HEALTH AND SAFETY MANAGEMENT OF LEAD IN SOIL IN U.S. AIR FORCE BASES

by

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ABSTRACT

Urban soils contaminated with lead can pose a health risk if vegetables and fruits from the garden are consumed. In general, we don't think our gardens as dangerous or toxic, but unfortunately some garden soils do contain toxic levels of lead. Chipping paint around older structures will raise the lead level in the soils directly adjacent to the building. Restrictions to lead paint started in the 1950's. Today lead paint content has been reduced; however paint companies are allowed to mix up to 0.05% lead in paints. Lead use has been reduced significantly, but not entirely eliminated. Soil can be contaminated with lead from other sources such as industrial sites, industrial sludge with heavy metals, auto emissions, old lead plumbing pipes or even old orchard sites in production when lead arsenate was in use.

The main concern with lead in firing ranges is the fate and transport of heavy metals from bullets fragments accumulating in soil. Of these metals, lead is the predominant contaminant. Lead is considered the top environmental threat to children's health. The U.S. military alone has cleaned up more than 700 firing ranges across the country over the past several years. The U.S. Air Force conducted a study at Shaw Air Force base to determine the lead concentrations in ground water and soil collected from the Small Arms Firing Range in 1992. The purpose of this study was to determine the levels of contamination in the soil in order to develop a restoration plan. The goal of the restoration plan was to clean up the land for future use.

The Defense Environmental Restoration Program (DERP) conducted a project at Beale Air Force Base to clean up contaminated lead soil and to prevent any future fine and environmental expenses for the base. The main goal was to protect the base population from the lead and other contaminants hazards.

In 1992 the Air Force conducted an investigation that included environmental sampling of soil and lead of the Tyndall Elementary School grounds. The Air Force collected lead samples in areas where children play on the school ground. Because lead concentrations results were below the toxic levels for lead, the Air Force concluded that no further action was needed. Further investigation for soil removal took part in 1992 and 2009. Under the Critical Removal Action field activities included site preparation, waste characterization, investigative sample chemical analysis, contaminated soil excavation, dust control, disposal, backfill and grading, and site restoration.

Over the years the Air Force has been able to educate the military community on health hazards in the base facilities especially lead exposure and have been able to implement programs dedicated to prevent any lead overexposure.

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Chapter 1 - General Introduction

Urban gardening is the process of growing plants of all types and varieties in an urban environment. Urban gardening, which is also known as urban horticulture or urban agriculture, encompasses several unique garden concepts, including: container gardening, indoor gardening, community gardening, guerrilla gardening, and greenroofs. Container gardening is common for people with small patios, yards or balconies and makes use of a variety of containers for growing plants for food and beauty. There is a wide use of community gardens in the Air Force bases. The Air Force bases community as well as other communities uses community gardens to improve user's health through increased fresh vegetables consumption and providing a venue for exercise. But there is also a concern of contaminated soil that could contaminate the gardens. Not only the concern is for the community gardens but also at the children playgrounds and the Small Arms Firing Range sites. The contaminant of concern is lead which is the primary soil contaminant of concern at the children playgrounds and the firing ranges. In every housing area of the Air Force base there are more than 5 children playgrounds. These are the playgrounds where kids play, get fit, and make friends. Children are more vulnerable to environmental health hazards because their bodies are still growing. At the firing range, lead dust from the fragment bullets is a main concern. The Air Force found elevated levels of lead in soil near the ranges. The main goal is to protect human health and the environment from lead's potential harmful effects.

The purpose of this study was to present the results of the lead concentrations in ground water and soil collected from the Air Force firing range areas. A restoration project took place at Beale Air Force Base to remove 17,000 tons of contaminated top soil as part of the Interim Removal Action for seven small arms munitions site. This project uses a revolutionary process that cleans contaminated groundwater in a fraction of the time and cost required for the traditional methods.

The Air Force conducted two investigations related to lead exposure. These investigations were conducted at Tyndall Elementary School. The 1992 lead investigation consisted of taking samples at the school playground area to determine the lead toxicity levels. The school's 21 acres were once a portion of Tyndall Air Force that was used as a shotgun range in the 1940s to train aerial gunners during World War II. The 2009 lead investigation was conducted at various munitions response areas at Tyndall Air Force Base. This investigation was part of the congressionally mandated Department of Defense Military Munitions Program. For both of these investigations the main goal was to determine the levels of lead at the school playground and firing ranges and to conduct a Health Assessment and implement a Management plan for the base.

Objectives

Urban gardening, the health concerns associated with lead and urban soils are reviewed in Chapter 2. The objective of Chapter 2 is to provide information on lead as an important contaminant, which may be found in urban soils and Air Force base soils. The objective in Chapter 3 and 4 is to review several Air Force actions to address lead contamination in soils at several Air Force bases.

The objectives of the first study, Contamination of Lead in Soil at Air Force Firing Range (Chapter 3), were to i) evaluate and determine the lead concentration in ground water and soil collected from the Firing Range area during 1992 at Shaw Air Force Base in Sumter County, South Carolina, ii) to start the investigation of using lead free frangible ammunition for small arms training and to implement their own Health Management Plan to prevent overexposure of lead to their personnel, and iii) to implement the Defense Environmental Restoration Program at Beale Air Force to remove lead contaminated soil to prevent any future fines and environmental expenses for the base.

The objectives of the second study, Lead at Tyndall Air Force Base Elementary School (Chapter 4), were to i) Improve health and safety management practices of lead in soil at U.S. Air Force Bases, ii) determine the extent to which lead contaminated soil along firing ranges old site has contaminated children playgrounds and schools at Tyndall Air Force Base, and iii) reduce exposure to risks of lead in soil.

Chapter 2 - Literature Review

Urban Gardening

Definition

"Urban gardening is the process of growing plants of all types and varieties in an urban environment. Urban gardening, which is also known as urban horticulture or urban agriculture, encompasses several unique garden concepts, including: container gardening, indoor gardening, community gardening, guerrilla gardening, and green roofs" (Ecolife 2014). "Container gardening is common for people with small patios, yards or balconies and makes use of a variety of containers for growing plants for food and beauty". "Indoor gardening is used when no patios, yards, or balconies are available". Plants can be grown in containers similar to those in container gardening (Ecolife 2014). Community gardening, the most common used at the Air Force bases, is a method of using outdoor or private spaces to cultivate gardens for food or pleasure as a group and is a great choice for those with no yard or outdoor space. "Guerrilla gardening is a more subversive form of urban gardening. It is a way of adding plants to public spaces that don't technically belong to the gardener such as a vacant lot, median, or in little strips of dirt. The greenroofs are roofs designed with a growing medium for the purpose of cultivating plants and can be used to grow food, trees, and many other types of plants" (Ecolife 2014).

Community Gardens on Air Force Bases

Community gardens provide fresh produce and plants as well as satisfying labor, neighborhood improvements, sense of community and connection to the environment. At Hanscom Air Force Base community garden is an annual event sponsored by the base community to get the family and children together. Children at the Hanscom Youth Center are able to enjoy vegetables and herbs all summer, as well as learn the responsibility for taking care of a garden themselves (Sillonis 2012). “In addition to the youth, volunteers from the base community assisted in planting flowers, vegetables and herbs in the garden for Hanscom children to enjoy all summer long” (Sillonis 2012).

Community gardens improve user’s health through increased fresh vegetables consumption and providing a venue for exercise. The gardens also combat two forms of alienation that plague modern urban life, by bringing urban gardeners closer in touch with the source of their food, and by breaking down isolation by creating a social community. “This was a fun opportunity to work alongside the youth group at Hanscom, and I am sure they’ll enjoy the fruits of their labor throughout the summer.” Said David Chicoine, senior vice president and plan CEO of US Family Health Plan at Brighton Marine. “As part of the Hanscom community since 1993, it is our mission to care for and support local military families.”(Sillonis 2012).

Underneath the sign proclaiming the community garden, volunteers planted marigolds. These flowers, as well as herbs will line one side of the raised bed. Inside the bed will be many vegetables, including tomatoes, bell peppers, lettuce, beans, broccoli and eggplant. “The kids who help with the garden are given the opportunity to harvest the produce, which they can take home, or they can take the produce back to the Youth Center and learn to prepare a dish” (Sillonis 2012).

