Environmental Health and Safety: Wisconsin Playground Heavy Metal Soil Survey

By: William Harriman

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Masters of Science in Occupational Environmental Health and Safety

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Wisconsin Playground Heavy Metal Soil Survey

By

William A. Harriman

The University of Wisconsin-Whitewater, 2013

Under the Supervision of Dr. Todd Loushine (Thesis Advisor)

Abstract:

The Wisconsin Department of Public Instruction (WDPI) administers environmental education programs supervised by the Wisconsin Department of Natural Resources (WDNR). These programs are meant to increase public awareness and knowledge about environmental problems, while educating the public with the necessary skills to make informed decisions and take responsibility. These environmental education programs encourage the development of outdoor learning laboratories and instructional gardens that teach students how to become engaged environmental stewards. These programs are focused to reduce the use and availability of heavy metal inside schools thus increasing the systems overall environmental health and safety. However these programs unintentionally overlook school playgrounds as plausible routes attributing to childhood heavy metal exposures.

Literature review identified that playground soils are plausible reservoirs that attribute to the heavy metal exposures endured by children. A method was created and determined to represent a viable means of predicting soil contamination. The method was confirmed by completing a soil survey of 33 Wisconsin school playgrounds. Information was collected that documented the schools original date of construction in conjunction with the schools geographic classification (rural, suburban, or urban). Environmental sampling was conducted and analyzed by portable x-ray fluorescence (pXRF) spectrometry. EPA method 6200 served as the blue print which established the observed level of heavy metal contamination found at each site. The data generated was specific to display the observed levels of Arsenic (As) and Lead (Pb) in parts per million (ppm).

Initial results indicated of the 33 playgrounds explored 100% of them had a detectable level of As, and 97 % of them had a detectable level of Pb. Although the data was not able to support prior literature and further establish that playground soils are plausible reservoirs of heavy metal contamination. The data did provide information that supports the existence of the urban metal island phenomena.

Acknowledgements:

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I also want to thank Geography and Geology Department Chair Peter Jacobs Ph.D., who graciously granted me access to the required lab space and equipment.

I to extend a professional courtesy to the DNR who provided me with the list of PLT/GHS participating schools, along with all of the participating schools, teachers, principals and engineering staff that aided this project in various ways.

Finally, I want send warm regards to my mother and brother, the UWW Biological Sciences Department, the Wisconsin State Lab of Hygiene, the Wisconsin Department of Public Instruction and Ryan Perroy, Ph.D.

TABLE OF CONTENTS:

List of Figures:

List of Tables:

Chapter 1

Introduction:

The United States has made tremendous progress in protecting the health of children by substantially reducing the point sources associated with lead (Pb) exposures (Filippelli and Laidlaw, 2010). In 1998, it was determined that our everyday use of metals has altered the planets geochemistry and the main locations of accumulation can now be observed in the built environments (Mielkel et al., 1998). These built environments are represented as those constructed structures we live, work, learn, play and entertain in. These built environments have contributed in part to the creation of "urban metal islands" (Davies, 1992). An urban metal island is analogous to the urban heat island, and refers to the observed environmental deposition of heavy metals in the immediate area. Although lead is one of the better understood heavy metals in terms of uptake and toxicological effect (Filippelli and Laidlaw, 2008), it has been demonstrated playground soils are probable reservoirs of Lead (Pb) contamination. These heavy metal reservoirs represent a plausible route leading to childhood exposures and may explain the observed blood lead levels (Filippelli and Laidlaw, 2010).

Efforts to identify possible routes associated with Pb exposures have prompted researchers to declare, they have come to a dead end and hit a wall in terms of being able to improve and reduce the rate of lead-poisoning in America (Filippelli and Laidlaw, 2010). A 1994 study expressed a need to develop strategies to identify the most vulnerable risk groups in order to reduce lead exposure in the United States (Brody et al., 1994). In 1998, Mielkel et al. stated "When the role of contaminated soil and dust are acknowledged as an important pathway of human exposure, more effective opportunities to improve prevention can become a reality". It has been determined over the last decade that one known source of lead found inside the home originates from contaminated dusts and soils that have been tracked in from various sources from outside of the home (Laidlaw et al., 2005, Hunt et al., 2006).

Scott et al., in 2012 using portable X-Ray Fluoresce (pXRF) spectrometry sampled soils from 11 school playgrounds in Louisiana, they expressed concern and the need to protect children from the Pb determined to be in those soils. Historically, lead has been found in the paint covering lockers, windows and in some cases outdoor bleachers and other playground equipment (Morgan, 2013). The observed contamination is considered to be a deposited from combination of our societies past use of leaded gasoline and Pb-based paints that have deteriorated from exterior surfaces. Lead based paints were banned by the EPA in 1978. The Clean Air Act of 1990 mandated the elimination of lead from all domestically consumed gasoline by January 1, 1996. This statement is however in accurate, the gradual reduction of lead from gasoline began in the early 1970s, but "unleaded gasoline" produced and consumed in America today is allowed to contain 5/100ths of a gram of lead per gallon (EPA, 2013).

The debate about the source of Pb found in interior dust is critical because Pb poisoning in children cannot be eliminated until the primary source has been identified (Elwood, 1984; Kurkjian and Flegal, 2003). When lead is deposited in soil from anthropogenic sources, it does not biodegrade or decay and is not rapidly absorbed by plants, so it remains in the soil at elevated levels; lead is estimated to have a half-time of residence in soil of 1,000 years" (Benninger et al., 1975). "EPA estimates that 23 percent, or 18 million, of the privately owned homes in the United States built before 1980 have soil-lead levels above 400 parts per million (ppm); that 3 percent, or 2.5 million, have levels exceeding 2,000 ppm; and that 3 percent, or 2.5 million, exceed 5,000 ppm" (EPA, 1996).

The more than two decades of research has yet to yield substantial progress or put into place adequate protections that safeguards American children. The literature review promotes that the phrase "the solution to pollution is dilution" remains the de facto standard.

Efforts initiated by the United Nations in the 1970's, accepted that our world had enough scientific evidence to support the creation of Environmental Education (EE) programs. These EE programs are meant to educate the public while encouraging them to take responsibility. The programs were intended to take preemptive steps and protect human health. The evolution of the EE curricula began with the adoption of the Stockholm Declaration in 1972 (http://legal.un.org/avl/ha/dunche/dunche.html). This Declaration was focused on the Human and the Environment, the document was comprised of 7 proclamations and 26 principles. These proclamations and principles where meant "to inspire and guide the peoples of the world in the preservation and enhancement of the human environment." The Belgrade Charter of 1975 (unesdoc.unesco.org/images/0001 /000177/017772eb.pdf), followed by the Tbilisi Declaration of 1977 (http://www. eenorthcarolina.org/tbilisi_declaration.pdf), continued to lay the foundation that prompted the US Congress to create the National Environmental Education Act of 1990 (http://www2.epa.gov/sites/production/files/documents/neea.pdf). These concepts were strengthened further in 1992 by the Rio Declaration and especially, Principle 15. That principle reads," In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm).

During the aforementioned EE curricula evolution, the U.S. Department of Education and their combined partners continued to encourage and strengthen policy that enhanced the development of environmental educational programs. These concepts are integrated in practices promoted by the National Environmental Education Foundation and the Office of Environmental Education, an office of the US-EPA (US Environmental Protection Agency). The various programs promoted by EE practitioners attempt to take preemptive and assertive steps to protect American children from various hazards and/or unintended chemical exposures. The shared goals of the EE programs intend to provide an environmental education curriculum that "Increases public awareness and knowledge about environmental issues or problems, and in doing so, provides the public with the necessary skills to make informed decisions and take responsible action" (http://www2.epa.gov/education). In essence, this statement can be interpreted to mean these partners have agreed and attempt to design and implement curriculum that can assess, correct, control and prevent factors in the environment from adversely affecting public health.

Project Learning Tree (PLT) and the Green and Healthy School (GHS) initiatives are two examples of EE programs presented by the US Department of Education and the National Environmental Education Foundation. PLT is a nationwide environmental service-learning program developed and provided by the American Forest Foundation in partnership with their 50-state PLT network, the U.S. forest service, The Corporation for

National and Community Service, and many other national, state, and local partners including the US Department of Education (https://www.plt.org/about-project-learning-tree-greenschools-program). The GHS program is administered in Wisconsin by the Department of Public Instruction (WDPI) and supervised by the Wisconsin Department of Natural Resources (WDNR). The GHS website publishes that Green & Healthy Schools Wisconsin is a "one-stop-shop" for resources and information that supports the transformation of learning environments that increases the health and environmental literacy of participating schools. Through the GHS program, schools can find support to get started or continue to move forward while receiving local and national recognition for implementing the suggested green and healthy measures. These measures include integrating environmental education into the standard curriculum, upgrading to efficient fluorescent lighting fixtures, expanding recycling efforts and reducing the use of chemicals and lab materials containing heavy metals (http://eeinwisconsin.org/core/item/page.aspx?s=110995.0.0.2209).

This project focused on schools participating in the Green and Healthy School (GHS) program. The GHS program is designed to be a web-based, voluntary, self-monitoring program (http://eeinwisconsin.org/net/org/info.aspx?s=110993.0.0.2209). Participants are required to complete and submit a twenty-two page, on-line self-assessment (http://eeinwisconsin.org/Files/eewi/2013/2013GHSApplication_forplanning.pdf). This online self-assessment does not document what year the school was originally constructed, nor does the assessment request and/or recommend any type of environmental sampling based on geographic classification (rural, suburban, urban). The GHS program curriculum does however place emphasis on the development of outdoor learning laboratories and/or instructional agricultural gardens. Despite the intention of program developers, they do not document information to establish whether a prospective school has the possibility of playground soils containing heavy metals. Are EE program developers inadvertently overlooking prior literature by not acknowledging the possibility that playground soils are undiscovered reservoirs of lead contamination (Brody et al., 1994, Mielkel et al., 1998, Laidlaw et al., 2005, Hunt et al., 2006, Filippelli and Laidlaw, 2010)?

It is the researcher's intention, that data produced by this project is used in efforts to expand the current GHS on-line self-assessment. This expansion includes the development of questions that address the need to identify and account for the possibility of playground soils being contaminated with heavy metals. This revised environmental health and safety assessment offers the potential to enhance the already commendable efforts initiated by GHS program administrators. The prescribed method offers program participants and administrators the means to collect information that yields a site specific snap shot to identify schools having the greatest potential for having heavy metal contamination. When the enhanced method of evaluation triggers a specific set of assigned parameters they initiate a protocol that promotes a need to investigate a sites playground via low cost environmental analysis. The identifiers employed by the method of evaluation include the documentation of the buildings original construction date paired with its geographical classification. This geographic classification is defined and identified as rural, suburban or urban. This geographic classification is completed by referencing historical data that provides a consistent means and justification of the classification assigned.

The completion of project began with the evaluation of 33 Elementary and Middle school sites throughout the state of Wisconsin; all of these sites were participating in the GHS program as of Sept 1, 2013. (Note: at the time of the project, the GHS program was in a state of restructuring, thus a combination of information specific to participant progress was extrapolated) Information obtained from WDPI (Wisconsin Department of Public Instruction) and WDNR (Wisconsin Department of Natural Resources) between August 1, 2012 and November 30, 2013 was used to complete the list documenting the schools progress in the tiered GHS program. The method began by documenting the buildings original construction date, in conjunction with the schools geographic classification identified as rural, suburban or urban. These actions were followed by the collection of 4 geographically unique soil samples harvested from the topsoil of the corresponding schools playground. These soil samples were analyzed utilizing pXRF (portable X-ray Fluorescence) spectrometry. The main focus of the project was to ascertain if Pb (lead) could be detected in Wisconsin playground soils, however as a secondary observation the level of As (arsenic) were documented. The research method followed protocols set forth and approved by EPA method 6200, a method specific to sampling topsoil via pXRF spectrometry.

The project assumed that there is no safe level of Pb that can be observed in playground soils, thus the expected background level of lead is of an un-detectable limit (UDL). The project also assumed that As levels would not exceed the global average reported background level of 5-7.2 ppm.

Hypotheses:

HØ1: School playground soils do not contain soil Pb above the expected background level.

HØ2: School playground soils do not contain soil As above the expected background level.

HØ3: There is no difference in soil Pb concentrations among Rural, Suburban, or Urban schools.

HØ4: There is no difference in soil As concentrations among Rural, Suburban, or Urban schools.

HØ5: There is no difference in soil Pb concentrations among step 1, step 2, step 3, or step 4 schools.

HØ6: There is no difference in soil As concentrations among step 1, step 2, step 3, or step 4 schools.

The data generated by this project were initially averaged and then analyzed via an array of statistical methods including single factor Anova, Linear Regression, and when appropriate the Tukey's a posteriori test was applied.

It is the hope of this researcher that project data be used to expedite further exploration of any playground found to contain unsafe levels of heavy metals. It is suggested any information presented by this project be utilized by Wisconsin Department of Public Health (WDPH). The WDPH could utilize the data to focus on sites having higher observed heavy metal topsoil contamination, in an effort to examine the blood lead levels of students and staff inhabiting those sites. The expanded data set could be used in order to determine if a public health impact is observed and to what extent.

Chapter 2

Justification/Background:

"Considerable efforts in the United States go into the assessment (monitoring and evaluation) of environmental factors associated with health, such as air quality, water quality, noise, solid waste disposal, housing, occupational conditions, and unsanitary surroundings" (Merrill, 2008). Yet, "An average of 4 people a day, are killed by acute exposure to hazardous substances. Birth defects kill an additional 35 babies daily, while cancer kills an additional 1300 Americans a day" (Goodman, 1991).

The EPA's published mission statement reads "to protect human health by safeguarding the air we breathe, water we drink and the land on which we live" (EPA, 1970 -2013). The National Research Council stated in 1980 that "Sometime in the near future it probably will be shown that the older urban areas of the United States have been rendered more or less uninhabitable" (NRC 1980, p. 271). The Department of Public Health publishes statistics that list children living in urban areas throughout the U.S., predominately in the East and Midwestern states, have lead poisoning rates of 15–20% above the norm (NHANES 2003). It has also been acknowledged that soil pollution is a threat throughout the world (Makino et al., 2010).

"The physiological absorption potential for lead is dependent mainly on age: the portion of ingested lead that is taken up in the body is typically less than 5% for adults, whereas it is as high as 50% for children" (Maddaloni et al., 1998; Ziegler et al., 1978; Filippelli and Laidlaw, 2010). Chronic exposure to lead (Pb) can cause mental lapses, nervous system and kidney damage, learning disabilities, poor muscle coordination, hearing damage, hypertension and decreased muscle and bone growth (EPA 1993, 2003;

Morgan, 2013). A study published by Needleman et al. in 1990, linked neurobehavioral problems associated with chronic low level Pb exposures in children contributing to lower IQ, reduced vocabulary and grammatical reasoning skills, increased absenteeism, and problematic behavior.

Arsenic (As) is a widely distributed metalloid that occurs naturally in rock and soil (Parsons et al., 2013). It is considered to be ubiquitous in the environment, often accumulating in the "A" horizon of the pedosphere. The global average level of As found in soil ranges between 5 and 7.2 ppm (Matschullat, 2000). The smelting of non-ferrous metals and the use of fossil fuels are the two major contributors that increase the observed As levels found in the air, water and soil (WHO, 2001). As is a well-known toxin and carcinogen (Parsons et al., 2013), historically found in schools across the country having outdoor wood products that were treated with arsenic-based preservatives intended to protect those products from rot and decay (Gardner et al., 2012). In 2004, the EPA removed arsenic from pressure treated wood products classifying them for non-residential applications only (Rahman et al., 2004). Gardner et al., in 2012 found in a similar school soil survey that arsenic levels in topsoil of 7 of the 11 schools surveyed were found to be above the state screening limit of 75 ppm. Absorption of arsenic in inhaled airborne particles is highly dependent on the solubility and the size of particles (WHO, 2001). Chronic exposure to metalloids like arsenic can lead to mental lapses, kidney, liver, and GI tract problems. It has also been known to induce skin lesions and adversely affect the central nervous system (Soil Survey Staff, 2000, Morgan, 2013).

It has been found the practice of soil abatement, although useful in certain areas, does not significantly decrease the potential for heavy metal exposures linked to negative human health outcomes (Farrell et al., 1998). Regulatory limits on heavy metals as applied to soils published by the EPA as of 2013, document that the observed level of As and Pb in soil should not exceed 75 parts per million (ppm) and 420 ppm, respectively (EPA, 2013). The Clean Water Act publishes that drinking water should not exceed levels observed As and Pb of 41 ppm and 300 ppm, respectfully. These standards can be explored further by researching the standards promulgated under the EPA's Toxic Substances Control Act (TSCA) section 403 and cross referenced via 40 CFR part 745.

Suggestions published by the EPA and echoed by the USDA (United States Department of Agriculture) as of 2013 advise topsoil lead levels of 50 ppm or less require no special precautions be observed, 50-400 ppm should prompt individuals to observe safe gardening practices limiting dust and soil ingestion by children. While topsoil having an observed Pb level ranging between 400-1200 ppm should not be used to grow leafy green vegetables or root crops. When the observed Pb level exceeds 1200 ppm they advise no vegetable or root crop production period. Gardening practices are mentioned because EE programs like the GHS program promote the creation of outdoor learning laboratories that include the development of outdoor learning environments including instructional agricultural gardens (EPA-USDA, 2013).

