: Health and Ecological Criteria Division; February 2003.

37. Agency for Toxic Substances and Disease Registry. Toxicological profile for manganese. Atlanta: US Department of Health and Human Services; September 2000.

38. Agency for Toxic Substances and Disease Registry. Toxicological profile for nickel. Atlanta: US Department of Health and Human Services; 1997 September.

39. Office of Disease Prevention and Health Promotion, HHS and Center for Nutrition Policy and Promotion. Nutrition and Your Health: Dietary Guidelines for Americans. Washington, DC: Departments of Health and Human Services and Agriculture; May 30, 2000.

40. US Environmental Protection Agency Region III. Risk based concentrations. Available at: http://www.epa.gov/reg3hwmd/risk/index.htm. Last Accessed August 1, 2003.

41. Agency for Toxic Substances and Disease Registry. Toxicological profile for vanadium. Atlanta: US Department of Health and Human Services; 1992 July.