Lead

Description

Lead is a soft and malleable metal with symbol Pb and atomic number 82. Metallic lead has a bluish-white color after being freshly cut, but it soon tarnishes to a dull grayish color when exposed to air. Lead has a shiny chrome-silver luster when it is melted into a liquid. It is also the heaviest non-radioactive element.

Lead has the highest atomic number of all of the stable elements. It has four stable isotopes 204, 206, 207, and 208 which have 82 protons. All four can be radioactive as the hypothetical alpha decay of any would be exothermic, but the lower half-life limit has been put only for lead-204: over 1.4×10^{17} years. "This effect is so weak that natural lead poses no radiation hazard. Aside from the stable ones, thirty-four radioisotopes have been synthesized: they have mass numbers of 178-215. Of these, the most-long lived isomer is 204m2 with a half-life of about 1.1 hours" (Wikipedia 2014).

Metallic lead does occur in nature, but it is rare. Lead is usually found in ore with zinc, silver and cooper, and is extracted together with these metals. The main lead mineral is galena (PbS) which contains 86.6% lead by weight (Department of the Air Force 1993). Its characteristic properties includes high density, softness, ductility and malleability, poor electrical conductivity compared with other metals, high resistance to corrosion, and ability to react with organic chemicals.

Because of its high density and resistance from corrosion, lead is used for the ballast keel of sailboats. Also more than half of the US lead production is used for automobiles, mostly as electrodes in the lead-acid battery. Lead-acid batteries consist of metallic Pb and lead dioxide as the electrodes with sulfuric acid as the electrolyte (Department of the Air Force 1993).

History of Lead Use

The history of lead use traces back many centuries. World production of lead 4,000 years ago has been estimated at 160 tons per year; 2.700 years ago, it was 10,000 tons per year; and, during the Roman Empire, lead production increased to 80,000 tons per year (Department of the

Air Force, 1993). "The occupational hazards of lead were first reported in 1713 by Bernardo Ramazzini, who described lead intoxication in potters working with leaded glaze" (Toxipedia 2014). "Later in the 18th century, Benjamin Franklin described the toxic effects of lead occurring in tradesmen who used lead in their occupations" (Toxipedia 2014).

"In the eighteenth, nineteen, and twentieth centuries the worst outbreaks of lead poisoning of adults were occupational in origin. It became common knowledge that to work in an industry where you handled lead was certain to make you sick or worse. These workers absorbed lead from inhalation of fine lead dust or fumes, contamination of food eaten at the workplace, or by absorption through the skin". "Lead's hazards to the reproductive process have been known for at least a century. British factory inspectors at the turn of the twentieth century noted that women who were exposed to lead through working in the cottage ceramic industry tended to be barren and that children who were born to those women were often short-lived. In most western countries during the 1930's through the 1970's, awareness among health workers was associated with more lead poisoning cases being reported, and laws protecting workers being enacted" (Needleman, 1998).

The favorable physical and chemical properties of lead accounted for its extensive use. Lead can be rolled into sheets which can be made into rods and pipes. It can be molded into containers and mixed with other metallic elements. Lead was used in building construction, especially roofing, cornices, electrical conduits, and water and sewer pipes. Lead compounds such as white lead and lead chromate were widely used as pigments in paint (making up as much as 50% of the dried paint by weight). Lead is also commonly present in varnishes and primers. Many houses built before 1978, and especially those built in 1950 or before, are believed to contain paint with high levels of lead (Department of the Air Force 1993).

Lead-based Paints

In the past, the use of lead in paint made it an excellent paint additive because of its durability, but the sweetness made it tempting to young children. Childhood lead poisoning was linked to lead-based paint in 1904. Several European countries banned the use of interior lead-based paints in 1909. At that time the baby cribs were painted with lead-based paint, which resulted in infant illness and death (CDC 1991). "In 1943 it was determined that children eating lead paint chips could suffer from neurological disorders including behavior, learning, and intelligence problems. Furthermore, in 1971, lead-based house paint was phased out in United States with the passage of the Lead-Based Paint Poisoning Prevention Act" (CDC 1991).

Homes built prior to 1978 may have lead-based paint either inside or outside, and homes and apartments built prior to 1950 are very likely to have lead-based paint both inside and outside and should be inspected carefully (Department of the Air Force 1993). This is a particularly serious problem for children living in older housing in Air Force bases where the majority of the houses were built before 1950. "A CDC report found that 35% of African-American children living in inner cities with more than 1 million people had blood lead levels greater than 10 μg/dL, which is the CDC action level established in 1991" (CDC 2005). In the 1990s, the EPA required that information on lead be disclosed when a home or apartment is sold or rented. In addition, specific training is required for workers removing lead from homes or apartments (CDC 2005). Lead-based paint continues to remain a serious problem for many children.

Lead in Children Playgrounds

In every housing area of the Air Force base there are more than 5 children playgrounds. Neighborhood and school playgrounds are places that kids play, get fit, and make friends. We expect playgrounds to be safe and clean environments for children to play in. However, too many playgrounds across America have unsafe play equipment and are not well maintained. Some may pose environmental health hazards. “Children are more vulnerable to environmental health hazards because their bodies are still growing. “Their exposure is increased by their universal hand-to-mouth activity; their gut absorbs lead more readily than an adult’s; and the developing Central Nervous System (CNS) is more vulnerable to toxicants than the mature CNS” (Needleman, 2004). Proportionally, they eat, drink, and breathe more per pound of body weight than adults” (CDC 2005). Children like to explore, which can expose them to more environmental threats than adults. But they also do not know how to identify and protect themselves from these hazards (CDC 2005).

Exposure is mainly through lead-based paint, contaminated soil, dust, and drinking water (lead pipes, soldered pipes). Because of weathering and time, old lead paint on playground equipment can deteriorate into chips and dust that contain lead (Healthy Schools 2013). The bare soil surrounding the playground equipment may also be contaminated with lead from deteriorating lead-based paint from the equipment or from unrelated sources such as nearby highway, steel structures, local sources of lead (firing range) or previous industrial use of the property. In 2008, EPA issued the Lead Renovation Rule (Healthy Schools 2013). Contractors doing renovation projects that disturb lead-based paint in homes, child care facilities, and schools built before 1978, have to be certified and follow specific work practices to prevent lead contamination.

Lead in Firing Range

Small arms firing ranges are essential to weapons training and the mission of the USAF. However, range use often produces soil contaminated with metals from spent bullets. “This contamination can create environmental and occupational health problems during range operation and maintenance, as well as during redesign, reuse, and remediation of the range" (Bannon, et al., 2013).

Lead is the primary soil contaminant of concern at these ranges. Antimony, a hardening agent in bullets, and cooper and zinc, the primary components in shell casings and jackets, can also contribute to soil contamination. Bullets are often fragmented and pulverized upon impact with backstops, berms, or bullet traps located at the range. "The normal operation of a range can produce lead concentrations of several percent (one percent = ten thousand parts per million) in solids located behind and adjacent to targets and impact berms" (Bannon et al., 2013). Elevated levels of lead have also been found in vegetation growing near impact berms. Care must be taken to protect human health and the environment from lead's potential harmful effects. Antimony, cooper, and zinc should be considered as secondary contaminants of potential concern when developing a list of contaminants targeted for analysis and/or cleanup.

There is a Department of Defense (DoD) Proposed Range Rule "DoD, Federal Register Vol. 62, No 187, 26 September 1997" that proposes a process for evaluating and selecting appropriate response actions at closed, transferred, and transferring military ranges (Fact Sheet 1998). The rule was proposed in response to the EPA Munitions Rule and addresses the management of closed, transferred, and transferring ranges, which were not addressed in the EPA Munitions Rule. The DoD Range Rule establishes procedures for evaluating and responding to safety, human health, and environmental risks on closed, transferred, and transferring military ranges (Fact Sheet 1998). To accomplish this, the DoD Range Rule proposes a five-part Range Response Process. This process evaluates appropriate response actions, consistent with CERCLA cleanup provisions, which evaluate actual risks posed by contaminants based on reasonably anticipated future land use. This could mean compliance with significantly different cleanup criteria than might be required under RCRA authority, which would apply if the munitions fragments at closed, transferred, and transferring ranges were designated RCRA solid wastes (Bannon et al., 2013).

Although the DoD Range Rule is a proposed rule, it outlines a reasonable approach to address risk-based management of lead contamination at small arms firing ranges.