September 2013, media coverage expressed new found concern for soil contamination at Coconut Grove Park, a city park located in Miami Florida. (http://www.miamiherald.com/2013/09/11/3621477/miami-to-take-more-soil-samples html). In the journal Environ Geochem Health (DOI 10.1007/s10653-007-9106-0) authors document extreme heavy metal contamination in the soils of South Park, located in the

Claddagh area of Galway City, Ireland. Similar studies have documented heavy metal contamination in city parks from Corpus Christi - Texas (http://www.caller.com/news /2010/nov/25/scientists-collect-dona-park-soil/) to Beijing - China, São Paulo - Brazil (DOI 10.1016/j.proenv.2011.03.035), Lam Thao and Phu Tho- Vietnam (DOI 10.3844/ajessp.2012.71.78), just to name a few.

The facts remain children spend a major portion of their developmental years in situations that have the potential for yielding unintended and/or undiscovered consequences. It is accepted that soil contamination is plausible via vehicle emissions, environmental deposition attributed from commercial, industrial and agricultural activities. That heavy metals, such as As and Pb are toxic to children and cause developmental problems and disease. It is also apparent the EPA, EE practitioners and school administrators want to protect children by preventing unintended exposure to heavy metals.

Children should play outside, simple assurances need to be made that establish that a child is protected and their immediate health and safety is paramount. Is it safe to gamble with a child's health and safety, should we promote or claim ignorance or is the determination and documentation of a schools playground soils advantageous? The Rio Declaration declares the precautionary approach shall be widely applied by States according to their capabilities, yet acknowledgment that playground soils are probable reservoirs of heavy metal contamination remain unexplored in Wisconsin. Literature identifies that incidental exposures are linked to soils containing heavy metals that are tracked into the built environment from various outdoor sources. These two potential sources of route exposure create an opportunity for these toxins to inflict harm to children. Soil particles that become attached to a child's hands, shoes or clothing must be considered.

School staff and EE curricula encourages children to play outside, to learn in outdoor laboratories and garden so they understand how and where their food comes from. It seems logical to take simple assertive steps to ensure playground soils are in fact free of heavy metal contamination. Could the method enhancements presented by this research increase the accountability and transparency of EE programs? Could adding questions to the current on-line self-assessment specific to documenting a schools original date of construction in conjunction with establishing a schools geographic classification (rural, suburban, or urban) be used to predict which soils have the greatest potential for having a detectable level of heavy metal contamination? Could the proposed program adaptations be used to enhance the programs while providing direction for future curriculum development?

This project assumed that there is no safe level of soil Pb that can be observed in playground soils. The EPA lists soil Pb levels in excess of 420 ppm require immediate action (EPA, 2013). The project also assumed that soil As levels would not exceed the reported background level of 5-7.2 ppm. The EPA lists soil As levels in excess of 75 ppm require immediate action (EPA, 2013). Principle 15 of the Rio declaration states," In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (UN, 1992).

Chapter 3

<u>Methods and Materials:</u>

The soil survey began with the collection of “A” horizon topsoil samples obtained from 33 Wisconsin Elementary and/or Middle school sites located throughout the state (Figures 1-2). This survey declares that there are no known potential sources of heavy metal contamination investigated. Each of the explored sites are represented by collection of a minimum of 4 geographically unique topsoil samples, which were harvested from bare and/or exposed soils only. Geographical depictions were created to show each site and where the corresponding soil sample was collected (See Appendix - figures are listed alphabetically by city).

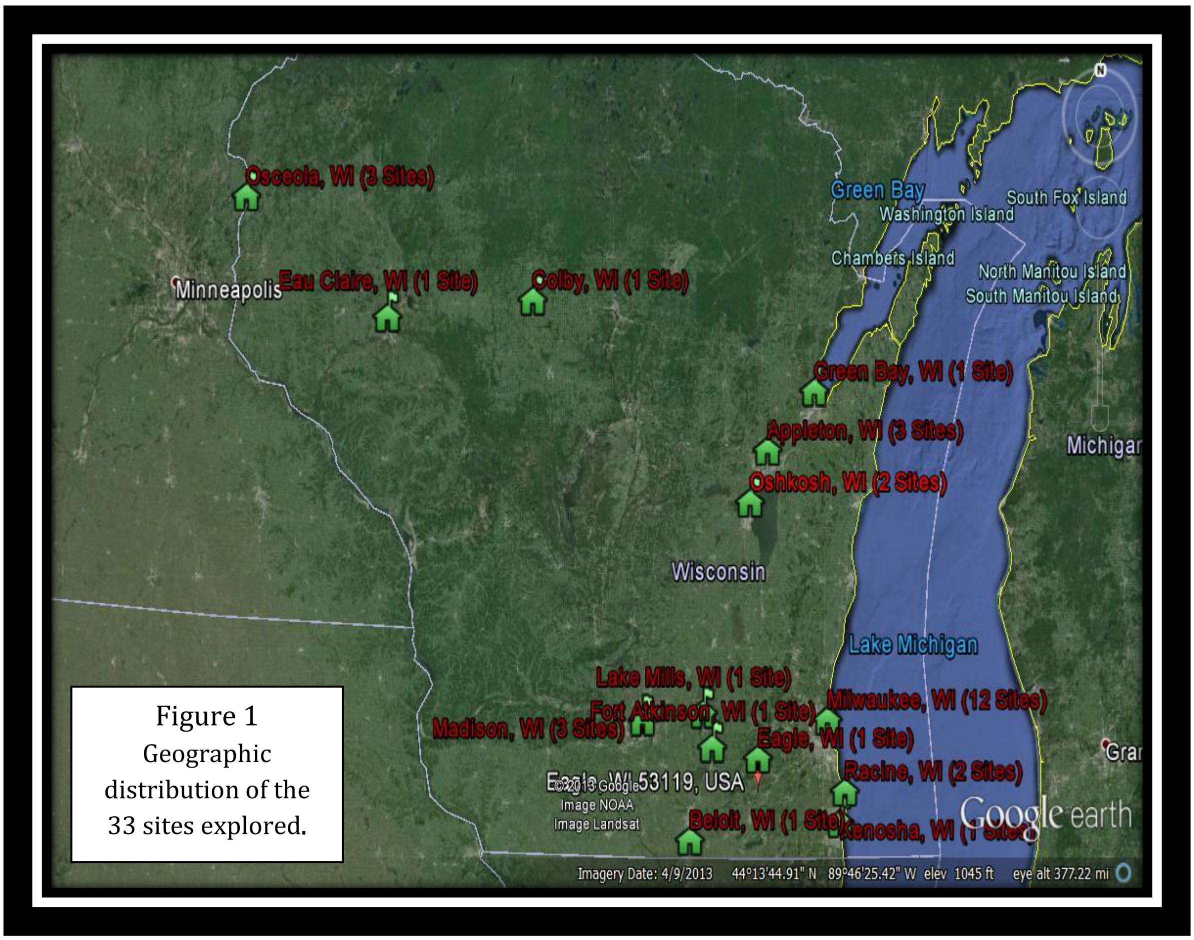


Figure 1
Geographic distribution of the 33 sites explored.

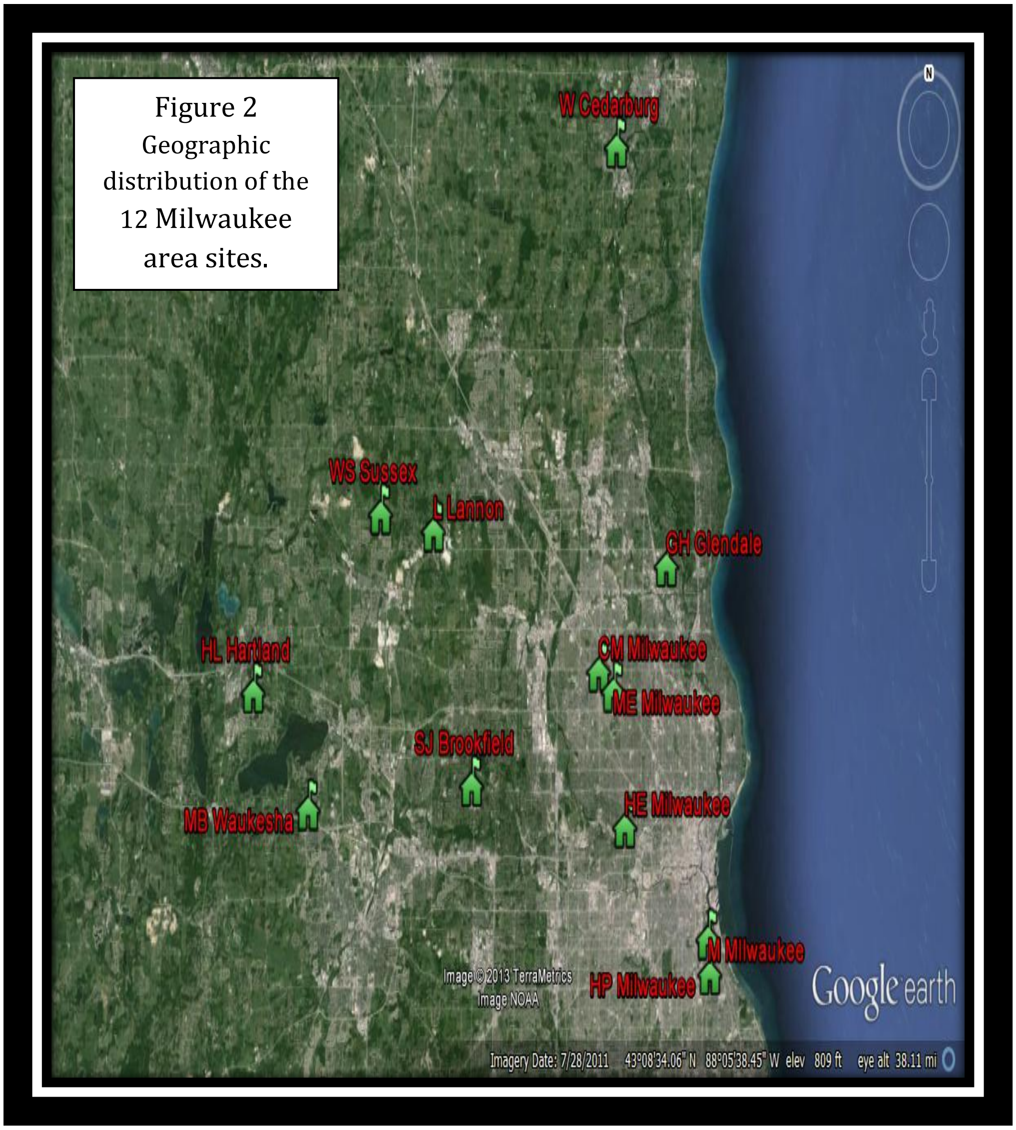


Figure 2
Geographic distribution of the 12 Milwaukee area sites.

The soil samples collected were evaluated and the data expressed to document the observed concentrations of heavy metals. The heavy metals of interest include Arsenic (As) and Lead (Pb). These metals were chosen specifically because the curriculum provided by GHS administrators is aimed at reducing their use and availability.

The soil samples were assessed for As and Pb by utilizing pXRF (portable X-ray florescence) spectrometry in accordance with EPA method 6200, the method specific to collecting and analyzing soil via pXRF. The pXRF analyzer was used to obtain rapid elemental analyses of the topsoil samples. Laboratory based XRF has been utilized for several decades during the analysis of major and minor elements in the fields of geochemistry, forensic science, and archaeology (Langford, 2005; Shackley, 2011). Portable XRF has several advantages when compared to other multi-elemental techniques such as inductively coupled plasma mass spectrometry (ICP-MS).The main advantage of pXRF analysis is that samples require limited preparation, it is non-destructive in nature, the analysis is rapid, there is zero hazardous waste produced, the system has a low start-up and running cost (Parsons et al., 2013).

The samples collected during this project required no field preparation except to be properly collected, bagged, identified and transported. The samples collected were prepared and analyzed in lab to insure consistent moisture and uniform particulate size. The data results were recorded specific to the heavy metal concentrations of As and Pb, the data generated were expressed and documented in ppm (parts per million).

The pXRF method was chosen by the researcher to conduct this study for several key reasons. First being that of convenience, the University of Wisconsin – Whitewater has a Bruker Tracer IV-SD pXRF analyzer available for use. The Department of Geography and Geology under the direction of Department Chair Peter Jacobs granted the researcher lab space and equipment access. Second, the method is nondestructive and cost effective. This was essential because the entire cost of the study was personally funded by the researcher. Third, the project required no special permits, site or state permissions. The researcher spoke directly to the WDNR and each school site individually to receive verbal permission prior to entering the property. Forth, after extensive literature review surrounding the proposed project, the researcher found the acceptance of pXRF as a viable means of data collection was considered to be sound and practical for the project.

Selection of the schools was completed by first obtaining a list of GHS participating schools from the WDNR (Wisconsin Department of Natural Resources) and the WDPI (Wisconsin Department of Public Instruction). The list provided by the WDNR and WDPI needed to be confirmed three times between August 1, 2012 and December 1, 2013. This confirmation was required due to the fact that at the time of the proposed project, the GHS program was being restructured to meet the guidelines of Project Learning Tree (PLT). With these issues acknowledged, I used a combination of information specific to a schools program progress that I accumulated over a 17 month period. The data collected constructed the list pertaining to a schools program progress and documented the current Step/Level observed at time of the investigation. The project focused on elementary schools, however for the sake of geographic variety, 6 middle schools and 1 pre-school were chosen for inclusion in the study. School sites were identified during the project by city, followed by the schools full name reduced to initials. Details of the site conversion can be viewed in the appendix, Table 3. The site conversion table is listed by city alphabetically followed by the sites initials. The full name of the institution, complete mailing address, and schools direct phone number are also listed.

This project acknowledges the potential for variability in the observed topsoil type found at each of the individual schools explored. For the purpose of this project the soil types found throughout the state of Wisconsin were considered similar. This determination was made because the basic composition of the topsoil's can be considered to be related glacial sediments. Also it is unlikely that any school would have sought to import topsoil from any source not be considered local, nor would the natural deposition of any topsoil deposited by run-off or seasonal flooding not be considered native. It is acknowledged that there is some variation of the topsoil composition induced by the parent material present, but these bedrock influences were not important for the purposes of this project thus remain undefined and undocumented. Each site explored will have information compiled that documents the date of original building construction, the schools geographic classification, alongside what Step or Level the school maintains in the GHS program (See Table 1).

Table1

GHS Program Details on Step/Level Progress and Completion

GHS program acceptance begins when a school agrees to sign the promisorry contract, this act enables them to enter the program, becoming a Sprout/Step 1 school.

New PLT Designation/Replaced GHS older Designation

- Sprout/Step 1
- Seedling/Step 2
- Sapling/Step 3
- Sugar Maple/Step 4

The process ends when a school reaches the Sugar Maple/Step 4.
As a school fulfills the ciricula as directed they progress up the steps of the program.
Steps can be completed simitainiously and do not need to be completed in order

As a means to justify the classification of rural, suburban, or urban, each site location was cross-referenced via historical aerial photography provided by the 1937 United States Department of Agriculture (USDA) state agricultural survey. This historical survey is accessed on-line through the University of Wisconsin Madison - Arthur H. Robison Map Library. This process is completed in attempt to provide justification on site classification. This classification is an attempt to develop a means of predictability that establishes the probability of problematic topsoil's typical to those geographic classes. The process begins when a school site is searched for and located on the interactive mapping website. Observers will note the apparent red dot; viewed adjacent to the site location, these dots represent the accessible aerial photography archive photos specific to the area of interest. When each archive file is accessed photos are classified as either urban, agricultural or water. When the site location is explored, each site found to be classified as an urban location, for the sake of simplicity remained classified as urban. When a site was found to be classified agricultural, but now is obviously a developed area, the site was classified suburban. Sites that were found to be agricultural and remain as a lesser developed area or remain predominately rural were classified rural. The Arthur H. Robinson Map Library – historical aerial photo maps can be accessed directly at http://www.geography.wisc.edu/maplib/aerial.html.

The topsoil sample collection protocol involved samples harvested from bare and/or exposed "A" horizon sources only. The samples were approximately 4 ounces (118 ml) each. The samples were obtained using a soil sampling kit. The kit contained a stainless steel pick, shovel and scoop. Cleaning of the tools between samples was achieved by wiping off each tool used with a non-filament producing cloth. The sample was placed into individually-wrapped sterile screw top polypropylene bottle and/or polypropylene soil sampling bag. The individual sample was identified by site name, sample number, and date of collection. All sample sites were depicted graphically utilizing Google Earth mapping software (see appendix). All of the collected samples were stored for transport and delivered to the University of Wisconsin – Whitewater Geography and Geology lab, for air drying, preparation and analysis.

The samples were air dried, rough ground with a mortar and pestle, (worked just enough to break up the large clumps), then passed through a number 10 - U.S. Standard Sieve (2mm mesh) to remove any foreign debris, such as rocks, sticks and/or twigs. The samples were then placed into SpectroCertified XRF sample cup No. 1530, utilizing No. 256 Mylar polyester film. Each of the sample cups were filled 2/3rds full, so that it could be shaken between analysis runs. Each of the samples analyzed were run three times at 240 seconds per run. Each of the four samples analyzed were averaged to produce the site contamination level observed.

The equipment utilized for this project was the Bruker Tracer IV (See Figure 3). The Bruker Tracer IV analyzer is considered one of the most flexible handheld pXRF analyzers on the market today (http://www.bruker.com/products/x-ray-diffraction-and-elemental-analysis/handheld-xrf/tracer-iv-series/overview.html). The analyzer uses Bruker's XFlash® Silicon Drift Detector (SDD) technology which features high count rate capability while retaining excellent resolution. The unit was configured for Standard Field Application-Analysis using the Pre-Programed Standard Library. The unit was configured via the following criteria; Type Function - Fundamental Parameters (FP), Method - Soil, Test Parameters set to Auto Timed Trigger – Duration 240 Seconds (4 Minutes) via Direct Data display on the attached PDA expressed in ppm. This configuration and time allotted assured maximum X-ray penetration and return producing the most accurate results with a minimum amount of error possible.