Lead in Gasoline

"Historically lead in gasoline has been one of the greatest public health issues of the 20th century. Tetraethyl Lead (TEL) was discovered in 1854 by a German chemist and in 1921, Thomas Midgley of the U.S. found that it reduces engine knock. A year later the U.S. Public Health Service issued a warning about the potential hazards associated with lead. In 1923 the Dupont Corporation began the first large-scale production of TEL and the first workers died from lead exposure. During this period Dupont acquired a 35% ownership of General Motors, and General Motors and Standard Oil formed a joint company, Ethyl Corporation to produce TEL. A year later 5 workers died from lead poisoning at the Ethyl facility in New Jersey, although the total number of workers affected by lead exposure was unknown" (Needleman, 1998).

The U.S. Surgeon General suspended the sale of TEL in 1925 to review the safety of TEL use. The next year a committee approved the use of TEL in gasoline and sales were immediately resumed. By 1936, 90% of the gasoline sold in the U.S. contained lead, and the Ethyl Corporation was expanding sales in Europe. By 1965 environmental concerns were highlighted in a 1965 report documenting that high levels of lead in the environment were caused by human use of lead. After serious efforts by the EPA to standardize the use of lead, in 1976 the EPA standards were upheld in court and in 1980 the National Academy of Sciences reported that leaded gasoline was the greatest source of environmental lead contamination. The fight to phase out leaded gasoline continued until 1986 when the primary phase phase-out of lead from gasoline was completed but in some areas of the country, such as Washington State, leaded gasoline was available until 1991. "It is estimated that 7 million tons of lead were released into the atmosphere from gasoline in the United States alone" (Toxipedia 2014).

Health Effects

The toxic effects of lead on human beings have been known for many years. Acute overexposure to lead can kill in a matter of days. Chronic overexposure to lead in adults may result in severe damage to the blood forming organs, and the nervous, urinary, and reproductive systems (Department of the Air Force 1993). The frequency and severity of medical symptoms increases with the concentration of lead in the blood. Many adults with blood lead levels (BLLs) of 80 micrograms per deciliter (ug/dl) or greater have symptoms or signs of acute lead poisoning; although in some individuals, symptoms may be so mild that they are overlooked (CDC 2005). Common symptoms of acute lead poisoning include: loss of appetite; nausea; vomiting; stomach cramps; constipation; difficulty in sleeping; fatigue; moodiness; headache; joint or muscle aches; anemia; and , decreased sexual drive. Long after exposure has ceased, physiological events such as: impaired hemoglobin synthesis; alteration in the central and peripheral nervous systems; hypertension; effects on male and female reproductive systems; and damage to the developing fetus. These health effects may occur at BLLs below 50 ug/dl. Blood lead levels of workers, both male and female, who intend to have children, should be maintained below 30 ug/dl (Department of the Air Force 1993).

Lead poisoning is primarily found in young children. It results from the inhalation or ingestion of contaminated lead-based paints/dust, soil, dirt, water, air, etc. Lead provides no physiological purpose; but once it is ingested or inhaled, it passes to the blood and bone marrow. Childhood lead poisoning is one of the most common and preventable pediatric health problems in the United States today. Children are particularly susceptible to lead's toxic effects. In 1984, the Agency for Toxic Substances and Disease registry estimated 17 percent of all American preschool children had BLL exceeding 15 ug/dl (Department of the Air Force 1993). Because of evidence showing adverse effects at low-blood lead levels, guidelines titled, "Preventing Lead poisoning in Young Children," [Center for Disease Control, October 1991], have lowered the definition of lead poisoning to a BLL greater than or equal to 10 ug/dl (Department of the Air Force 1993).

Lead injuries in children start even before birth. Fetuses are exposed to lead passed through the placenta from a woman with lead in her system. The effects of lead poisoning on the brain and central nervous system are irreversible and cause delays in emerging cognitive and language development. Umbilical cord blood lead levels of 10 to 15 ug/dl appear to be associated with reduced gestational age and reduced birth weight. Fetal exposures to low lead levels have been shown to decrease stature and affect the ability to maintain steady posture.

Young children are more likely to ingest or inhale lead because of their proximity to the floor or ground, and frequent hand to mouth behaviors. Given a certain quantity of lead ingested, a child will absorb approximately 40% compared to 10% in an adult. Elevated blood lead level, with an accompanying iron deficiency, will enhance lead absorption from the GI tract. Children have more trouble than adults in isolating lead in their bones, so a larger fraction of the body burden of lead is available to targeted organs. Developing brains are also more susceptible to the toxic effects of lead. Children develop rapidly in their early years, a time when lead poisoning has its most devastating effects. Symptoms in children include: vomiting, seizures, aggressive behavior disorders, developmental regression, mental retardation, alterations in consciousness, intractable seizures, and coma (Department of the Air Force 1993).

Research findings indicate that blood levels in children as low as 10 ug/dl, which do not cause distinctive symptoms, are associated with decreased intelligence. "Lead damages the kidneys, central and peripheral nervous system, the hematopoietic system, and causes impairment of the biosynthesis of the active vitamin D metabolite which is detected at blood lead levels of 10 ug/dl to 15 ug/dl" (CDC 1991). It has been shown that lead poisoned children have lower serum total and ionized calcium levels. Survivors of severe lead poisoning may have severe mental retardation. With lower levels, a child may suffer from developmental delay, a lower IQ, hyperactivity, learning disabilities, behavioral problems, impaired hearing, and stunted growth. Very high levels of lead can cause seizures, coma, and death.

Urban Soil

Definition

How do you define "soil"? It depends on who you ask. A Botanist will define it as a medium for plant growth. An Engineer or Geologist will define it as the loose material that lies between the ground surface and solid rock and a Soil scientist will define it as the unconsolidated mineral or organic matter at the earth's surface which has been altered by pedogenetic processes. Soil has different meanings to different people but the dictionary definition according to Wikipedia is that "Soil is a "natural body consisting of layers that are primarily composed of minerals which differ from the parent materials in their texture, structure, consistency, color, chemical, biological and other characteristics" (Wikipedia 2014). Urban soil is the cultivation of crops in urban or suburban areas for local consumption or sale. While individuals may develop backyard gardens or develop or begin a for-profit venture, the focus of this report is on community gardens that can be established on a vacant parcel or at a school or another communal location in a neighborhood. Soil is the unconsolidated mineral organic material on the immediate surface of the earth that serves as a natural medium for the growth of plants. Soil studies in urban areas have found that soil compaction, low organic matter content, and low levels of contamination, usually from air deposition or from historical uses of site, are common attributes of urban soils. "The issue of assessing soil quality becomes two-fold: the health of the soil as a growing medium needs to be addressed as well as the possible contamination that may be present" (Evaluation of Urban Soils 2014).

Lead in Soils

Urban soils contaminated with lead can pose a health risk if vegetables and fruits from the garden are consumed (Lead in Soil 2012). The health risk of lead in soil on the surface of the produce is much greater than lead taken up through the roots because lead uptake is usually small. In general, we don't think our gardens as dangerous or toxic, but unfortunately some garden soils do contain toxic levels of lead. Chipping paint around older structures will raise the lead level in the soils directly adjacent to the building. Restrictions to lead paint started in the 1950's. Today lead paint content has been reduced; however paint companies are allowed to mix up to 0.05% lead in paints. Lead use has been reduced significantly, but not entirely eliminated (Lead in Soil 2012). Soil can be contaminated with lead from other sources such as industrial sites, industrial sludge with heavy metals, auto emissions, old lead plumbing pipes or even old orchard sites in production when lead arsenate was in use (Lead in Soil 2012).

Other potential toxic metals in soil are cadmium, cooper, chromium, mercury, nickel and zinc. All these metals are trace elements which mean that each exists in all soils at some normal range of background levels. Background levels usually do not pose a risk to plants, animals, or people. Human activity tends to elevate the concentration of some of these metals in soils to levels which may pose a toxicity risk under some circumstances.

Lead could stay in soil for a very long time. Organic matter will bind and hold lead and other metals very effectively. In a heavily contaminated soil the only effective ways to eliminate the contamination are to cover it with fresh soil or remove it completely. When the soil lead level is over 5000 ppm total lead, the garden soil should be removed and replaced with clean topsoil. Direct ingestion of contaminated soils and the airborne soil dust can only be eliminated by removing the soil (Rosen 2010).

Moderate levels of lead contamination can be actively managed to minimize the risk of lead intake. Contamination is considered to be moderate up to 300 to 500 ppm, depending on the situation (Rosen 2010). Lead intake could occur by eating contaminated plants, eating the soil itself, or breathing soil dust. Several methods are used to minimize intake. Lime the soil as needed to maintain the pH above 6.5 (Rosen 2010). Addition of compost or leaves will maintain an ample organic matter level. Surface contamination can be removed by thorough washing. It is essential to clean the vegetables before eating. Root vegetables and tubers can actually be more thoroughly cleaned than leafy vegetables if they are peeled. Seed vegetables, like corn and peas, will have no surface contamination problem since there is a physical barrier. It is best to avoid growing leaf vegetables in moderately contaminated soils. You can grow fruits and seed vegetables instead (Rosen 2010).

Testing for lead will help to evaluate the lead hazard level. An increased soil lead level implies a greater hazard. The Massachusetts recommendations for limiting exposure to lead are based on the test results of soil lead levels. No legal regulations for soil lead levels are in effect, and no tests have linked health effects to high soil levels. The results from laboratory analysis in lead will be returned listing the parts per million (ppm) of lead from either an extracted or total lead test. Table 2.1 will help understand the test results (Lead in Soil 2012). When taking soil samples, they should be taken from several areas to determine the location of the contamination. The greatest lead concentration is often in the top one to two inches of the soil. Children's play areas or vegetable gardens should be sampled separately. Avoid mixing several sites into one sample and sample high risk areas to locate potential problems. The soil should be sampled by taking 6 to 12 subsamples from the area of concern (Lead in Soil 2012). Mix the subsamples thoroughly in a plastic pail, remove about a one cup volume, and submit to a laboratory in a clean container.

There are several methods established by gardeners to reduce the risk of lead poisoning from lead contaminated soils. "Vegetable gardens should be located away from old painted buildings, heavy traffic and sites where sludge with heavy metals was applied" (Rosen 2010). "Vegetables and fruits can accumulate lead in their leafy green tissues, although lead accumulation will be lower in fruits. As mentioned before, wash and peel fruits and vegetables to reduce this risk. Discard the outer wrapper leaves of greens before washing" (Rosen 2010). Wash off excess dirt from root crops outside the home, preferably at an outside hose bib to prevent bringing contaminated soil into the home. In terms of protecting the soil from contamination, you can also add organic matter such as compost, leaf mold or grass clippings to the gardening site. Add phosphorus to the soil as recommended by a soil test. To reduce the risk of bringing lead contaminated soil into home, rinse and launder gardening clothing promptly (Rosen 2010). Since children may directly ingest soil when playing, do not allow children to play in contaminated soils. Frequent hand washing and rinsing outside toys will reduce the amount of soil ingested. Wash hands before eating meals or snacks. In a soil contaminated area where children play, build a plastic-lined sand box for a clean area to play.

Another important contributor to elevated blood lead levels in children exposed to lead contaminated environments is ingested soil. Most of the exposure to lead for children is from children playing in playgrounds. The mitigation strategies conducted by the Air Force that will be studied in this report are focused on excavation and removal of the contaminated soil. However, this is not always feasible for addressing widely disseminated contamination in populated areas often encountered in urban environments. The rationale for amending soils with phosphate is that phosphate will promote formation of highly insoluble lead species in soil, which will remain insoluble after ingestion and, therefore, inaccessible to absorption mechanisms in the gastrointestinal tract. Amending soil with phosphate might potentially be used in combination with other methods that reduce contact with or migration of contaminated soils, such as covering the soil with a green cap such as sod, clean soil with mulch or gravel (Scheckel et al., 2013).

For soils, the term bioavailability means the portion of a substance or element in a soil that is available for absorption into living organisms, such as humans, animals, or plants. For lead, the major concern is the bioavailability to humans through accidental ingestion of soil. The term bioavailability is used here to describe the amount of soil lead that is available for absorption into the human blood stream. As discussed earlier lead phosphates and in particular pyromorphites, are one of the most stable forms of lead in soils under a wide range of environmental conditions. “Formation of pyromorphites upon addition of apatite or soluble inorganic phosphorus amendments was observed in lead contaminated soil materials. Some studies done such as in vivo and in vitro assays indicated lead availability in the mammalian gastrointestinal system is dependent on the form and relative dissolution rates of lead solids. Therefore the formation of lead phosphates in soils contaminated with both Pb and P is responsible for immobilizing Pb, thereby reducing the bioavailability of Pb”. This has been suggested to be a cost-effective remediation option for lead contaminated soils in residential areas and children playgrounds as well (Hettiarachchi and Pierzynski, 2004).

Analytical Methods to Measure Lead in Soils

The analytical method used by the Air Force to measure lead in soil is the XRF spectrum analyzer technology. Currently most of the Air Force bases maintain only one XRF meter with spectrum analyzer capabilities available. This unit is manufactured by Thermo Scientific Corporation. The XRF Spectrum Analyzer is configured to measure the “K” and “L” shell x-ray emission lines of lead. “The K shell line, or higher energy emission, is normally used for paint analysis because it measures lead in all layers of the paint films. L shell x-rays are attenuated by paint film matrices”. Thus, measurement of the L shell x-ray is useful for soil analysis but not paint analysis (XRF Analyzer 2014).

Soil analysis using XRF is a widely used and accepted method for site investigation, assessment, remediation, and monitoring. It is a good tool to obtain accurate, reportable soil analysis data quickly and easily. The XRF has made it possible to measure lead at much lower concentrations. “This advance, along with more refined epidemiological techniques and better outcome measures, has lowered the least observable effect level until it approaches zero. As a consequence, the segment of the population who are diagnosed with exposure to toxic levels has expanded" (Needleman, 2004). The XRF analyzers provide lab-quality soil/sediment chemistry in seconds. It is easy to operate but requires for the user to follow safety procedures. All users must meet USAF Radioactive Material Permit (RAM) training requirements through the manufacturer or the School of Aerospace Medicine (USAFSAM), and read and become familiar with the manufacturer's operations manual (XRF Analyzer 2014).

Remediation of Lead-contaminated Soils

There are different ways to deal with high lead soils that could be implemented at U.S. Air Force bases. One way could be to immobilize the lead by raising soil pH and adding organic matter followed by planting sod. Also by mixing or covering the high lead soil with clean soil or eliminate the lead by physically removing the soil (Rosen 2010). Another proposed method recommended by the Minnesota Pollution Control Agency is to grow lead accumulating plants on these soils and then harvest and remove the plants. This process, termed bioremediation, has shown promise for cleaning up soils that have been contaminated with cadmium, zinc, and cooper, but at the present time is of limited value for lead. "While plants differ in their ability to accumulate lead, even the lead accumulating leafy vegetables do not accumulate enough lead to make bioremediation of this metal practical" (Rosen 2010).

As a safety precaution, always wash vegetables from the site. For sites where soil contaminant levels may be of concern avoid bringing children and pregnant women to the site when working soils or when ground cover is not in place. Use grass, mulch, and other ground cover for walkways and growing areas to reduce exposure of visitors and nearby residents to soils, and to retain soil moisture for plant growth. If working the soil, use protective clothing (e.g., gloves, dust masks, long-sleeved shirts and pants) and avoid bringing soil particles into residences by immediately washing shoes, clothes and skin.

Table 2.1 Soil Lead Levels*

Soil Lead Levels		
Relative Soil Lead Levels	Extracted Lead (ppm)	Total Lead (ppm)
Low	0-32	0-499
Medium	33-110	500-999
High	111-857	1000-3000
Very High	above 857	above 3000

* Lead in Soil (2012)

Chapter 3 - Contamination of Lead in Soil at Air Force Firing Range

Small-Arms Firing Range at Shaw Air Force Base

Introduction

This is a study done in Shaw Air Force Base where water samples were collected from four shallow observation wells in the water-table aquifer beneath the Small-Arms Firing Range. Analyses of the samples indicated that total lead concentrations in the shallow ground water beneath the study area do not exceed the U.S. Environmental Protection Agency maximum contaminant level established for lead and drinking water (0.05 mg/L) (Landmeyer 1994). Other analyses of trace elements were performed on soil samples collected from the study area. Concentrations of lead above the U.S. Environmental Protection Agency maximum contaminant level of 5.0 mg/L are present to a depth of 10 feet from the surface of the 20-foot high impact berm. Soil samples collected from the impact berm contained concentrations of total lead, chromium, barium, mercury, and arsenic in amounts greater than the analytical detection limit (Landmeyer 1994).