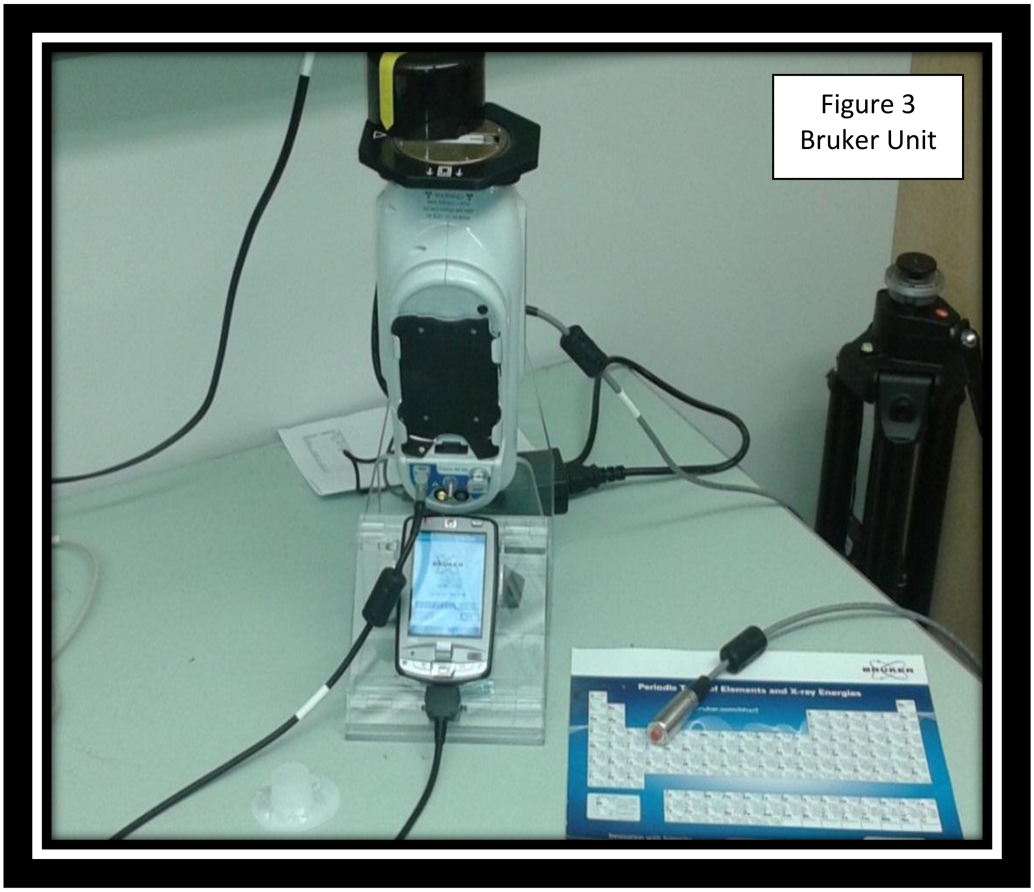


Figure 3
Bruker Unit

The validity of the standard library preprogramed into the Bruker unit will be assessed by analyzing NIST (National Institute of Standards and Technology) standard samples. These two standards will be representative as “positive control” samples. These samples include Montana soil 2711, batch 392306 and Montana soil 2710a, batch 485258. There will be two samples that will be representative as “negative control” samples. First, a sample of play sand obtained from the Biology Department Green House, which will be the Blank or Double Negative control. Second, a sample of protected topsoil obtained from Kettle Moraine State Forest, Ottawa Lake recreational area (42.93445400 N 88.45562800 W). This topsoil sample was provided by Geography and Geology Department Chair, Dr. Peter Jacobs. The Kettle Moraine State Forest (KMSF) sample is representative as the normal or expected pristine soil typical to Wisconsin. To view data associated with justifying calibration of the Bruker Tracer IV-SD series pXRF analyzer see appendix Table 3.

Data storage will be accomplished by means of the Bruker Tracer IV-SD which stores data directly on to the systems attached Personal Digital Assistant (PDA). The files are individually numbered, stored electronically and expressed in ppm on the PDA display. All of the created files are automatically backed-up via electronic transfer on to the PDA's attached Secure Digital Card (SD Card) as a Microsoft Excel file. As a precaution a laboratory note book was kept and updated with every soil sample analyzed, but for the purpose of this project the data were limited to document the values specific to As and Pb in ppm. All of the raw data and soil samples will be available upon request for three years (ending December 18, 2016).

The structure of the analyses will be specific to the hypotheses. The project assumed that there is no safe level of Pb that can be observed in playground soils, thus the expected background level of lead is of an un-detectable limit (UDL). The project also assumes that As levels would not exceed the reported background level of 5-7.2 ppm.

The Hypotheses:

HØ1: School playground soils do not contain soil Pb above the expected background level.

HØ2: School playground soils do not contain soil As above the expected background level.

HØ3: There is no difference in soil Pb concentrations among Rural, Suburban, or Urban schools.

HØ4: There is no difference in soil As concentrations among Rural, Suburban, or Urban schools.

HØ5: There is no difference in soil Pb concentrations among step 1, step 2, step 3, or step 4 schools.

HØ6: There is no difference in soil As concentrations among step 1, step 2, step 3, or step 4 schools.

The data generated by this project were initially averaged and then analyzed via an array of statistical methods including single factor Anova and Linear Regression, and when appropriate the Tukey's a posteriori test was applied.

Chapter 4

Results:

Beginning with a basic analysis of the initial data generated by pXRF indicate that of the 33 sites explored 100% of the topsoil samples had a detectable level of As and 97 % of the topsoil samples had a detectable level of Pb.

Because the method called for a minimum of 4 geographically unique topsoil samples to be collected from the 33 sites, (excluding Beloit M, where 5 topsoil samples were collected) a grand total of 133 topsoil samples were collected and analyzed by pXRF. Of those 133 total topsoil samples, 100% of them had a detectable level of As and 78.9% of them had a detectable level of Pb. The method created a total of 399 data values when the 133 topsoil samples were analyzed three times in succession. During the process of analysis 5 extra data values were created by human error, this error resulted in a grand total of 404 data values available for statistical analysis. Of the 404 total data values produced 100% of them had a detectable level of As and 64.86% of them had a detectable level of Pb.

Further analyses of the topsoil samples proceeded by following the parameters identified by the defined direction for either confirming or rejecting the HØ hypotheses.

The Hypotheses:

HØ1: School playground soils do not contain soil Pb above the expected background level.

HØ2: School playground soils do not contain soil As above the expected background level.

HØ3: There is no difference in soil Pb concentrations among Rural, Suburban, or Urban schools.

HØ4: There is no difference in soil As concentrations among Rural, Suburban, or Urban schools.

HØ5: There is no difference in soil Pb concentrations among step 1, step 2, step 3, or step 4 schools.

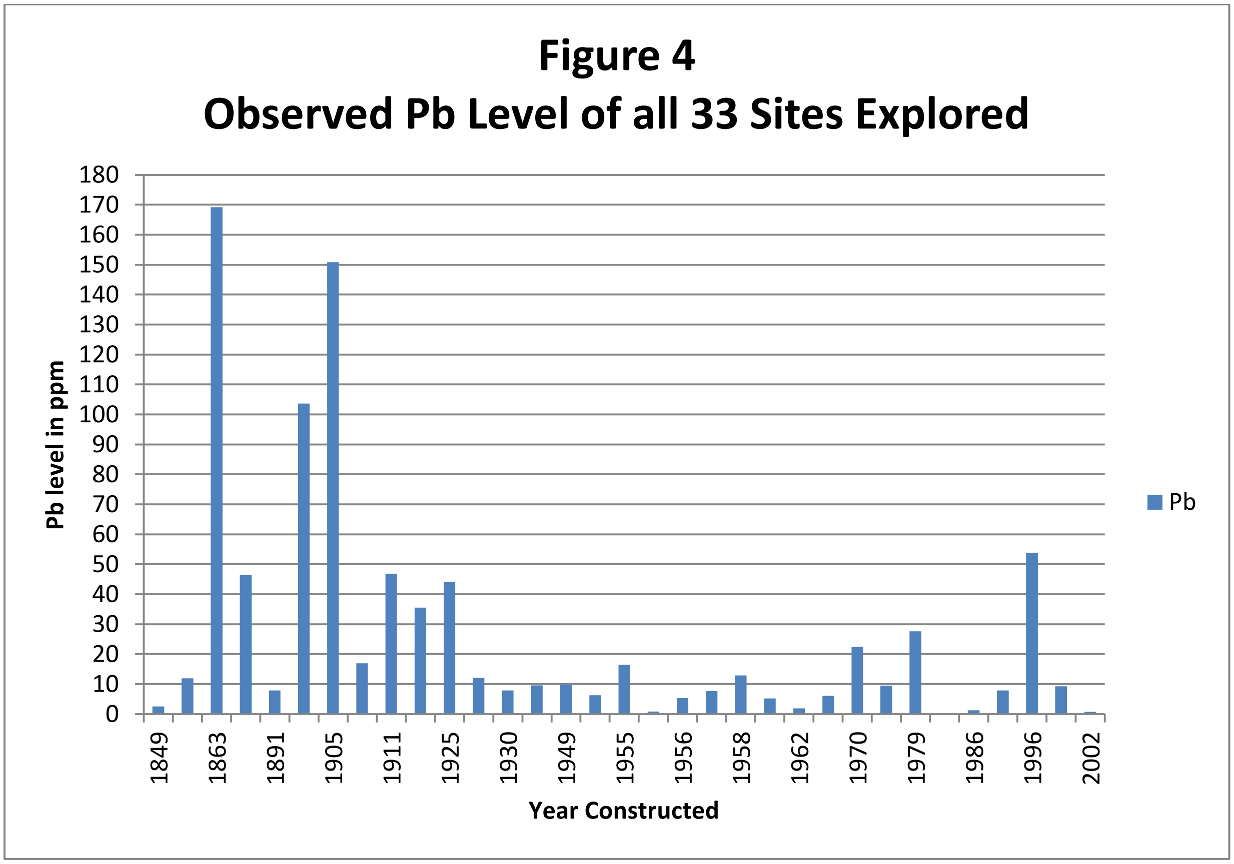
HØ6: There is no difference in soil As concentrations among step 1, step 2, step 3, or step 4 schools.

Hypothesis investigation began by ascertaining the observed averaged values for both As and Pb. The 404 data values were first averaged to produce the observed site average. This process was completed by ascertaining site averages obtained by calculating observed levels produced by the original 4 or 5 topsoil samples. This process reduced the data set to represent the observed site average level of As and Pb for each of the 33 sites included in this project. These observed site average values were used to confirm or reject the hypothesis investigated.

HØ1: School playground soils do not contain Pb above the expected background level.

The project assumed that there is no safe level of Pb that can be observed in playground soils, thus the expected background level of lead is of an un-detectable limit (UDL). The rational and justification of this statement is confirmed by the analysis of the negative control samples referenced during this project. The analysis of the blank control sample (play sand) referenced Pb levels to be of an undetectable limit (UDL). The analysis of the pristine or expected control sample (Kettle Moraine State Forest) referenced Pb levels to be an UDL.

The HØ1 hypothesis was rejected. The data indicate that soil Pb can be indeed detected in 97% of the Wisconsin playground topsoil's analyzed. The levels of Pb observed indicated that Wisconsin playground soils have detectable range of Pb to be between UDL and 503 ppm. The observed soil Pb level observed representative of the site average produces a range between UDL and 177 ppm (See Figure 4).



Across all schools the initial data indicate that only 1 site had soil Pb level at UDL, 14 sites had an observed soil Pb range between UDL and 20 ppm, 7 sites had an observed soil Pb range between 20 and 40 ppm, 2 sites had an observed soil Pb range between 40 and 60 ppm, 4 sites had an observed soil Pb range between 60 and 80 ppm, 1 site had an observed soil Pb range between 80 and 100 ppm, 2 sites had an observed soil Pb range between 100 and 200 ppm, 1 site had an observed soil Pb range between 200 and 300 ppm, 1 site had an observed soil Pb range between 300 and 400 ppm, and 1 site had an observed soil Pb range between 400 and 520 ppm.

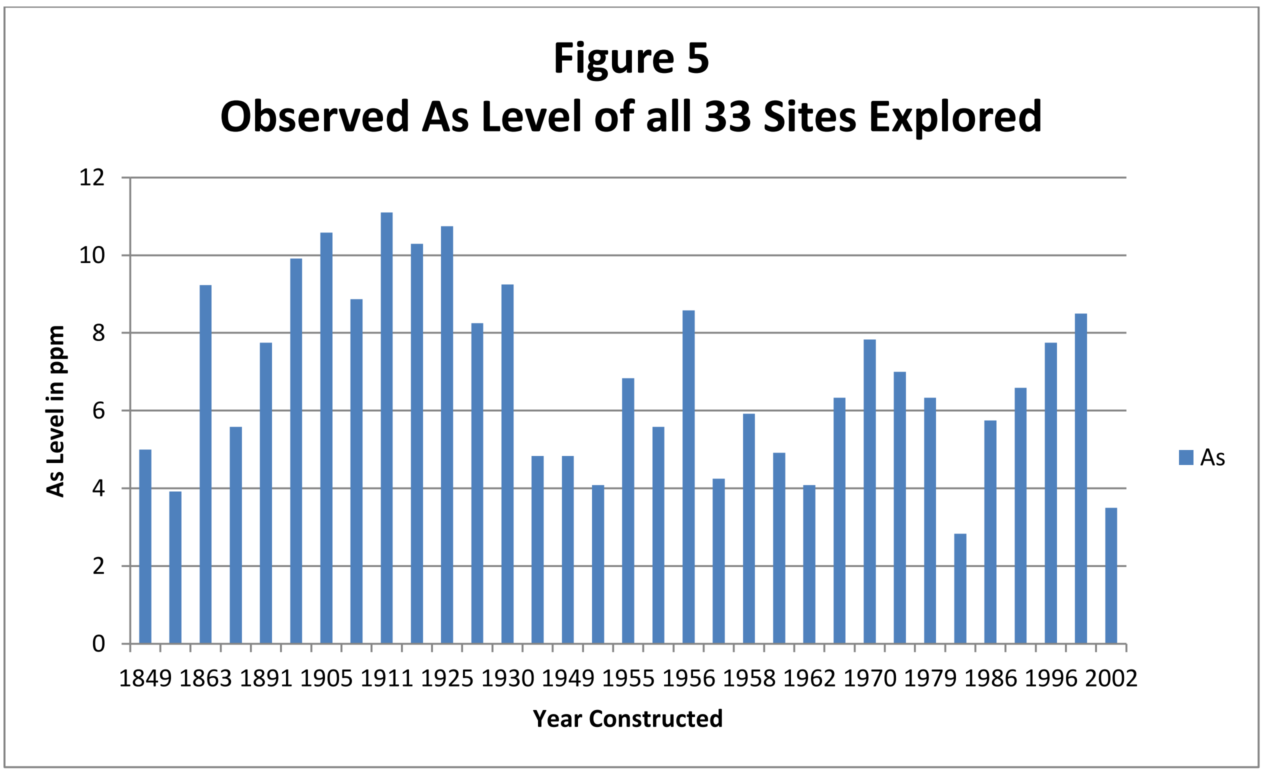
A closer look at the initial data indicates Osceola OM was the only playground to have a soil Pb level at UDL. This observation suggests that it is possible to find school playgrounds that are soil Pb free in Wisconsin.

The two highest soil Pb levels observed were produced by Milwaukee HE and Racine W. In reference to Milwaukee HE it was determined that one of the four soil samples collected generated a soil Pb value greater than the EPA action level of 420 ppm. The sample obtained from Milwaukee HE sample site 1 produced an observed soil Pb range between 443-503 ppm. Further review of the data indicate that Milwaukee HE has an observed soil Pb range between 13 and 503 ppm, these values produce a soil Pb site average of 151 ppm. Racine W was found to be the most uniformly contaminated site. The four soil samples produced a soil Pb range between 93 and 370 ppm. Further review of the data indicates that soil sample site 1 produced an observed soil Pb level range between 104-115 ppm, soil sample site 2 between 154-329 ppm, soil sample site 3 between 143-370 ppm, and soil sample site 4 between 93-147 ppm. When these observed soil Pb levels were averaged the observed site average of soil Pb was calculated to 177 ppm.

HØ2: School playground soils do not contain soil As above the expected background level.