The location of the impact berm at the Small Arms Firing Range has changed since initial construction in 1967. From 1967 until 1986, the original impact berm was located 150 ft north of its present day (1994) location. In 1986, after a storm damaged the range baffles beyond repair, the impact berm of the range was moved by bulldozing the old berm 150 ft to the south to its present location. The historic background of this site was essential in designing an assessment program, and particularly in selecting background soil and ground-water quality sample collection sites (Landmeyer 1994). Because of this lead fragments contained in the old berm might still exist 150 ft. to the north of the current impact berm. Also, the stratification of lead fragments that developed in the old berm has been upset by a vertical mixing within the soil during the movement of the berm soil that forms the present impact berm. These factors influenced placement of all observation wells and soil boreholes. The highest potential for the concentration of lead occurs on the western half of the impact berm in target lanes 1, 2, and 3. Soil-sampling efforts were focused in these areas in order to study the worst-case scenario for trace element concentration (Landmeyer 1994).

The purpose of this study was to present the results of the lead concentrations in ground water and soil collected from the Small Arms Firing Range area during 1992 at Shaw Air Force Base. The study area included the impact berm and adjacent areas. The technique used to collect the samples involved installing four permanent, shallow ground water observation wells, collecting and analyzing ground water quality samples, and six boreholes to obtain soil samples for grain-size and total and leachable trace elements analyses. "The hydraulic conductivity of the unconfined water-table sands beneath the study area was determined by performing slug tests in completed observation wells. Some previous published hydrologic data and data collected in the area as part of this study were used in the assessment of concentrations of lead in the shallow ground water and soils at the study area" (Landmeyer 1994).

Description of Study Area

"The study area at the Small Arms Firing Range is located on the eastern boundary of Shaw Air Force Base. The 22,500-ft^2 range consists of a concrete firing bay about 150 ft in length and 20 ft.-high impact berm composed of native soil. A series of metal baffles placed 10 ft above the range floor, over the firing range area, provides ricochet protection. The Small Arms Firing Range is bounded on the east by cultivated farm land. To the north and west are 20 to 30 year old pine trees, and a model-airplane field. Garden plots of Shaw Air Force Base personnel lie to the south of the study area" (Landmeyer 1994).

Shaw Air Force Base was completed in 1941 and encompasses 3,326 acres. It is in a predominantly rural community and located 7 miles west of Sumter and 35 miles east of Columbia, South Carolina. The general topography ranges from rolling hills in the western part of the base to a flatter, more swampy terrain in the eastern part. The range is approximately 209 feet above sea level. The swampy area is characterized by numerous elliptical shaped hardwood swamps called Carolina bays that are present in greater number to the east and south of the base boundary. The base is in an area underlain by a generally southwestward-thickening wedge of unconsolidated sediment of the Atlantic Coastal Plain coastward of the Fall Line.

Health Management

The analytical results collected from the ground water indicate that concentrations of most trace elements including lead were below the analytical method detection limit. The total lead concentrations in soil samples at this site ranged from below the detection limit to 3.89 mg/kg. Even though these results were below the Occupational Exposure Limit of 400 mg/kg, This lead the Air Force to start the investigation of using lead free frangible ammunition for small arms training and to implement their own Health Management Plan to prevent overexposure of lead to their personnel because they were still showing results above the levels and their main goal was to bring the levels below the detection limit (Landmeyer 1994). Historically, most small arms firing range health related problems stemmed from the presence of lead and lead compounds found in the bullets and priming mixtures and eventually end up in the soil (Bannon 2009). Increasingly stringent federal and state environmental regulations caused the Air Force to develop new range designs that significantly reduce or eliminate the discharge of lead into the environment. Open ranges with earth backstops or impact ranges began to be replaced in the mid-1990s. The newer ranges restrict the path of the bullet and contain all bullets within the confines of the range. The ranges are partially or fully contained using walls and commercial bullet traps (Landmeyer 1994).

The Air Force began investigating the use of lead frangible ammunition for small arms training for the M-9, M-16, and M-4. The frangible rounds were considered non-toxic because lead was removed from the bullet and the primer. Additionally, the frangible rounds had little to no ricochet hazard significantly reducing the safety hazard distance. The Air Force is currently using a frangible bullet consisting of powder copper metal and nylon binder manufactured by Federal Cartridge Company.

Conclusion

The remediation of lead contaminated soils at firing ranges, either as part of maintenance or site closure activities, does not differ significantly from any other soil remediation project. Development of remediation goals depends upon whether the proposed action is maintenance at an active firing range or remediation supporting a potential change of land use. In July of 1994, the Environmental Protection Agency (EPA) issued "Revised Interim Soil Lead Guidance CERCLA Sites and RCRA Corrective Action Facilities."(U.S. EPA, 1994). This memorandum provides "screening levels" to be used as a tool to define a level of lead contamination above which there may be enough concern to warrant further site specific study. The guidance encourages the risk manager to select, on a site-specific basis, the most appropriate combination of remedial measures, from intervention to abatement, needed to address lead exposure threats. The memorandum sets a screening level in soils of 400 mg/kg, below which no corrective action is recommended, and a screening level in soils of 5,000 mg/kg, above which corrective action is recommended. Concentrations falling between these screening levels could warrant corrective action depending upon the results of site-specific risk evaluations. Remediation goals should be developed to be protective of receptors consistent with planned future land use.

Restoration Project at Beale Air Force Base

Introduction

The Beale Air Force Base Military Munitions Response Program completed excavation of more than 17,000 tons of contaminated top soil as part of the Interim Removal Action for seven small arms munitions response sites. Beale environmental professionals, in conjunction with environmental consultants, recently completed a project that greatly expands the base's ability to perform critical environmental cleanup operations. The project uses a revolutionary process that naturally cleans contaminated groundwater in a fraction of the time and cost required for the traditional methods. The goal was to remove lead and polycyclic aromatic hydrocarbons contaminating the soil and to prevent any future fines and environmental expenses for the base. Kent Hawley, Beale's environmental prevention program manager, said "the soil had a lead contamination above 80 parts per million, which exceeded the limits and had to be removed."(Pollard 2014) "The Environmental Protection Agency and California State Law has a limit of contamination allowed in the soil," said Hawley. "With all the soil removed and replaced the base is free from any future environmental issues and fines."(Pollard 2014). This limit set by the Air Force represents a conservative estimate for a level that would be protective of public health in residential soils based on an analysis of the direct ingestion pathway for children. This value is for guidance only and is not enforceable.

Defense Environmental Restoration Program

The Defense Environmental Restoration Program (DERP) was established by section 211 of SARA, giving the Department of Defense (DoD) the authority, responsibility, and funding mechanism for environmental restoration at military facilities (IRP 1999). These include active installations (like Beale Air Force Base under the Installation Restoration Program), and former DoD facilities (such as Camp Beale) under the Formerly used Defense Sites (FUDS) program. The DERP operates under its own statute but program activities are carried out consistent with CERCLA Section 120 which makes CERCLA applicable to federal facilities (IRP 1999).

Three program categories have been established under DERP: Installation Restoration Program (IRP), Other Hazardous Waste (OHW), and Building Demolition/Debris Removal (BD/DR). The IRP program, which is the program used at Beale Air Force Base, includes cleanup activities associated primarily with CERCLA-defined hazardous substances, pollutants, and contaminants (IRP 1999). Like the CERCLA cleanup program, the IRP seeks to minimize public health and environmental hazards associated with contaminated sites. The IRP prescribes investigation and restoration activities conducted through a phased approach. Each phase systematically studies the effects of past environmental activities. At any point in the process, the governing agencies may determine that no further action is required and screen the site out of the process. Any site posing an immediate threat to human health or the environment may require the federal government to undertake emergency response actions (IRP 1999).

"At Beale Air Force Base, the Environmental Restoration Project disposed of approximately 16,000 tons of soil at Recology Ostrom Road Landfill as non-hazardous waste, and approximately 1,500 tons of soil were disposed at Clean Harbors Buttonwillow Landfill as hazardous waste" (Pollard 2014). After excavation was completed, the areas were backfilled with approximately 10,500 cubic yards of approved soil. Also, 27,000 linear feet of post-construction fiber rolls were installed in order to protect the water quality from erosion and sediment runoffs. Finally, 16 acres of hydro seed mulch was applied to the fresh soil to begin vegetation regrowth, and electric fences were installed around six of the seven sites in order to keep cattle out during restoration process. “With that land below the hazardous limits for lead and other contaminants, Beale no longer has to worry about annual environmental expenses,” Said Hawley. “Once the project is completed and all documents are closed, the land becomes free for unlimited use.”(Pollard 2014).

Conclusion

The Department of Defense (DoD) primarily conducts environmental restoration activities in accordance with the Comprehensive Environmental Response, Compensation, and liability Act (CERCLA), also known as Superfund. This Superfund was utilized at Beale Air Force Base for Munitions Response Program action to cleanup seven small arms munitions sites. The Department began cleaning up contamination in 1975 under the Installation Restoration Program (IRP). The IRP addresses contamination from a hazardous substance or pollutant or contaminant. In this case the contaminant of concern was lead. For this restoration project the Military Munitions Response Program was used to comply with environmental cleanup laws such as CERCLA.

The cleanup program was a complete success for Beale Air Force Base where the base was able to disposed of tons of contaminated soil using methods recommended by the DERP. The contaminated soil was loaded to trucks and transported to a landfill that specializes in the disposal of hazardous wastes. The second phase of the process involved hiring local landscapers to replace the excavated soil with new soil and to restore the facilities to their pre-excavation state. Further testing then confirmed the absence of toxic levels of lead-contaminated soil or airborne lead dust.

Chapter 4 - Lead at Tyndall AFB Elementary School

Introduction

Tyndall Air Force Base is an active Military facility located in Bay County, Florida, approximately 12 miles southwest of Panama City, Florida (Health Consultation 2012). The base covers about 28,800 acres on a narrow 18-mile peninsula connected to land on its southeastern boundary. Tyndall Air Force Base is connected to the Panama City area by the Dupont Bridge via highway 98. Administrative, residential, and Tyndall Elementary School are south of the highway. Tyndall Elementary School was constructed by the Air Force in 1951. The school's 21 acres were once a portion of Tyndall Air Force Base that was used as a shotgun range in the 1940s to train aerial gunners during World War II (figure 4.1). Gunners fired 12-gauge shot guns containing lead shot at clay targets (skeet) launched into the air from fixed towers. The targets would shatter, scattering debris and lead shot fell to the ground. The exact area of the former target range area as well as the extent of lead shot, lead debris, and clay target contamination were not fully identified or characterized prior to the removal action (Health Consultation 2012).

Tyndall Elementary School was operated by the Air Force as a school for base dependents until 1974 when the operation and maintenance of the school was transferred to the Bay County School District. Since that time, the school has been operated as a public school serving both air force families and the public. Approximately 800 students from pre-kindergarten to fifth grade attend this school (Bay County Schools 2010). The playgrounds at the school extend from the front of the school to the west, south, and east of the school buildings and are within the fenced area.

Air Force 1992 Lead Investigation

In May 1992, a student brought home lead pellets (shot) she collected while playing at recess on the Tyndall Elementary School playground. Her father notified the school, who then contacted the Air Force authorities, causing them to take action. Initially, the playground was declared off limits (Health Consultation 2012). However, after input from the Bay County Health Department, restrictions were expanded limiting children from playing on school property for the three weeks remaining of the school year. "The Air Force conducted an investigation that included environmental sampling of soil and lead, as well as surface radiation of the Tyndall Elementary School grounds" (Health Consultation 2012).

The Air Force collected a total of 34 samples from Tyndall Elementary School which 30 of those were taken within the fenced area and four outside the fence on school grounds. Additional samples were collected outside the school grounds (Health Consultation 2012). Samples were sent to the Air Force certified lab for lead analysis. The test results found lead concentrations in soil ranging from 7.2 mg/kg to 20,000 mg/kg. The highest lead concentration was taken from an area beside the front gate of the school which was a grass-covered area that was not part of the playground. The second highest concentration, 340 mg/kg, was found in the southeastern corner of the school grounds on the playground. The lead concentration in the playground ranged from 6.3 mg/kg to 340 mg/kg. The average concentration within the playground was 97 mg/kg. The EPA standard for lead in residential bare-soil play areas is 400 mg/kg (Health Consultation 2012).

The Air Force also collected four air-borne lead samples in areas where children play on the school grounds. Air sample results, as reported in the base newspaper article, were in the margin of 0.13 and 0.23 ug/m^3 (BCDOH 2010). The health risk standard at the time was 1.5

mg/m^3. There was no notation on the visual appearance of soil, sand, or debris or the presence of lead shot or clay targets debris (Health Consultation 2012). Because lead concentrations at the playground were below the EPA standards and air sampling results indicated no increased risks, the Air Force concluded that no further action was needed. Children were allowed back on the playground (Health Consultation 2012).

Health Assessment

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted a site visit to Tyndall Air Force Base in 1997 to gather information needed for a health assessment. The focus of this visit was the Elementary School because of its past exposure to lead. During this visit, ATSDR did not see visible signs of lead shot in the playground area and noted that sand had been deposited onto the playground. Consequently, as the lead concentrations in the playground area and related exposures were associated with lead levels below the EPA recommended soil standards for residential soil, ATSDR released the final health assessment for Tyndall Air Force Base in July 2000 stating that soil lead levels were too low to present a health hazard. ATSDR was not aware that lead shot remained accessible to children on the playground (Health Consultation 2012) .

"Later, on June 3, 2009, EPA notified ATSDR that the Air Force had found lead shot at the base elementary school. Two days later, on June 5, 2009, EPA requested assistance from ATSDR to address the public health issue of lead found in the playground area. ATSDR and EPA visited the site and met with school representatives and Air Force and Bay County health department from June 16-18, 2009, and again from November 18-20, 2009" (Health Consultation 2012). They coordinated and agreed to write a notification letter to parents on June 24, 2009 which recommended that concerned parents have their children's blood's lead level tested. The hazard that lead shot presents is not solely based on its chemical characteristics property to dissolve into a soil matrix, adhere to a child's hand, and be ingested or carried by rainwater into an aquifer. The hazard described in this health assessment is direct and intentional ingestion of lead shot by a curious child.

Air Force 2009 Lead Investigation

After the Health Assessment conducted by ATSDR in 1997 and 2009, the Air Force began Phase I investigations at various munitions response areas at Tyndall Air Force Base. This investigation is part of the congressionally mandated Department of Defense, Military Munitions Response Program. Their investigation included the former stationary Target Range which they designated as SR170. In May and June 2009, Tyndall Air Force Base conducted two soil sampling events, discrete samples at 0.5, 1.0, 1.5, and 2.0 feet depth intervals below the ground surface using X-ray fluorescence (XRF) technology which can easily provide detection limits for lead-in-soil of less than 100 ppm, well below the typical regulatory levels of 300 to 1500 ppm. Any lead shot present was removed from the samples prior to analysis, along with other large particles of rock and debris to comply with the sampling protocol. A field log book is to be used to document any information about the sample location that is out of the ordinary. Furthermore, document the presence of any projectiles, clay target debris, or other small arms debris near the sample collection (Health Consultation 2012).

Sampling Results

Initially Tyndall Air Force Base collected approximately 270 discrete soil samples in and around the school yard as part of the Phase II to address the former shooting area which encompasses Tyndall Elementary School property. The lead concentrations in soil ranged from non-detectable to 4.302 mg/kg. In June 2009, 130 additional soil samples were collected to further delineate the lead contamination. The results ranged from non-detectable to 495 mg/kg (Health Consultation 2012).

In general, 175 samples representing 42% of the total number of samples were collected at 0.5 feet bgs. This data represents the soil depth that children would contact. The average lead concentration at this depth was 226 mg/kg with values ranging from non-detectable to 3,602 mg/kg. The 95% upper confidence limit of the average was 1,151 mg/kg and the geometric mean was 77 mg/kg. Approximately 19 of the samples were greater than or equal to 400 mg/kg (Health Consultation 2012).

Approximately 175 samples were collected at 1.0 feet bgs. The average lead concentration at this depth was 168 mg/kg and values ranged from non-detectable to 4,302 mg/kg. Approximately 18 of the samples were greater than or equal to 400 mg/kg. Approximately 44 samples were collected at 1.5 feet bgs representing 9.5% of the total sampling. The average lead concentration at this depth was 118 mg/kg and values ranging from non-detectable to 901 mg/kg. Two of the samples or 4.7% were greater than 400 mg/kg. Six samples were collected at 2.0 feet bgs representing 1.5% of the total sampling. The average lead concentration at this depth was 435 mg/kg and values ranged from non-detectable to 2,024 mg/kg. One sample or 16% was greater than 400 mg/kg (Table 4.1) (Health Consultation 2012).