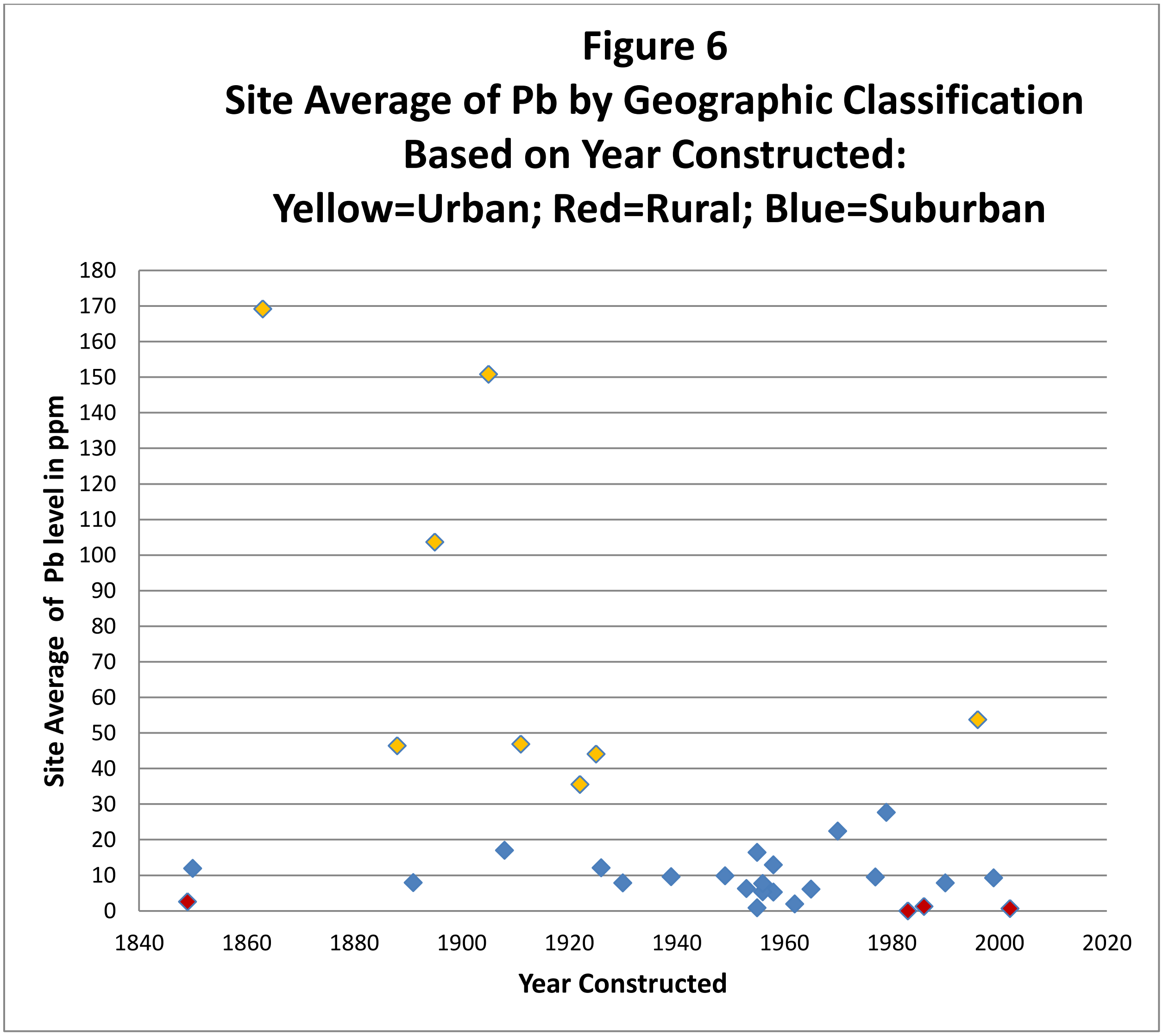
This project assumed that there would be no observed level of As above the expected background level. The rational and justification of this statement is confirmed by the analysis of the negative control samples referenced during this project while acknowledging the documented global average. The negative control samples (Play sand and Kettle Moraine State Forest) used in this project indicated As to be UDL in the play sand sample, while the KMSF sample produced an observable range between 5-9 ppm (Average 6ppm). Recall the global observed average for As is documented to be in an observed range between 5-7.2 ppm.

The HØ2 hypothesis was rejected. It was determined 51.6% of the sites explored had detectable As levels above the global average of 7.2 ppm. These data suggest that As levels are below global estimates in only 48.4% of the sites investigated (See Figure 5).

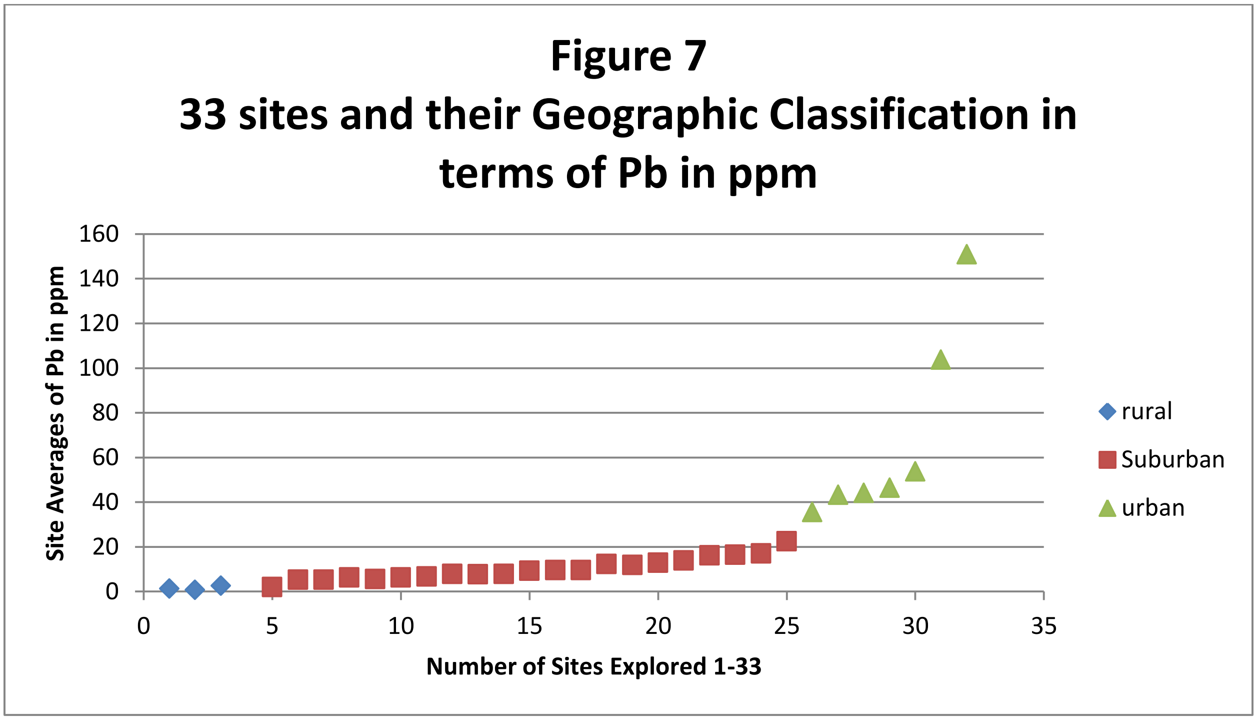


HØ3: There is no difference in soil Pb concentrations among rural, suburban, or urban schools.

HØ3: hypothesis was rejected. Single factor Anova for Pb levels indicated there was a statistically significant difference among sites located in rural, suburban, or urban locations ($F_{2, 130}$= 29.96 p≤ 1.98654E-11). Tukey's analysis was completed in order to determine where the significant difference could be observed. The analysis confirms the significant difference can be observed between 2 of the 3 groups. A significant difference exists between rural vs. urban and suburban vs. urban but was not observed between the rural vs. suburban groups (See Figure 6).

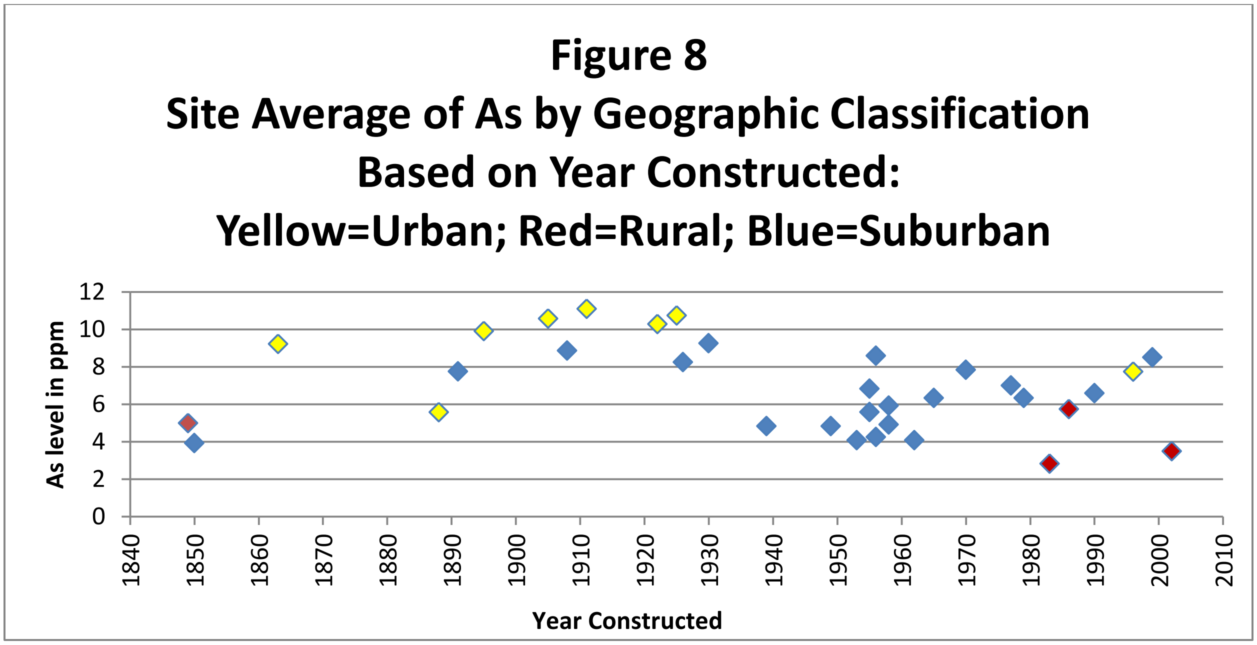


Linear regression analysis comparing construction date to the observed average Pb content suggests a degree of predictability exists in sites located in rural, suburban, or urban locations ($R^2 = 0.1927$). The R^2 value indicates the older the site, the higher the soil Pb value (See Figure 7).

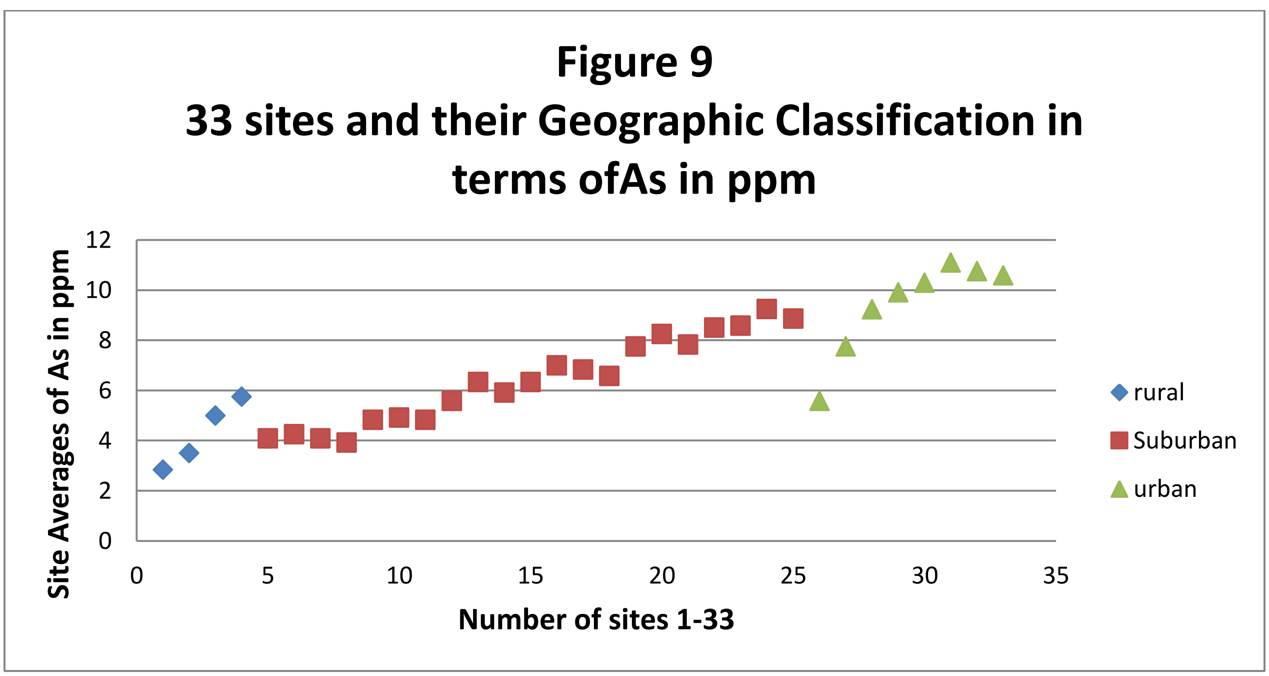


HØ4: There is no difference in soil As concentrations among rural, suburban, or urban schools.

HØ4: hypothesis was rejected. Single factor Anova for As levels indicated there was a statistically significant difference among sites located in rural, suburban, or urban locations ($F_{2,\,130}$= 22.73 p≤ 3.41806E-09). Tukey's analysis was completed in order to determine where this significant difference could be observed. The analysis confirms the significant difference can be observed between all three groups. A significant difference exists between rural vs. urban and rural vs. suburban and suburban vs. urban (See Figure 8).



Linear regression analysis comparing construction date to the observed average As level suggests a degree of predictability exists in sites located in rural, suburban, or urban locations ($R^2 = 0.0718$). The R^2 value indicates the older the site, the higher the soil As value (See Figure 9).



HØ5: There is no difference in soil Pb concentrations among step 1, step 2, step 3, or step 4 schools.

HØ5: Hypothesis was confirmed. Anova single factor for soil Pb levels indicate there was no significant difference in soil Pb levels among step 1, step 2, step 3, or step 4 schools ($F_{3, 125} = 2.65$ $p \leq 0.05$).

HØ6: There is no difference in soil As concentrations among step 1, step 2, step 3, or step 4 schools.

HØ6: Hypothesis was confirmed. Anova single factor for soil As levels indicate there was no significant difference in soil As concentrations among step 1, step 2, step 3, or step 4 schools ($F_{3, 125}=1.33$ $p \leq 0.26$).

Chapter 5

Discussion:

At this point the project only confirms that although detectable levels of As were observed in 100% of the school soils surveyed, none of the sites produced soil As concentration levels greater than the EPA action level of 75 ppm. The project also confirms that although detectable soil Pb levels were consistently observed in the majority of the school soils surveyed, none of the sites when averaged had detectable Pb levels greater than the EPA action level of 420 ppm. However the data do suggest the need to explore two sites further, Milwaukee ME and Racine W. These sites produced observed peak levels of soil Pb to be 503 ppm at Milwaukee ME and 370 ppm at Racine W, these levels warrant further investigation. Of all the 33 sites included in the survey these two sites present the greatest possibility of inducing unintended harm to children. Special precautions should be considered, for example immediately informing those schools of the probable risks associated with topsoil contamination and unintended exposure.

It is suggested that all of the geographically classified sites listed as urban require further exploration. These sites include Milwaukee HE, Racine W, Oshkosh S, Milwaukee HP, Milwaukee M, Racine RM, Eau Claire LS and Kenosha D. All data produced in reference to these sites further support the existence of the urban metal island phenomena and should be explored further. Glendale GH, Milwaukee ME, Waukesha MB, and Sussex WS are the geographically classified suburban sites determined to have soil Pb levels greater than 40 ppm. It is suggested that these sites be explored as soon as time and resources allow so that the true extent the soil Pb contamination can be documented. The remaining 21 sites explored in the course of this project all produced observable soil Pb levels to be less than

40 ppm. These sites require no further exploration unless some future event or circumstance encourages those sites to explore the extent of soil Pb level contamination on their own accord. However as a precaution these sites should be provided access to an expanded curriculum that informs staff to the risks and associated with exposing children to problematic topsoil's.

The data generated by this project justifies the need for the development and implementation of an enhanced environmental health and safety curriculum. A curriculum that informs school administrators and academic staff on the required precautions that must be observed if they want to reduce the possibility of children being exposed to heavy metals. This project highlights that problematic topsoil's have been found to be representative of a plausible route of exposure. This declaration must be addressed, monitored and remedied. The state and EE program administrators are obligated to develop a curriculum as soon as possible. The implementation of the curriculum must be a priority if program administrators intend to reduce the possibility of children being exposed to heavy metals during outdoor activities including those involved with outdoor laboratory exercises and instructional agricultural activities. The goal of the yet to be developed curriculum should be to limit the exposure and ingestion of problematic topsoil's by children.

The project indicates that since Osceola OM was the only site to have soil Pb levels observed at UDL, that it is conceivable that other schools in the state can achieve Pb free playgrounds. Because soil Pb levels were observed at detectable levels in the majority of the school playgrounds, this fact alone should stress the need to explore, identify, monitor and when necessary provide guidance and/or fiscal assistance to remedy the possible hazards associated with problematic soils.

The researcher would like to emphasize that the data identified a similar trend across all of the sample sites. When the data is observed in relation to the location of the where the greatest soil Pb levels are observed they all seem to be located at or near bus drop-off and pick-up site. A logical question to investigate next would be to ascertain if these locations are actually and/or have been historically where the bus drop-off and pick-up site is/was located. The answer to that question may explain why levels seem to have this visible trend. Further exploration would include documenting if the diesel fuels used by the bus companies still contain detectable levels Pb and at what concentrations.

It can be said, this project and its intention of providing a plausible method to provide a means for EE program administrators to identify schools with problematic soils has been achieved. The suggested expansion of the on-line self-assessment to include implementing the addition of questions that collect information specific to when the school was originally constructed, in conjunction with the sites geographic classification does offer a potential for providing the means to identify schools with problematic topsoil's. The no cost method of identification offers GHS program administrators a fiscally manageable and easily implemented protocol.

The suggestion of developing a curriculum which specifically educates school staff on the risks posed by the existence of problematic topsoil's, is substantiated and seems a logical requirement. Together these actions could help ensure students continue to enjoy EE program suggestions associated with outdoor learning laboratories and instructional agricultural gardens. Simultaneously the preliminary data suggests a true need to expand an environmental sampling protocol and strongly urge EE program administrators to seek and find the means to expand those efforts.

The WDPH (Wisconsin Department of Public Health) may consider devoting resources to test students blood lead levels of sites where the greatest concentrations of Pb where observed. This specific resource devotion could refute the possibility that site soils are attributing a notable negative effect on the health and safety of the child.

Chapter 6

Conclusion:

The completion of this project enabled me to expand my understanding of environmental health and safety field and lab work. Fulfillment of the obligation to plan and complete the project in conjunction with the experience obtained through the numerous professional interactions was invaluable to my personal growth as an environmental health and safety scientist.

The developed method for which offers the potential to accurately predict the level of heavy metal contamination of any given school playground, simply by documenting the sites geographic classification in conjunction to buildings original date of construction has the potential to alter current understanding of playground sols. The method offers EE curriculum developers a viable means to focus on sites having the greatest potential for soil contamination while securing the health and safety of the greatest number of children possible. The project established a need for the development and implementation of EE program curriculum that specifically educates school staff on the precautions that should be observed when problematic soils are present.

The WDPI could employ this method in stages while seeking to expand a curriculum to add it to their existing tool box. The proposed tool box expansion has the potential to provide an alternative means that charts EE program progress while expanding accountability and transparency. Together these protocols could go a long way to protect Wisconsin children from unintended heavy metal exposures, and if widely applied could be accessed by the WDPH.

The data generated by this project will be used first to educate the schools that participated in the project. School administrators will be informed to the results specific to their schools, recommendations and possible resources and curriculum direction will also be proposed. School administrators will be informed that the developed method can be used by anyone and the schools should prepare public relations to address the questions that may be posed by concerned parents as a preemptive precaution. The simple act of acknowledgement of the potential threat will minimize the probability of media coverage and possible legal action induced by fear. A suitable action plan that limits the potential of exposure in conjunction with a practical hand washing policy that actively reduces the possibility a child will ingest food immediately after activities associated with outdoor learning seems prudent.

The next step for this project includes seeking grant funds to expand and refine the developed method. A closer look at urban areas like Beloit which contain numerous schools in all three geographic classifications seems ideal. This process could be repeated in communities like Madison and Milwaukee. Once this objective is complete a closer review of prior land use and historical records specific to residential, commercial or industrial use would be collected in attempt to further refine the method. Information specific to the explored communities would be requested from the WDPH. Information would include obtaining the observed blood lead levels of the children playing on the grounds explored. This process has the potential to establish that playground soils are a route of exposure the medical establishment seeks to identify.

The pXRF spectrometry unit and the EPA method 6200 used during this project provided invaluable professional experience that I found to be exceptional. The developed method and Bruker Tracer IV provided a simple yet effective means that justified the method that was ultimately proven by the data produced by this project. Further refinement and justification is required but the initial data provided does have the potential to yield substantial progress that may prove the existence of urban metal islands while documenting there influence on playground soils.

Budget:

Direct XRF supplies	$476.80
Sampling kit and collection equipment	$224.56
XRF training	$498.64
Car rental	$206.41
Total fuel costs for 1272 driven miles in 6 days	$116.15
Hotel accommodations	$552.37
Food costs during travel	$456.28
Undergraduate student assistance for multiple tasks	$200.00
Total Direct Cost	$2731.21
Researcher Laboratory Labor Hours (72 at 10.00 per)	$720.00
Grand Total Cost of Research	$3451.21

The total work devoted to the project by the researcher exceeded 280 labor hours.

(The Total Direct Cost was paid for by the researcher without fiscal assistance from the University or any other Grant Source.)

(Cost of thesis publication including purchase of 20lb. 25% cotton stock and cd-r disc cost approximately $50.00)

(Note: As of September 16, 2013 the researcher paid out of pocket expenses totaling $2731.21)

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Appendix:

Figures identifying each individual are presented alphabetical order by city. Each site includes a depiction of the school surveyed, included on the map is reference to soil sample location noted by numerical designation. Immediately under the site map is the sites construction date, current program standing (Sprout/1, Seedling/2, Sapling/3, Sugar Maple/4) followed by the geographic classification (Rural, Suburban, Urban). One table and one graph expressing data generated followed by a small descriptive paragraph entailing site analysis and related suggestions.

Appendix Key:

Bruker PDA/SD File # - references the specific file stored in the Bruker IV-SD unit PDA – SD Card.

Soil Sample ID – references the soil sample harvested and correlates to the map of site.

As (PPM) – documents the observed level of As (Arsenic) in PPM.

As (PPM) Site Average –Site Average calculated utilizing the observed data.

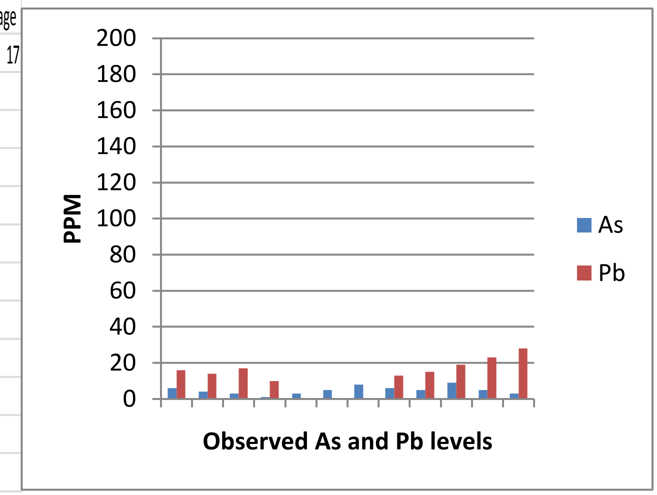
Pb (PPM) – documents the observed level of Pb (Lead) in PPM.

Pb (PPM) Site Average – Site Average calculated utilizing the observed data.

(Appleton FRA J)

Constructed: 1949 – Sugar Maple/Step 4 - Suburban

Bruker SD/PDA File #	Soil Sample #	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
265	1	6	5	16	17
266	1	4		14	
267	1	3		17	
268	2	1		10	
269	2	3		UDL	
270	2	5		UDL	
271	3	8		UDL	
272	3	6		13	
273	3	5		15	
274	4	9		19	
275	4	5		23	
276	4	3		28	

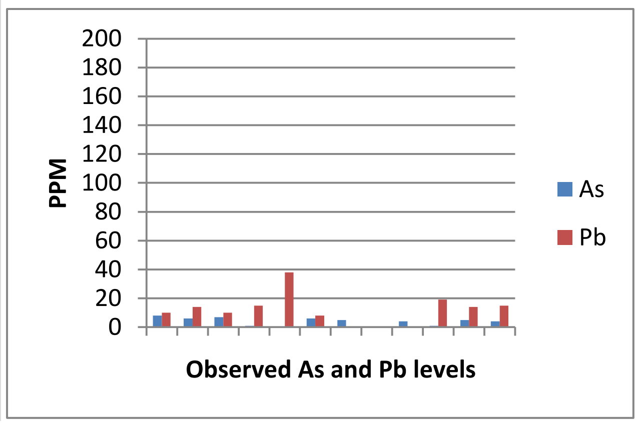


Appleton FRA J: The site has As levels present in ranges of 3 ppm – 9 ppm. The site average for As is calculated at 5 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 28 ppm. The site average for Pb is calculated at 17 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Appleton HS)

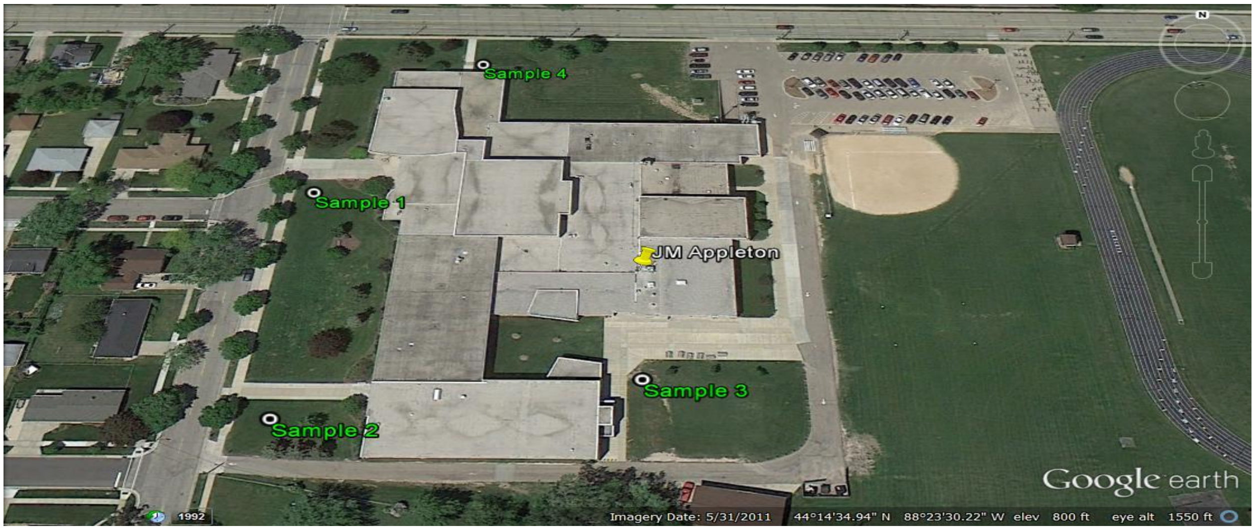
Constructed: 1850 - Sapling/Step 3 – Suburban

Bruker SD/PDA File#	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
253	1	8	5	10	16
254	1	6		14	
255	1	7		10	
256	2	1		15	
257	2	UDL		38	
258	2	6		8	
259	3	5		UDL	
260	3	UDL		UDL	
261	3	4		UDL	
262	4	1		19	
263	4	5		14	
264	4	4		15	



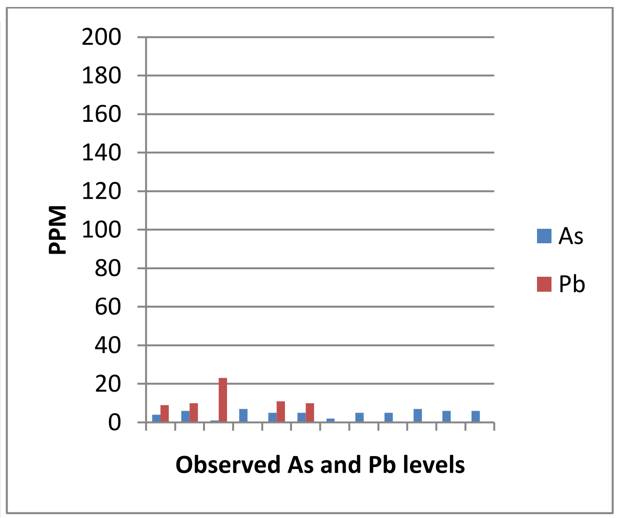
Appleton HS: The site has As levels present in ranges of 1 ppm – 8 ppm. The site average for As is calculated at 5 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 38 ppm. The site average for Pb is calculated at 16 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Appleton JM)



Constructed: 1958 – Sapling/Step 3 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
389	1	4	5	9	13
390	1	6		10	
391	1	1		23	
392	2	7		UDL	
393	2	5		11	
394	2	5		10	
395	3	2		UDL	
396	3	5		UDL	
397	3	5		UDL	
398	4	7		UDL	
399	4	6		UDL	
400	4	6		UDL	

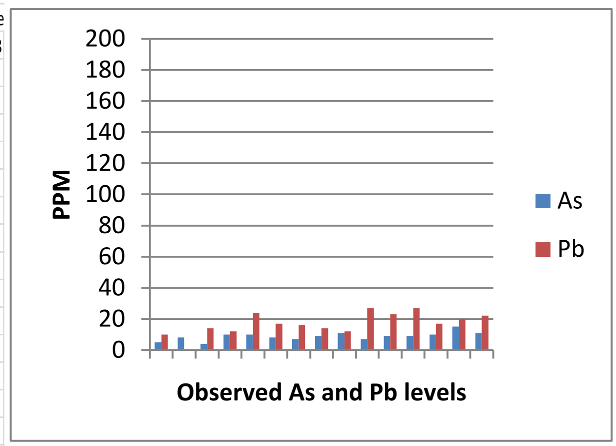


Appleton JM: The site has As levels present in ranges of 1 ppm – 7 ppm. The site average for As is calculated at 5 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 23 ppm. The site average for Pb is calculated at 13 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Beloit M)

Constructed: 1908 – Sprout/Step 1 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
238	1	5	9	10	18
239	1	8		UDL	
240	1	4		14	
241	2	10		12	
242	2	10		24	
243	2	8		17	
244	3	7		16	
245	3	9		14	
246	3	11		12	
247	4	7		27	
248	4	9		23	
249	4	9		27	
250	5	10		17	
251	5	15		20	
252	5	11		22	

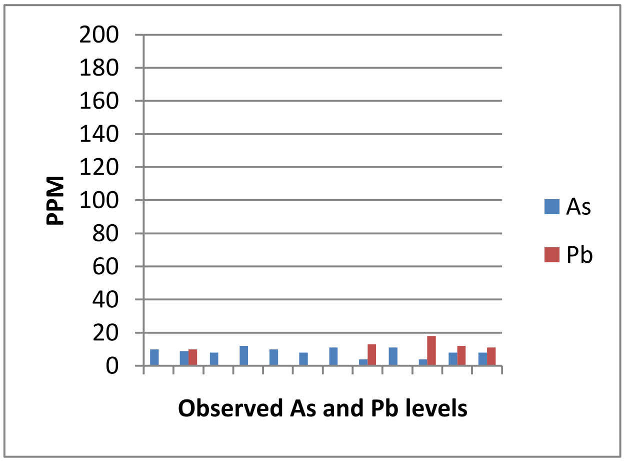


Beloit M: The site has As levels present in ranges of 4 ppm – 15 ppm. The site average for As is calculated at 9 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 27 ppm. The site average for Pb is calculated at 18 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Brookfield SJ)

Constructed: 1956 – Sapling/Step 3 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
141	1	10	9	UDL	13
142	1	9		10	
143	1	8		UDL	
144	2	12		UDL	
145	2	10		UDL	
146	2	8		UDL	
147	3	11		UDL	
148	3	4		13	
149	3	11		UDL	
150	4	4		18	
151	4	8		12	
152	4	8		11	

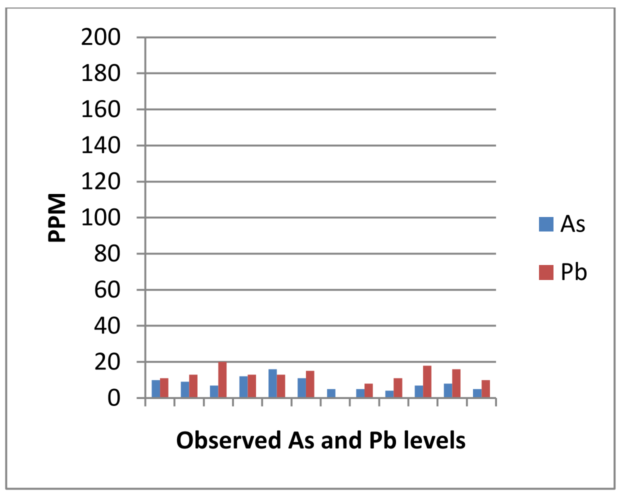


Brookfield SJ: The site has As levels present in ranges of 4 ppm – 12 ppm. The site average for As is calculated at 9 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 18 ppm. The site average for Pb is calculated at 13 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Cedarburg W)

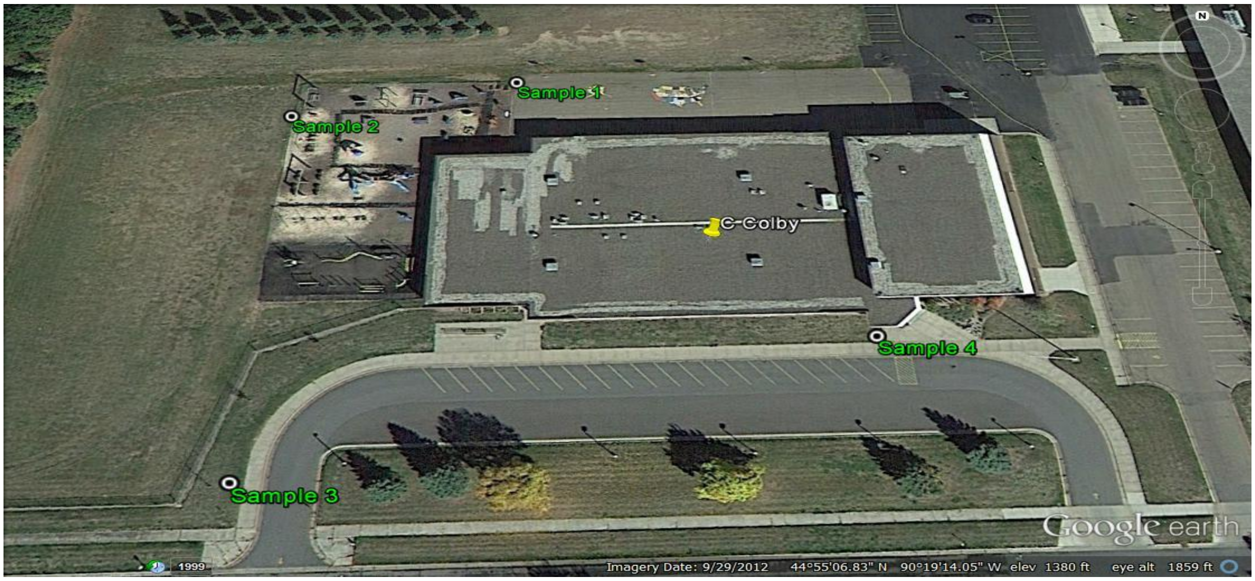
Constructed: 1926 – Sugar Maple/Step 4 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
93	1	10	8	11	13
94	1	9		13	
95	1	7		20	
96	2	12		13	
97	2	16		13	
98	2	11		15	
99	3	5		UDL	
100	3	5		8	
101	3	4		11	
102	4	7		18	
103	4	8		16	
104	4	5		10	