The Phase II screening analysis showed average soil lead concentration for combined depths to be approximately 180 mg/kg. About nine percent of the total soil samples collected showed lead levels above 400 mg/kg, EPA’s residential soil standard for bare soil. In conclusion, these data indicate that there are several "hot spots," but the average soil lead concentration is lower than the EPA standard (Health Consultation 2012).

Air Force 2009 Soil Removal

The removal of the contaminated lead soil at the Tyndall Elementary School began in July 2009 under a Critical Removal Action. Field activities completed as part of the Removal Action included site preparation, waste characterization, investigative samples chemical analysis, contaminated soil excavation, dust control and monitoring, tree removal, transportation and disposal, equipment decontamination, backfill and grading, and site restoration (Health Consultation 2012).

The criteria used to remove the soil was in according to the clean levels established by EPA. Depending on the lead concentration, soil was excavated down to either 0.5 or 2.5 feet. There were areas where underground utilities were encountered where the excavation could not proceed down to 2.5 feet. In these areas, soil was excavated to a depth of 1.5 feet (Health Consultation 2012). All excavated areas were filled with clean soil cover. Soil samples with Toxicity Characteristic Leaching procedure (TCLP) lead test results greater than 5 mg/L were treated in-situ (in place) prior to excavation and disposal. The in-place treatment consisted of mixing the soil with a commercial calcium sulfate compound that binds the lead, making it resistant to dissolving out the soluble components. Once the sampling results are confirmed below the cleanup levels, excavated area were backfilled with off-site borrow material and the site was graded, re-vegetated, and restored with playground equipment. Sand was placed around the playground equipment to meet the drop fall zone requirements (Health Consultation 2012). The goal of the soil removal was to remove soil until sampling results indicated that contaminant concentrations were below their clean-up values, but because of utility lines, excavation could not reach two feet bgs. Approximately 34,900 bank cubic yards (BCY) of soil were excavated. Materials obtained from off-site sources were tested for volatile organic compounds, semi-volatile organic compounds, pesticides, and metals to be used for back fill of the playground area. New playground equipment was installed (Health Consultation 2012).

Prior to the soil removal, Air Force divided the area into 73 grids of approximately 100 by 100 ft (BCDOH 2010). Soil was screened for lead in the field using X-ray fluorescence (XRF). The XRF was used for in-place screening of soil within the excavation to determine if additional soil removal was required prior to confirmation sampling. Sampling points were arranged in a squared grid pattern with an approximate spacing of 50 feet between samples. The number of samples collected per grid was based on the total grid area, with generally four samples per 100 by 100 foot grid. Samples were collected at different depths from 0.5 to 2.5 inches below the surface grade. Each confirmation sample was analyzed for lead using the XRF. Ten percent of the soil samples screened by XRF were selected for confirmation laboratory analysis to determine the accuracy of the XRF screening (Health Consultation 2012).

When XRF screening results were below the field value of 300 mg/kg for lead, then a discrete confirmation soil sample was collected from the grid for lead by XRF. If XRF results for the lead confirmation soil sample were above the field value, an additional 0.5 feet soil was removed from the grid and the grid was re-screened using XRF for lead. The process was then repeated. If confirmation soil sample analytical results indicated that lead was below the removal action cleanup levels, the grid was identified as passing. Passing grids were cordoned off, eliminating cross-contamination from heavy equipment and personnel until the grid could be backfilled.

Exposure to Lead

As a consequence of the exposure to lead at Tyndall Elementary School, in June 24, 2009 parents were advised to have their children receive complimentary blood lead test. The Air Force and the Bay County Health Department offered the testing. Parents were given a state of Florida standard Lead Poisoning Prevention Questionnaire (Bay County 2010).

"A total of 102 children had their blood lead tested from June 26 to September 10, 2009. That only represents 13% of the total population of children attending Tyndall Elementary School. The half-life of lead in adult human blood has been estimated to be from 28 days to 36 days. This means that once in the blood stream, it takes roughly one month for blood levels to decrease by half the value once exposure has stopped. Children were tested more than 28 days after exposure was prevented by instruction and the installation of orange plastic safety fencing in April 2009. Therefore, it is only possible to detect a high exposure level in a small percent of children" (BCDOH 2010).

Eighty-nine children ranging in age from 3 to 13, received blood lead testing at Tyndall Air Force Base medical center. Blood levels ranged from 1 to 6 ug/dl. Two children had blood levels at 3 ug/dl. Two children had blood levels at 6 ug/dl indicating that the children were exposed to lead from some undetermined source. Neither child was living in a home built before 1978. Even though results of the blood lead tests indicated that no child had a blood lead level at or above CDC's recommended level of 10 ug/dl, ATSDR recommended that the Air Force follow-up with these families to try to identify the source of lead exposure and to reduce further exposures (Health Consultation 2012). Thirteen of the 102 children, ranging in age from 6 to 11, were tested at the Bay County Health Department. Blood levels ranged from non-detectable to 4 ug/dl. There were two children with blood lead levels at 3 and 4 ug/dl, respectively. The families of all children tested for lead received educational material about lead, lead sources, and how to reduce potential exposure to lead (Health Consultation 2012).

Lead Prevention Program

The Lead Contamination Control Act of 1988 authorized the Center for Disease Control and Prevention (CDC) to initiate program efforts to eliminate childhood lead poisoning in the United States. As a result of this act, the CDC childhood Lead Poisoning Program was created, with primary responsibility to: develop programs and policies to prevent childhood lead poisoning; educate the public and health departments to determine the extent of childhood lead poisoning by screening children for elevated blood levels, helping to ensure that lead-poisoned infants and children receive medical and environmental follow-up, and developing neighborhood-based efforts to prevent childhood lead poisoning; and support research to determine the effectiveness of prevention efforts at federal, state, and local levels. CDC collects elevated blood lead data on children less than 6 years old from the Childhood Blood Level Surveillance program from each state (Health Consultation 2012). Data from the program show that national averages of blood lead levels have been steadily decreasing over time. The national average percent of children with elevated blood lead levels in 2007 was 1% of the children tested, which is down from 7.6% in 1997. "The national average blood lead level for children 1 to 5 years old of age was 1.9 ug/dl in 2002" (CDC 2005).

Between 1960 and 1990, the blood lead level for individual intervention in children was lowered from 60 ug/dl to 25 ug/dl. "In 1991 CDC recommended lowering the level for individual intervention to 15 ug/dl and implementing community lead poisoning prevention activities in areas where many children have Blood lead levels above 10 ug/dl" (CDC 2005).

Activities, such as taking an environmental history, educating parents about lead, and conducting follow-up blood lead monitoring were suggested for children with blood lead levels above 10 ug/dl.

According to the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP), low level lead exposure harms children. This was identified in a report released in January 2012. Based on its conclusions that blood lead levels below 10 ug/dl harm children, the ACCLPP recommended "elimination of the use of the term "blood lead level of concern" and instead, the use of a reference value based on the 97.5^{th} percentile of the generated blood lead distribution in children age 1-5 years (currently 5 ug/dl) to identify children with elevated blood lead levels (Health Consultation 2012). These lower levels currently impact approximately 450,000 U.S children. Changes to CDC's policy would not have an impact for the Tyndall Elementary School lead contamination site because follow-up actions were taken with the families of the two children who had lead levels above 5 ug/dl, health education was provided to families, and lead contaminated soil was removed.

Recommendations

The ATSDR recommendations are listed below (Health Consultation 2012):

1. The Air Force should prevent children from accessing areas beyond the school fence. A buffer zone just beyond the school fence perimeter should be established and cleaned up to ensure that contamination does not directly or indirectly migrate onto the school grounds. Cleanup should begin in those areas where access cannot be controlled.