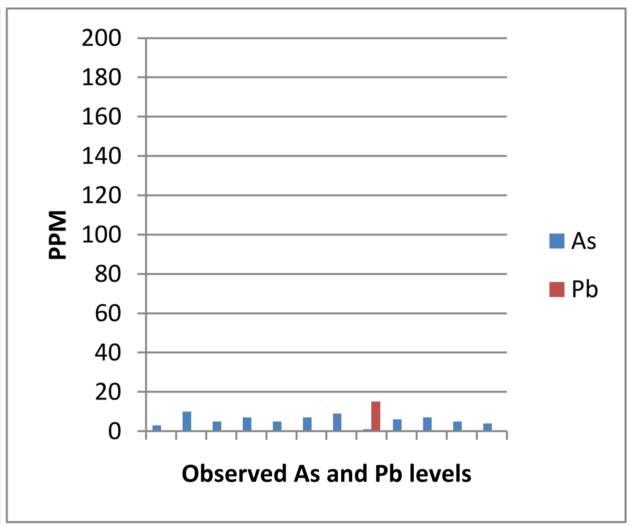
Cedarburg W: The site has As levels present in ranges of 4 ppm – 16 ppm. The site average for As is calculated at 8 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 20 ppm. The site average for Pb is calculated at 13 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Colby C)



Constructed: 1986 – Sugar Maple/Step 4 - Rural

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
313	1	3	6	UDL	15
314	1	10		UDL	
315	1	5		UDL	
316	2	7		UDL	
317	2	5		UDL	
318	2	7		UDL	
319	3	9		UDL	
320	3	1		15	
321	3	6		UDL	
322	4	7		UDL	
323	4	5		UDL	
324	4	4		UDL	

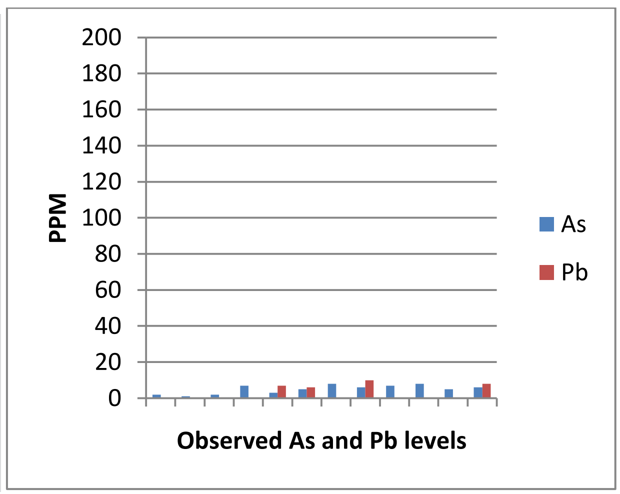


Colby C: The site has As levels present in ranges of 1 ppm – 10 ppm. The site average for As is calculated at 6 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 15 ppm. The site average for Pb is calculated at 15 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Eagle EC)

Constructed: 1849 – Sapling/Step 3 - Rural

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM)	Pb (PPM)	Pb (PPM) Site Average
449	1	2	5	UDL	8
450	1	1		UDL	
451	1	2		UDL	
452	2	7		UDL	
453	2	3		7	
454	2	5		6	
455	3	8		UDL	
456	3	6		10	
457	3	7		UDL	
458	4	8		UDL	
459	4	5		UDL	
460	4	6		8	

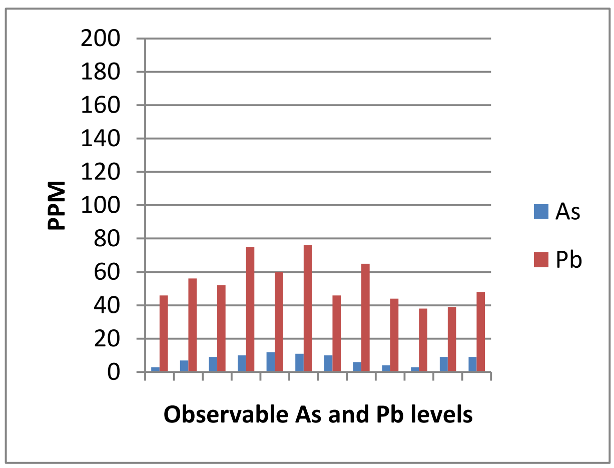


Eagle EC: The site has As levels present in ranges of 1 ppm – 8 ppm. The site average for As is calculated at 5 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 10 ppm. The site average for Pb is calculated at 8 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Eau Claire LS)

Constructed: 1996 – Sapling/Step 3 - Urban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	AS (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
325	1	3	8	46	54
326	1	7		56	
327	1	9		52	
328	2	10		75	
329	2	12		60	
330	2	11		76	
331	3	10		46	
332	3	6		65	
333	3	4		44	
334	4	3		38	
335	4	9		39	
336	4	9		48	

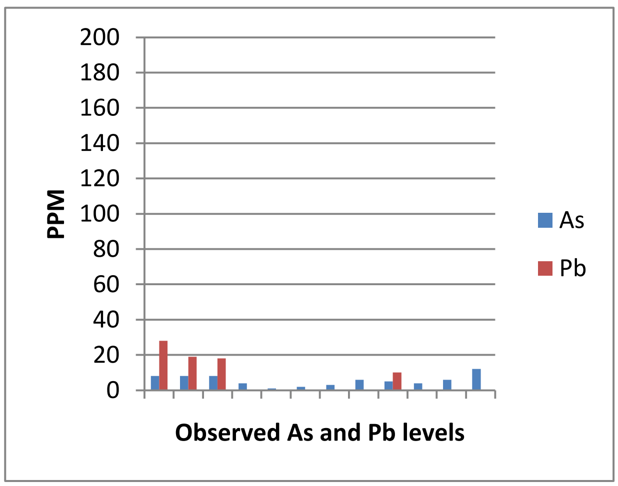


Eau Claire LS: The site has As levels present in ranges of 3 ppm – 12 ppm. The site average for As is calculated at 8 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of 38 ppm – 76 ppm. The site average for Pb is calculated at 54 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Fort Atkinson P)

Constructed: 1955 – Sugar Maple/Step 4 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
437	1	8	6	28	19
438	1	8		19	
439	1	8		18	
440	2	4		UDL	
441	2	1		UDL	
442	2	2		UDL	
443	3	3		UDL	
444	3	6		UDL	
445	3	5		10	
446	4	4		UDL	
447	4	6		UDL	
448	4	12		UDL	

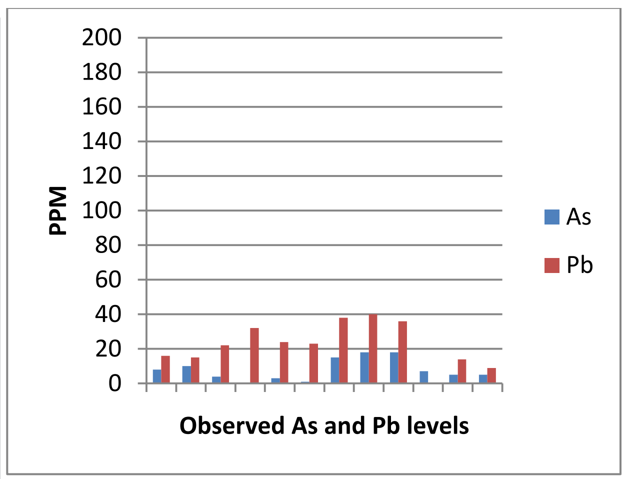


Fort Atkinson P: The site has As levels present in ranges of 1 ppm – 12 ppm. The site average for As is calculated at 6 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 28 ppm. The site average for Pb is calculated at 19 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Glendale GH)

Constructed: 1970 – Sprout/Step 1 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
153	1	8	9	16	24
154	1	10		15	
155	1	4		22	
156	2	UDL		32	
157	2	3		24	
158	2	1		23	
159	3	15		38	
160	3	18		40	
161	3	18		36	
162	4	7		UDL	
163	4	5		14	
164	4	5		9	

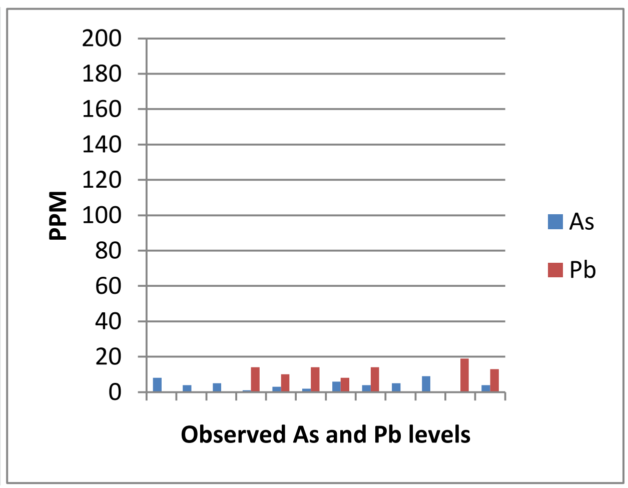


Glendale GH: The site has As levels present in ranges of UDL – 18 ppm. The site average for As is calculated at 9 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 40 ppm. The site average for Pb is calculated at 22 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Green Bay W)

Constructed: 1956 – Seedling/Step 2 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
301	1	8	5	UDL	13
302	1	4		UDL	
303	1	5		UDL	
304	2	1		14	
305	2	3		10	
306	2	2		14	
307	3	6		8	
308	3	4		14	
309	3	5		UDL	
310	4	9		UDL	
311	4	UDL		19	
312	4	4		13	

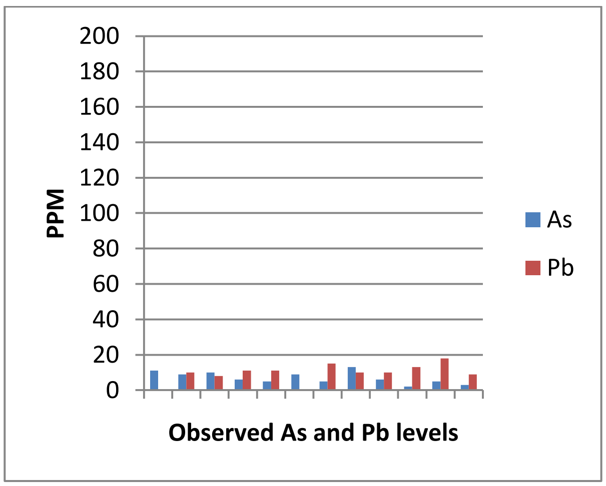


Green Bay W: The site has As levels present in ranges of UDL – 9 ppm. The site average for As is calculated at 5 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 19 ppm. The site average for Pb is calculated at 13 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Hartland HL)

Constructed: 1977 – Seedling/Step 2 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
129	1	11	7	UDL	12
130	1	9		10	
131	1	10		8	
132	2	6		11	
133	2	5		11	
134	2	9		UDL	
135	3	5		15	
136	3	13		10	
137	3	6		10	
138	4	2		13	
139	4	5		18	
140	4	3		9	

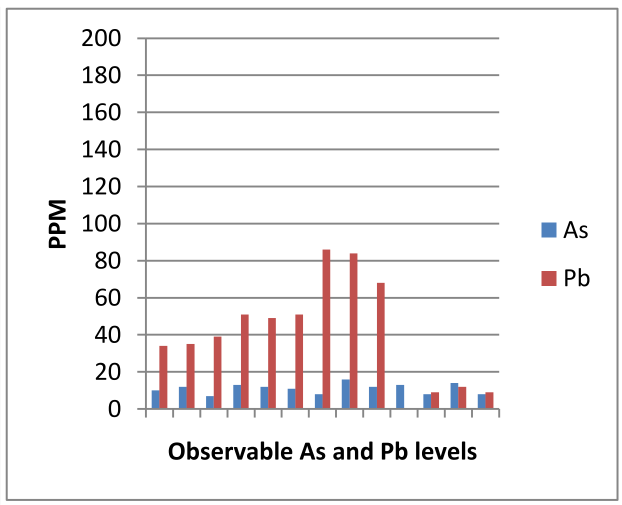


Hartland HL: The site has As levels present in ranges of 2 ppm – 13 ppm. The site average for As is calculated at 7 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 18 ppm. The site average for Pb is calculated at 12 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Kenosha D)

Constructed: 1911 - Sugar Maple/Step 4 - Urban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
80	1	10	11	34	44
81	1	12		35	
82	1	7		39	
83	2	13		51	
84	2	12		49	
85	2	11		51	
86	3	8		86	
87	3	16		84	
88	3	12		68	
89	4	13		UDL	
90	4	8		9	
91	4	14		12	
92	4	8		9	

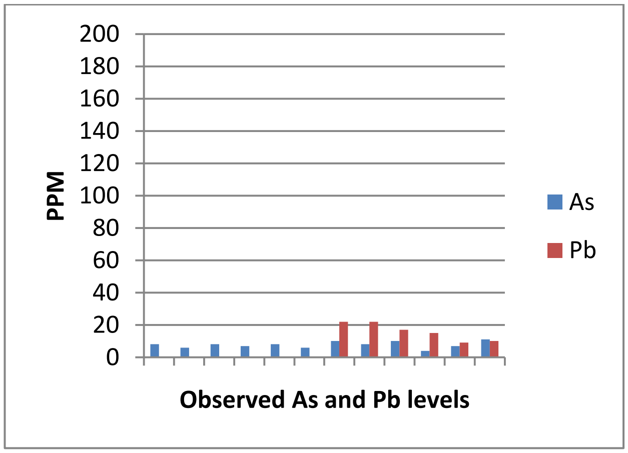


Kenosha D: The site has As levels present in ranges of 7 ppm – 16 ppm. The site average for As is calculated at 11 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 86 ppm. The site average for Pb is calculated at 44 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Lake Mills LMM)

Constructed: 1891 – Sprout/Step 1 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
425	1	8	8	UDL	16
426	1	6		UDL	
427	1	8		UDL	
428	2	7		UDL	
429	2	8		UDL	
430	2	6		UDL	
431	3	10		22	
432	3	8		22	
433	3	10		17	
434	4	4		15	
435	4	7		9	
436	4	11		10	

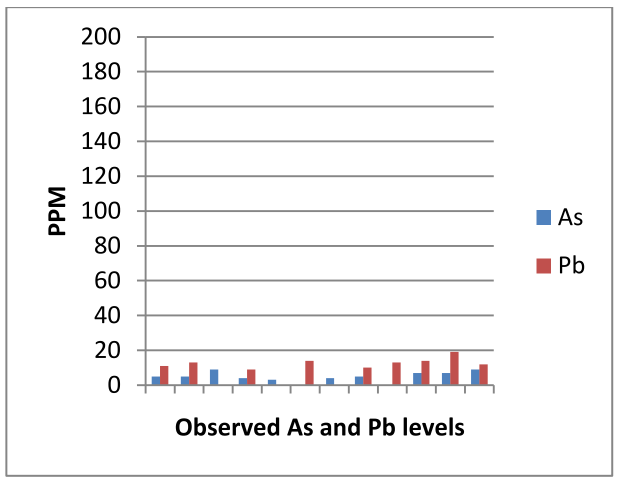


Lake Mills LLM: The site has As levels present in ranges of 4ppm – 11 ppm. The site average for As is calculated at 8 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 22 ppm. The site average for Pb is calculated at 16 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Lannon L)

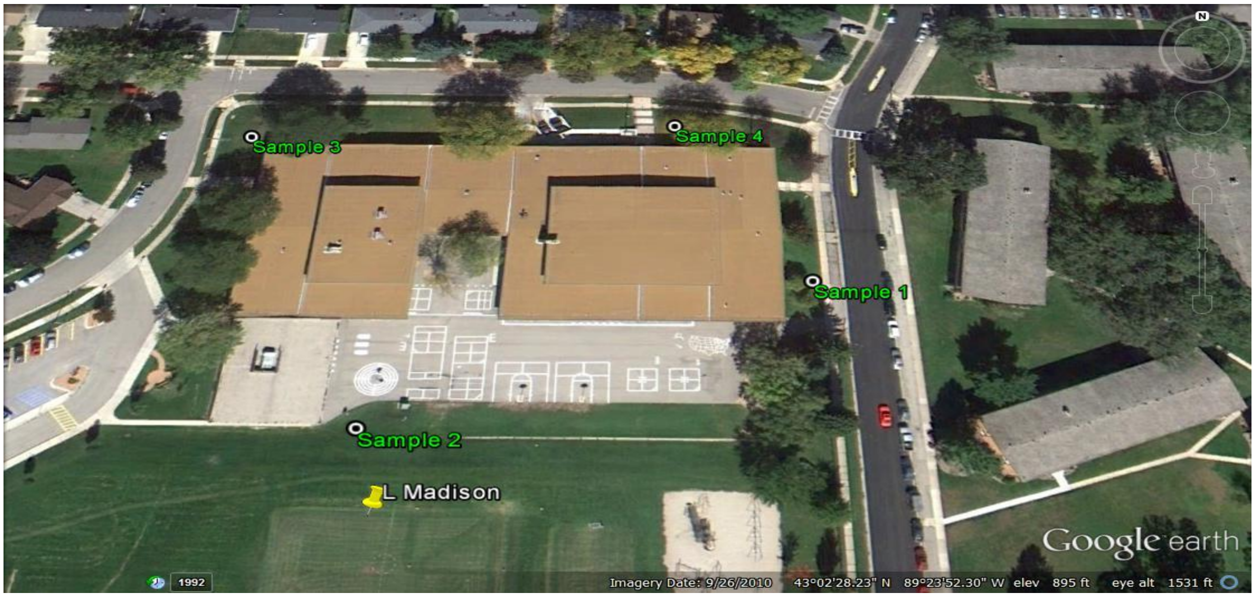
Constructed: 1939 – Sapling/Step 3 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	PB (PPM) Site Average
165	1	5	6	11	13
166	1	5		13	
167	1	9		UDL	
168	2	4		9	
169	2	3		UDL	
170	2	UDL		14	
171	3	4		UDL	
172	3	5		10	
173	3	UDL		13	
174	4	7		14	
175	4	7		19	
176	4	9		12	



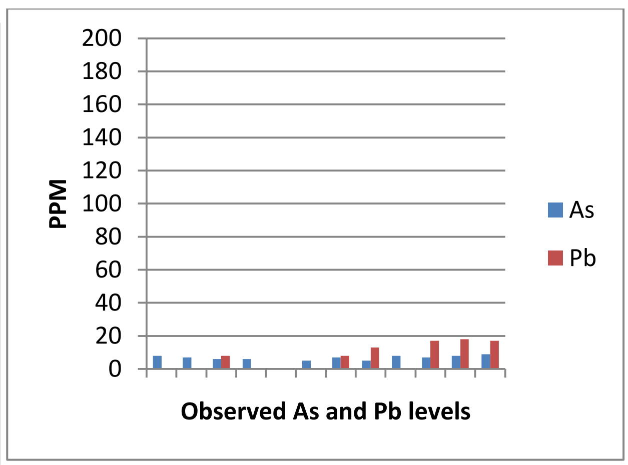
Lannon L: The site has As levels present in ranges of UDL – 9 ppm. The site average for As is calculated at 6 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 19 ppm. The site average for Pb is calculated at 13 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Madison L)



Constructed: 1965 – Sprout/Step 1 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
413	1	8	7	UDL	14
414	1	7		UDL	
415	1	6		8	
416	2	6		UDL	
417	2	UDL		UDL	
418	2	5		UDL	
419	3	7		8	
420	3	5		13	
421	3	8		UDL	
422	4	7		17	
423	4	8		18	
424	4	9		17	

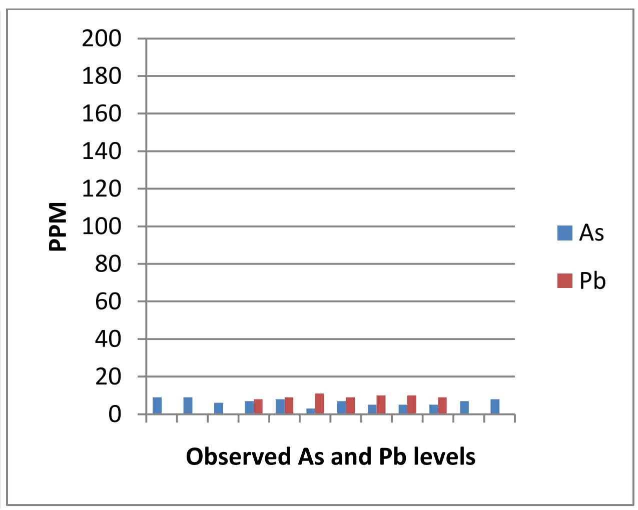


Madison L: The site has As levels present in ranges of UDL – 9 ppm. The site average for As is calculated at 6 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 18 ppm. The site average for Pb is calculated at 14 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Madison PSA)

Constructed: 1990 – Sprout/Step 1 - Suburban

Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
1	9	7	UDL	9
1	9		UDL	
1	6		UDL	
2	7		8	
2	8		9	
2	3		11	
3	7		9	
3	5		10	
3	5		10	
4	5		9	
4	7		UDL	
4	8		UDL	

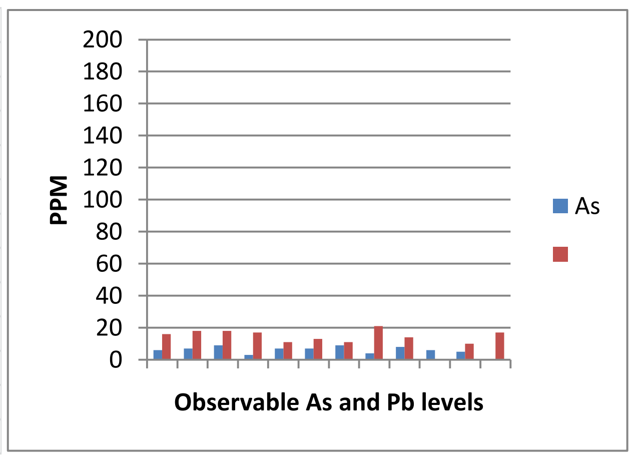


Madison PSA: The site has As levels present in ranges of 5 ppm – 9 ppm. The site average for As is calculated at 7 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 11 ppm. The site average for Pb is calculated at 9 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Madison SH)

Constructed: 1958 – Seedling/Step 2 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
373	1	6	6	16	15
374	1	7		18	
375	1	9		18	
376	2	3		17	
377	2	7		11	
378	2	7		13	
379	3	9		11	
380	3	4		21	
381	3	8		14	
382	4	6		UDL	
383	4	5		10	
384	4	UDL		17	

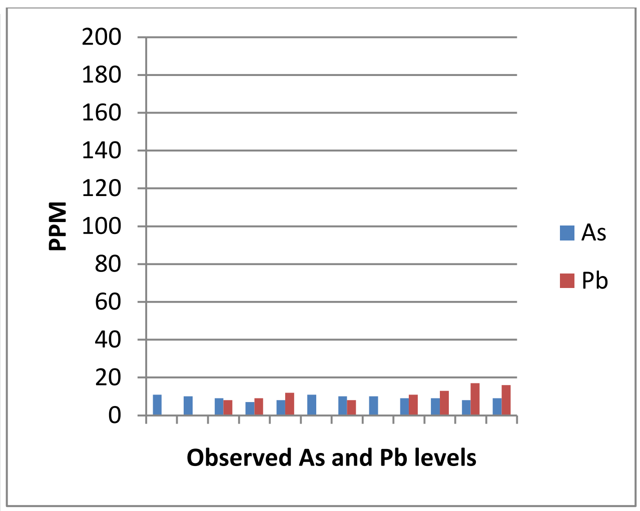


Madison SH: The site has As levels present in ranges of UDL – 9 ppm. The site average for As is calculated at 6 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 21 ppm. The site average for Pb is calculated at 15 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Milwaukee CM)

Constructed: 1930 – Sprout/Step 1 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
177	1	11	9	UDL	12
178	1	10		UDL	
179	1	9		8	
180	2	7		9	
181	2	8		12	
182	2	11		UDL	
183	3	10		8	
184	3	10		UDL	
185	3	9		11	
186	4	9		13	
187	4	8		17	
188	4	9		16	

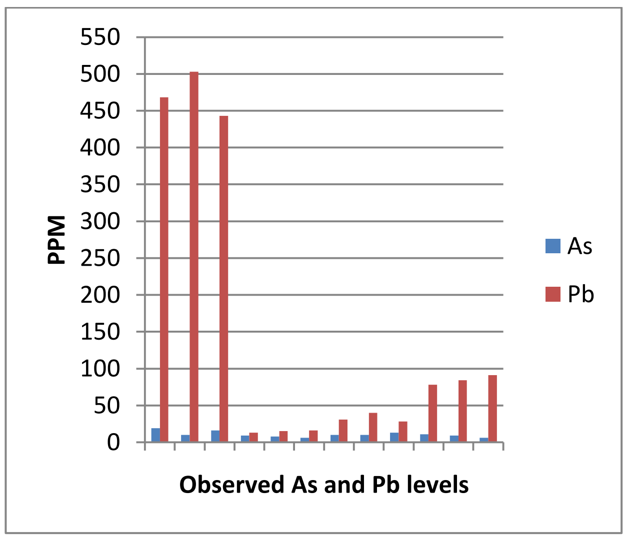


Milwaukee CM: The site has As levels present in ranges of 7 ppm – 11 ppm. The site average for As is calculated at 9 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 17 ppm. The site average for Pb is calculated at 12 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Milwaukee HE)

Constructed: 1905 – Sapling/Step 3 - Urban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
225	1	19	11	468	151
226	1	10		503	
227	1	16		443	
228	2	9		13	
229	2	8		15	
230	2	6		16	
231	3	10		31	
232	3	10		40	
233	3	13		28	
234	4	11		78	
235	4	9		84	
236	4	6		91	

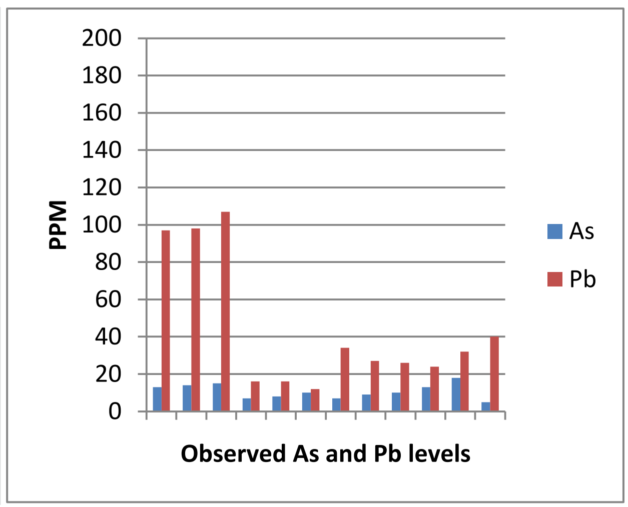


Milwaukee HE: The site has As levels present in ranges of 6 ppm – 19 ppm. The site average for As is calculated at 11 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of 13 ppm – 503 ppm. The site average for Pb is calculated at 151 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Milwaukee HP)

Constructed: 1925 – Sapling/Step 3 - Urban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
213	1	13	11	97	44
214	1	14		98	
215	1	15		107	
216	2	7		16	
217	2	8		16	
218	2	10		12	
219	3	7		34	
220	3	9		27	
221	3	10		26	
222	4	13		24	
223	4	18		32	
224	4	5		40	

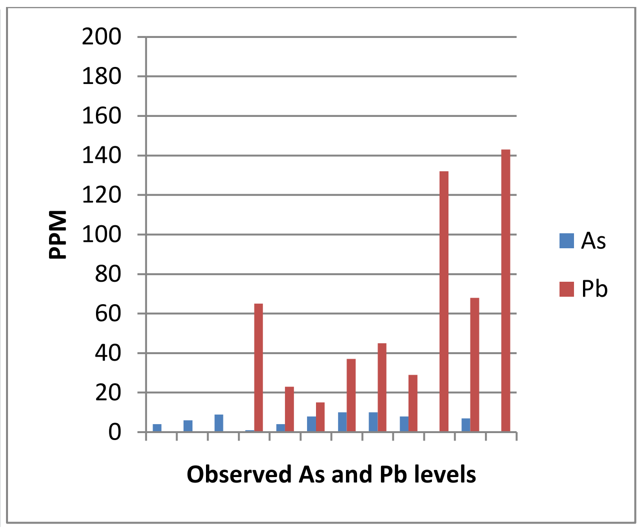


Milwaukee HP: The site has As levels present in ranges of 7 ppm – 18 ppm. The site average for As is calculated at 11 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of 12 ppm – 107 ppm. The site average for Pb is calculated at 44 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Milwaukee M)

Constructed: 1888 – Sapling/Step 3 - Urban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
189	1	4	7	UDL	62
190	1	6		UDL	
191	1	9		UDL	
192	2	1		65	
193	2	4		23	
194	2	8		15	
195	3	10		37	
196	3	10		45	
197	3	8		29	
198	4	UDL		132	
199	4	7		68	
200	4	UDL		143	

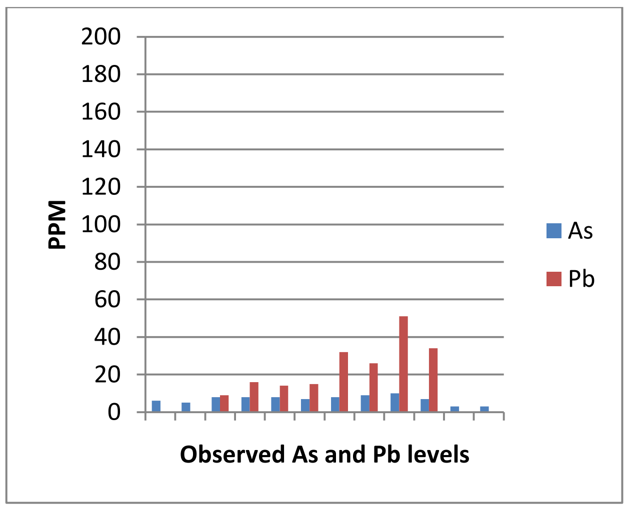


Milwaukee M: The site has As levels present in ranges of UDL – 10 ppm. The site average for As is calculated at 6 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 143 ppm. The site average for Pb is calculated at 62 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Milwaukee ME)

Constructed: 1955 – Sprout/Step 1 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
201	1	6	7	UDL	25
202	1	5		UDL	
203	1	8		9	
204	2	8		16	
205	2	8		14	
206	2	7		15	
207	3	8		32	
208	3	9		26	
209	3	10		51	
210	4	7		34	
211	4	3		UDL	
212	4	3		UDL	

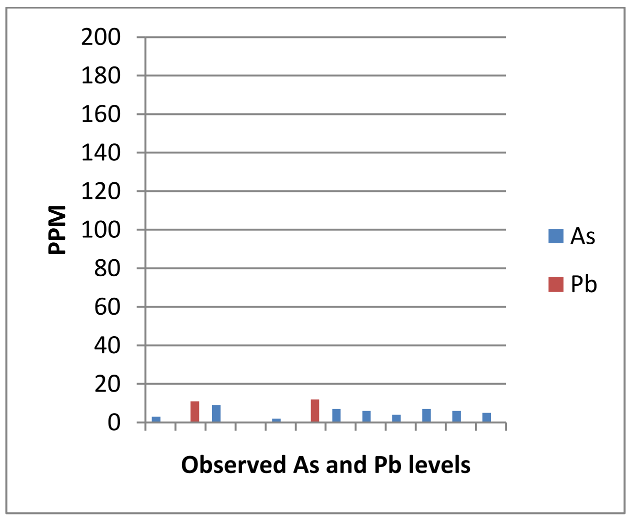


Milwaukee ME: The site has As levels present in ranges of 3 ppm – 10 ppm. The site average for As is calculated at 7 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 51 ppm. The site average for Pb is calculated at 25 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Osceola OE)

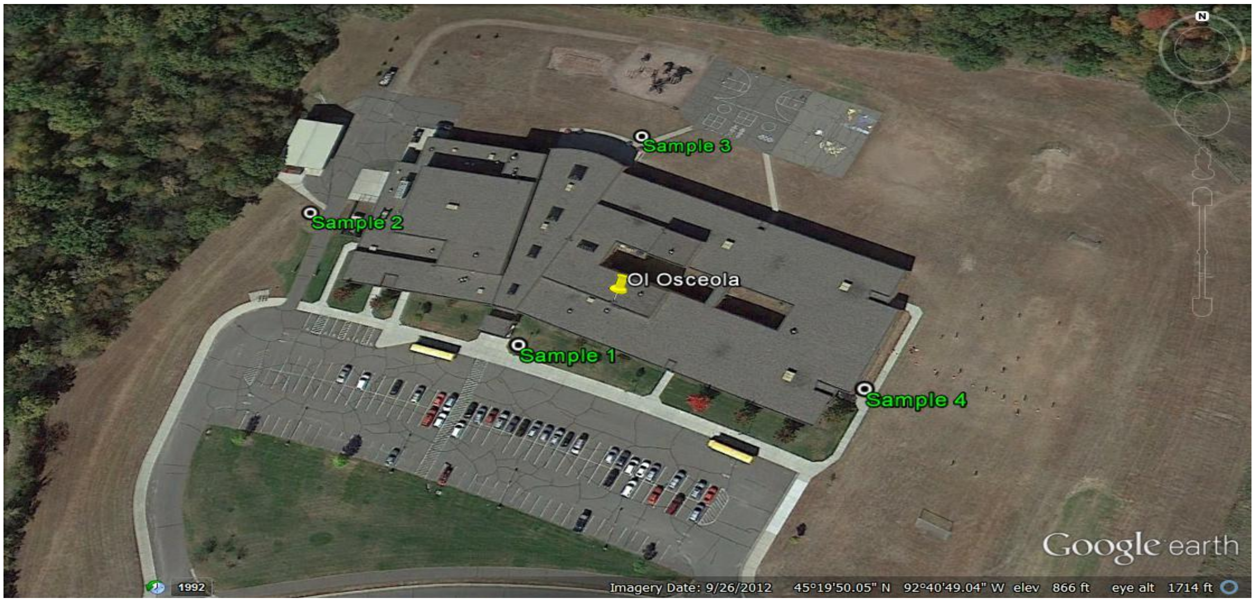
Constructed: 1962 – Sprout/Step 1 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
361	1	3	5	UDL	12
362	1	UDL		11	
363	1	9		UDL	
364	2	UDL		UDL	
365	2	2		UDL	
366	2	UDL		12	
367	3	7		UDL	
368	3	6		UDL	
369	3	4		UDL	
370	4	7		UDL	
371	4	6		UDL	
372	4	5		UDL	