2. The Air Force should conduct semi-annual grounds inspection for lead shot, lead debris and upkeep to include adding up to 6 inches of clean sand to the high foot-traffic areas of the playground.
3. Public Health education for Tyndall Elementary School children and personnel should continue to help reduce the likelihood of harm from lead exposures. Parents should be informed that children may have brought lead shot or target debris home presenting a hazard to them and their sibling.
4. The Air Force and the Bay County Health Department should offer free annual blood lead testing for children attending Tyndall Elementary School. A testing day at the school to increase the percentage of participating students to at least 25% should be considered.
5. ATSDR is requesting the Air Force become environmental public health stewards by requesting that the Department of Defense notify all services that they should take prudent action to prevent children's exposures to lead shot at all schools, day care centers, homes, or playgrounds located near former shooting ranges. The notification should also stress that current environmental procedures might not assess the risk of acute lead poisoning.
6. ATSDR recommends that all Department of Defense entities adopt the Interstate Technology and Regulatory Council (ITRC) recommendations for the characterization and remediation of Soils at Closed Small Arms Firing Ranges.
7. Additionally, ATSDR recommends instituting the following procedures at former shooting ranges and other metal debris areas:

a. Identification, characterization, and quantification of lead shot and metal debris.

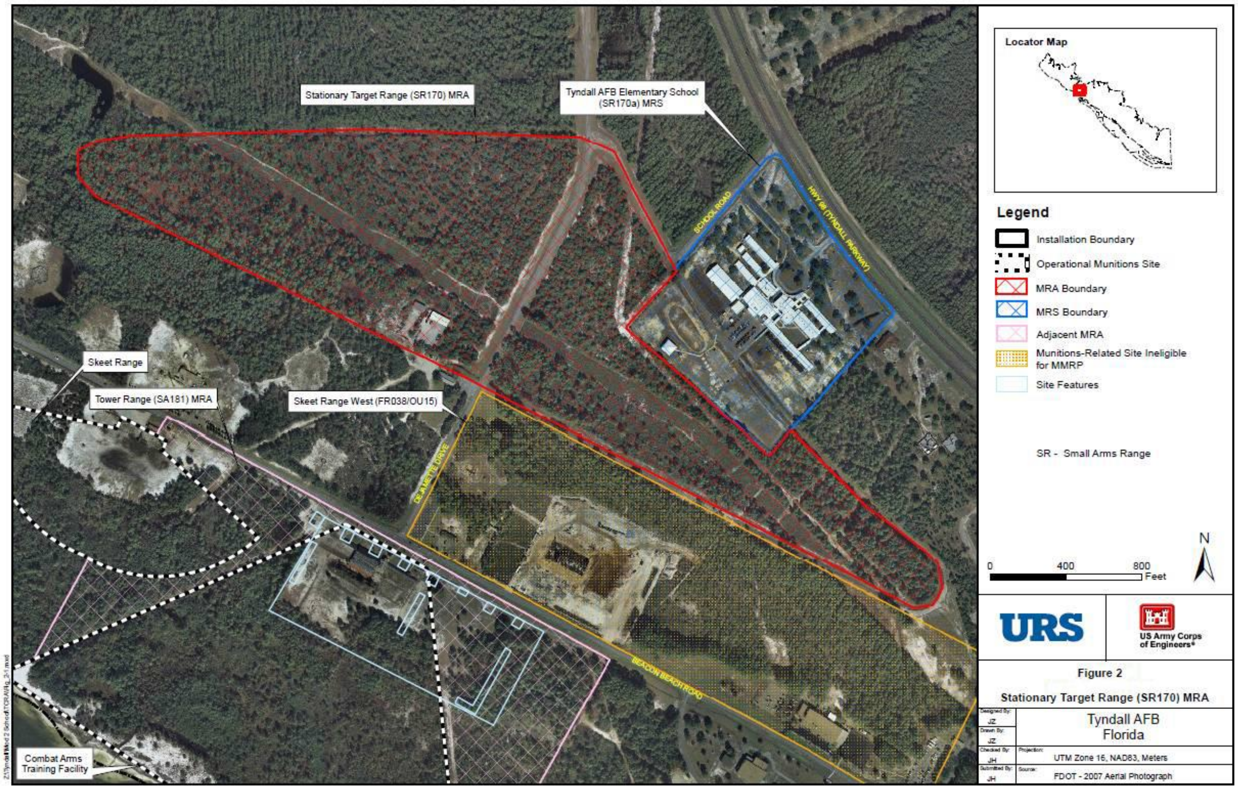
b. Semi-annual review and removal of lead shot containing soil after ground disturbing activities such as sidewalk replacement, road paving, maintenance, renovation, or construction as these activities may bring lead shot and debris to the surface where children may come in contact with them.

c. Provide or post continuous education on the lead hazards present for all users.

Conclusion

The Lead shot and lead fragments found on the Tyndall Elementary School grounds presented an urgent public health hazard to children who may have ingested the lead shot prior to the removal action. The Time Critical Removal Action was warranted. While most of the lead shot and fragments have been removed along with sand and soil, a small amount of lead shot may still remain on the school grounds under sidewalks and near utility conduits. Remaining lead shot may be brought to the surface during ground disturbing activities such as sidewalks repairs, road paving, and maintenance, renovation, and construction such that children may come in contact with such items. ATSDR cannot determine the impact that lead shot in the playground has had on the Tyndall Elementary School students because of the low numbers of children tested and the delay from the time of possible exposure to the time when blood testing was conducted. Additionally, soil sampling methods did not take into account the direct ingestion pathway of lead fragments. Therefore, the analytical results did not sufficiently represent the nature of the hazards at former small arms ranges such as Tyndall Elementary School where the potential for direct poisoning of injury to children existed.

Figure 4.1 Stationary Target Range overlapping Tyndall Elementary School property1*



*(Health Consultation 2012)

Table 4.1 Comprehensive Site Evaluation Sampling Summary2

Depth (feet bgs)	Samples>400 mg/kg/samples at Depth	Average Lead Concentration (mg/kg)	Geometric Mean Lead Concentration (mg/kg)	Percent Above 400mg/kg*
0.5	19 / 175	226	77	10.8
1.0	18 / 175	168	56	10.2
1.5	2 / 44	118	51	4.6
2.0	1 / 6	435	65	16

*EPA standard bare residential soil. (Health Consultation 2012).

Chapter 5 - General Conclusion

The Environmental Protection Agency guidance for corrective action at facilities provides screening levels to be used as a tool to define a level of lead contamination above which there may be enough concern to warrant further site specific study. The memorandum sets a screening level in soils of 400 mg/kg, below where no corrective action is recommended, and a screening level in soils of 5000 mg/kg, above which corrective action is recommended. Remediation goals should be developed to be protective of receptors consistent with planned future land use.

The Department of Defense environmental restoration program utilized the superfund at Beale Air Force for Munitions Response Program to clean up seven small arms munitions sites. They were able to dispose of tons of contaminated soil using methods recommended by the DERP. The excavated soil was replaced with new soil and the land was restored for future land use. Further testing then confirmed the absence of toxic levels of lead-contaminated soil or airborne lead dust.

The Tyndall Elementary School Health Assessment at the school grounds presented an urgent public health hazard to children who may have ingested the lead shot prior to the removal action. While most of the lead shot and fragments have been removed along with sand and soil, a small amount of lead shot may still remain on the school grounds under sidewalks and near utility conduits. The ATSDR was not able to determine the impact that lead shot in the playground has had on the Tyndall Elementary School because of the low number of children tested and the delay from the time of possible exposure to the time when blood testing was conducted. Over the years the Air Force have been able to educate the military community on health hazards in the base facilities especially lead exposure and have been able to implement programs dedicated to prevent any lead overexposure.

The field use of X-ray fluorescence (XRF) allows for soils to be examined with a hand held instrument. Since garden sites and play areas can be investigated inexpensively, this should be done on Air Force Bases because lead may be present from past activities. If lead contamination is observed, further testing should be done. One of the future projects the Air Force should implement as part of the Installation Restoration Program should be phosphate amendments to mitigate risks from exposure to lead in soils. The rationale for amending soils with phosphate is that the addition of phosphate will promote formation of highly insoluble lead species, such as pyromorphite. The formation of pyromorphite thereby reduces the risk of lead leaching through soils into drinking waters and absorption by soil and it remains inaccessible to physiological transport in the gastrointestinal system following incidental ingestion by humans.

The first step in the Air Force Base facilities Lead Program should be the development of the base management plan. An effective and successful management plan cannot be developed unless the long-term and short-term objectives are identified. This will require a commitment of all players involved such as Civil Engineering, Bioenvironmental Engineering, Public Health, etc. Worker protection is also an important aspect of the in-place management program. It is essential that all workers involved in reducing lead in soil hazards receive training in the hazards of lead, proper procedures and work practices, and the need for protective equipment and proper hygiene. Great care must be exercised to protect workers from excess lead exposures and to prevent them from taking lead dust home on their clothing or belongings.

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