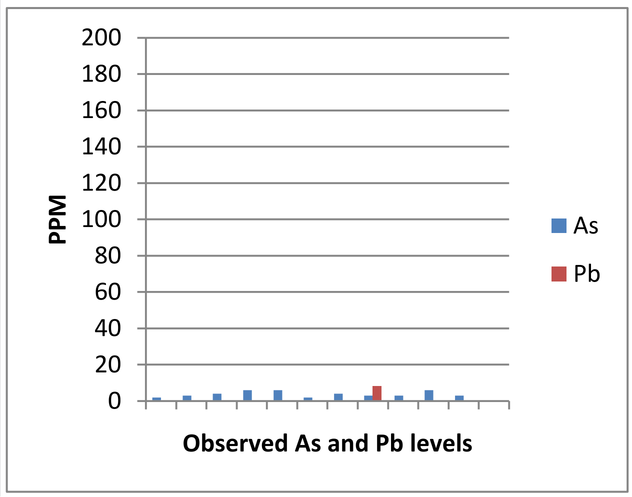
Osceola OE: The site has As levels present in ranges of UDL – 9 ppm. The site average for As is calculated at 5 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 12 ppm. The site average for Pb is calculated at 12 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Osceola OI)



Constructed: 2002 – Sapling/Step 3 - Rural

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
337	1	2	4	UDL	8
338	1	3		UDL	
339	1	4		UDL	
340	2	6		UDL	
341	2	6		UDL	
342	2	2		UDL	
343	3	4		UDL	
344	3	3		8	
345	3	3		UDL	
346	4	6		UDL	
347	4	3		UDL	
348	4	UDL		UDL	

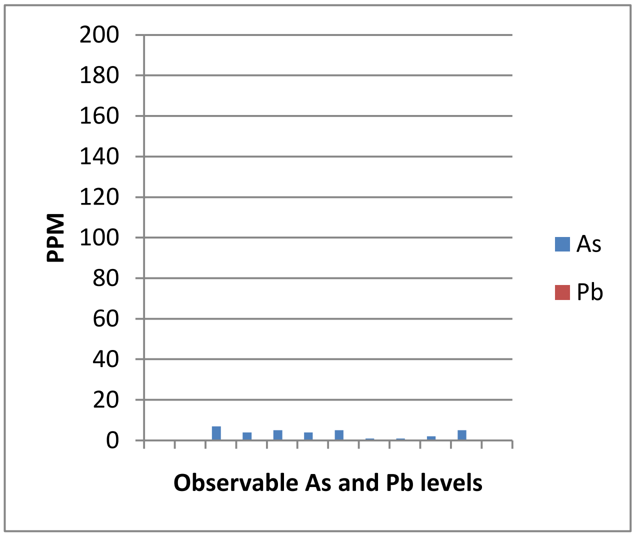


Osceola OI: The site has As levels present in ranges of UDL – 6 ppm. The site average for As is calculated at 4 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 8 ppm. The site average for Pb is calculated at 8 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Osceola OM)

Constructed: 1983 – Sapling/Step 3 - Rural

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
349	1	UDL	4	UDL	UDL
350	1	UDL		UDL	
351	1	7		UDL	
352	2	4		UDL	
353	2	5		UDL	
354	2	4		UDL	
355	3	5		UDL	
356	3	1		UDL	
357	3	1		UDL	
358	4	2		UDL	
359	4	5		UDL	
360	4	UDL		UDL	

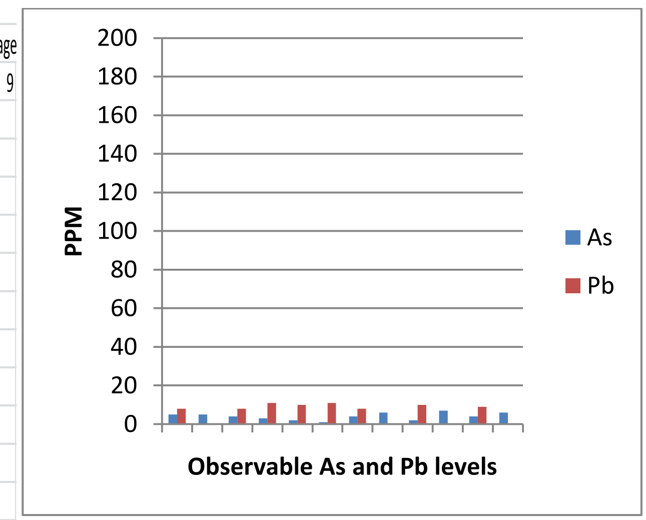


Osceola OM: The site has As levels present in ranges of UDL – 7 ppm. The site average for As is calculated at 4 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has UDL of Pb levels observed. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. No caution should be observed since Pb is not present; it is not recommended that the site limit dust exposure while children are playing. Care should not be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Oshkosh OW)

Constructed: 1953 – Sapling/Step 3 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
277	1	5	4	8	9
278	1	5		UDL	
279	1	4		8	
280	2	3		11	
281	2	2		10	
282	2	1		11	
283	3	4		8	
284	3	6		UDL	
285	3	2		10	
286	4	7		UDL	
287	4	4		9	
288	4	6		UDL	

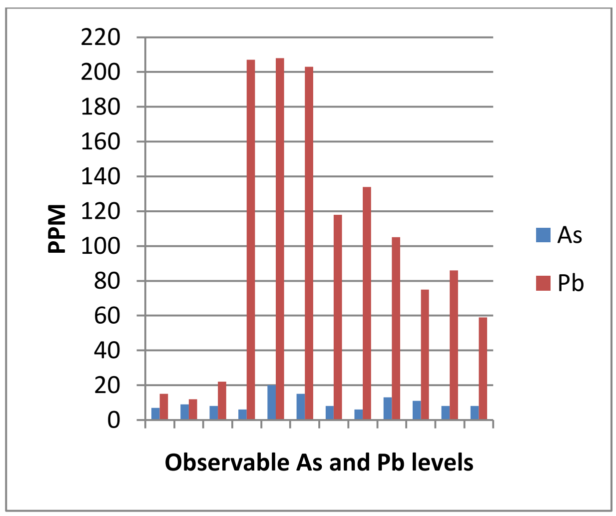


Oshkosh OW: The site has As levels present in ranges of 1 ppm – 7 ppm. The site average for As is calculated at 4 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 11 ppm. The site average for Pb is calculated at 9 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; no further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Oshkosh S)

Constructed: 1895 – Sapling/Step 3 - Urban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
289	1	7	10	15	104
290	1	9		12	
291	1	8		22	
292	2	6		207	
293	2	20		208	
294	2	15		203	
295	3	8		118	
296	3	6		134	
297	3	13		105	
298	4	11		75	
299	4	8		86	
300	4	8		59	

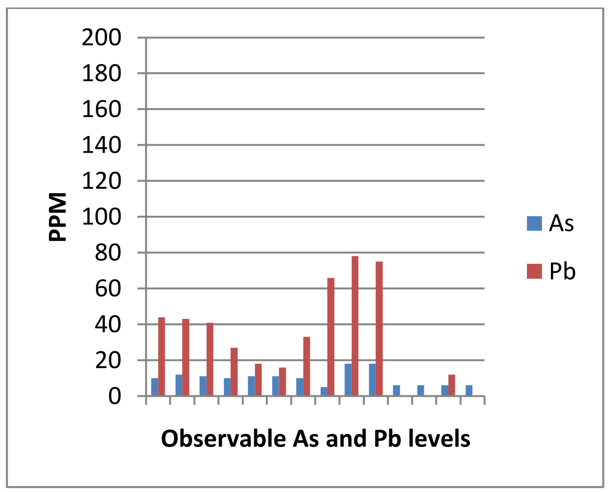


Oshkosh S: The site has As levels present in ranges of 6 ppm – 20 ppm. The site average for As is calculated at 10 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of 12 ppm – 208 ppm. The site average for Pb is calculated at 104 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Racine RM)

Building Constructed: 1922 – Sugar Maple/Step 4 - Urban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
53	1	10	10	44	41
54	1	12		43	
55	1	11		41	
56	2	10		27	
57	2	11		18	
58	2	11		16	
59	2	10		33	
60	3	5		66	
61	3	18		78	
62	3	18		75	
63	4	6		UDL	
64	4	6		UDL	
65	4	6		12	
66	4	6		UDL	

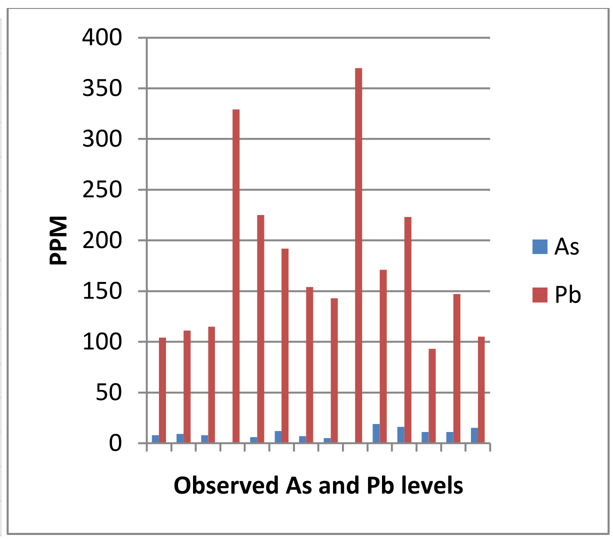


Racine RM: The site has As levels present in ranges of 5 ppm – 18 ppm. The site average for As is calculated at 10 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 78 ppm. The site average for Pb is calculated at 41 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Racine W)

Constructed: 1860 – Sapling/Step 3 – Urban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
67	1	8	11	104	177
68	1	9		111	
69	1	8		115	
70	2	UDL		329	
71	2	6		225	
72	2	12		192	
73	2	7		154	
74	3	5		143	
75	3	UDL		370	
76	3	19		171	
77	3	16		223	
78	4	11		93	
79	4	11		147	
461	4	15		105	

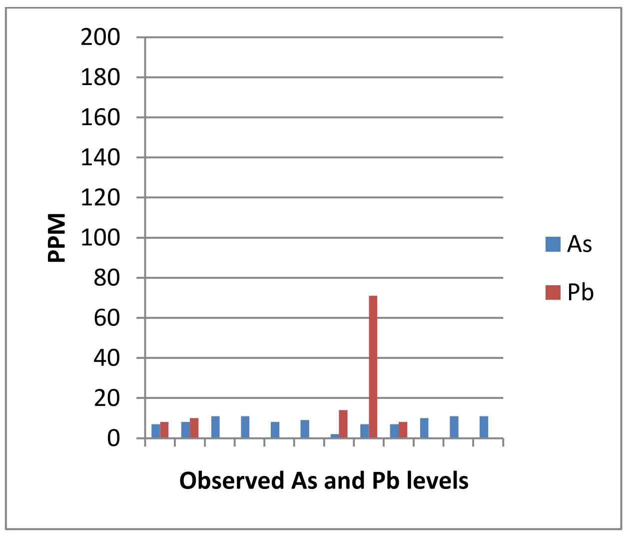


Racine W: The site has As levels present in ranges of UDL – 19 ppm. The site average for As is calculated at 11 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of 93 ppm – 370 ppm. The site average for Pb is calculated at 177 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Sussex WS)

Constructed: 1999 – Sapling/Step 3 - Suburban

Bruker SD/PDA File #	Soil Sample ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
117	1	7	9	8	22
118	1	8		10	
119	1	11		UDL	
120	2	11		UDL	
121	2	8		UDL	
122	2	9		UDL	
123	3	2		14	
124	3	7		71	
125	3	7		8	
126	4	10		UDL	
127	4	11		UDL	
128	4	11		UDL	

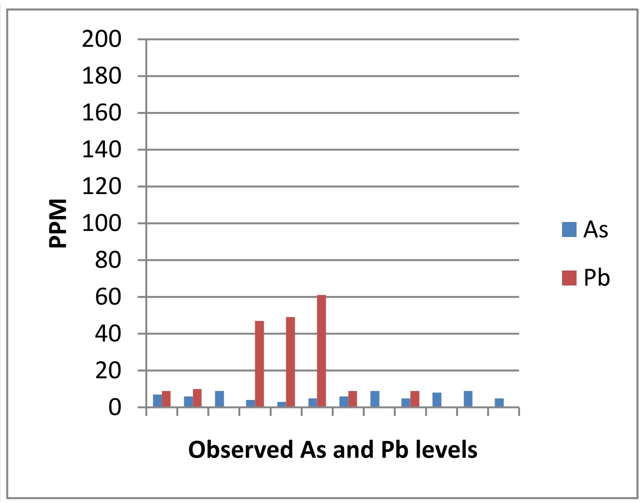


Sussex WS: The site has As levels present in ranges of 2 ppm – 11 ppm. The site average for As is calculated at 9 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 71 ppm. The site average for Pb is calculated at 22 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Waukesha MB)

Constructed: 1979 – Sugar Maple/Step 4 - Suburban

Bruker SD/PDA File #	Soil Samle ID	As (PPM)	As (PPM) Site Average	Pb (PPM)	Pb (PPM) Site Average
105	1	7	6	9	28
106	1	6		10	
107	1	9		UDL	
108	2	4		47	
109	2	3		49	
110	2	5		61	
111	3	6		9	
112	3	9		UDL	
113	3	5		9	
114	4	8		UDL	
115	4	9		UDL	
116	4	5		UDL	



Waukesha MB: The site has As levels present in ranges of 3 ppm – 9 ppm. The site average for As is calculated at 6 ppm. The site is similar to the expected back ground level of As when compared to the Kettle Moraine State Forest sample having a documented observed range of 5 ppm – 9 ppm. The site has Pb levels present in ranges of UDL – 61 ppm. The site average for Pb is calculated at 28 ppm. The observed Pb level is considered safe as determined by the standards published by the EPA; further evaluation is suggested to document the extent Pb is present. Caution should be observed since Pb is present, it is recommended that the site limit dust exposure and ensure children not ingest soils while playing. Care should be observed when growing leafy green vegetables and root crops for the sole purpose of allowing child consumption.

(Table 2)

Data justifying factory Calibration of Bruker-Tracer IV pXRF: Standards and Controls (-) and (- -)

Validation of calibration/run prior to any sample being analyzed					
Bruker SD/PDA File #	Name	As (PPM)	As (PPM) NIST Certification	Pb (PPM)	Pb (PPM) NIST Certification
Positive Controls (NIST) Standards			Observed Range		Observed Range
47	2710a	1680	1300–1600	4720	4700–5800
48	2710a	1680	1300–1600	4720	4700–5800
49	2710a	1780	1300–1600	4900	4700–5800
50	2711	98	88-110	1000	930-1500
51	2711	92	88-110	993	930-1500
52	2711	95	88-110	1000	930-1500
Negetive Control (Kettle Moraine State Forest/Prestine soils)					
385	KMSF	5		UDL	
386	KMSF	9		UDL	
387	KMSF	5		UDL	
Averaged values			6		
Blank/Double Negetive Control (Play Sand)					
388	PLAY SAND	UDL		UDL	
462	PLAY SAND	UDL		UDL	
462	PLAY SAND	UDL		UDL	
Final Run-after all samples were analyzed					
463	2710A	1660	1300–1600	4720	4700–5800
464	2711	97	88-110	997	930–1500

(Table 3)

Conversion from Site Name to Actual School Name, Location and Phone Number

Site Name	Institution Name	Address	Phone number
Appleton FRA J	Fox River Academy/Jefferson Elementary	1000 S Mason St. Appleton, WI 54914	(920) 832-6260
Appleton HS	Holy Spirit Catholic School	W2796 Cty KK, Appleton WI 54915	(920) 733-2651
Appleton JM	James Madison Middle School	2020 S Carpenter St, Appleton WI 54915	920-832-6276
Beloit M	Merril Elementary School	1333 Copeland Ave, Beloit WI 53511	(608) 361-2600
Brookfield SJ	St. John Vianney School	17500 W Gebhardt Rd, Brookfield WI 53045	1 262-796-3942
Cedarburg W	Westlawn Elementary	W64 N319 Madison Avenue Cedarburg, WI 53012	262.376.6900
Colby C	Colby Elementary School	202 West Dolf Street Colby, WI 54421	715-223-3939
Eagle EC	Eagleville Charter Elementary School	S101 W34511 Hwy LO, Eagle WI 53119	1 262-363-6258
Eau Claire LS	Lake Shore Elementary	711 Lake St, Eau Claire WI 54703	715-852-3400
Fort Atkinson P	Purdy Elementary School	719 South Main St. Fort Atkinson, WI 53538	920-563-7822
Glendale GH	Glen Hills Middle School	2600 West Mill Rd Glendale, WI, 53209	(414)351-7160
Greenbay W	Webster Elementary	2101 South Webster Avenue • Green Bay, Wisconsin • 54301	920-448-2143
Hartland HL	Hartland School of Community Learning	651 E Imperial Dr Hartland, WI 53029	262-369-6720
Kenosha D	Dimensions of Learning Academy	6218 - 25th AVE, Kenosha WI 53143	(262) 359-6849
Lake Mills LMM	Lake Mills Middle School	318 College St Lake Mills, WI 53551	920-648-2358
Lannon L	Lannon Elementary School	7145 N Lannon Rd, Lannon WI 53046	262-255-6106
Madison L	Lincoln Elementary School	909 Sequoia Trail, Madison, WI 53713	(608) 204-4900
Madison PSA	Preschool of the Arts	11 Science Ct Madison, WI 53711	608-233-1707
Madsion SH	Spring Harbor Environmental Middle School	1110 Spring Harbor Dr Madison, WI 53705	608-204-1100
Milwaukee CM	Craig Montessori	7667 W Congress St Milwaukee, WI 53218	(414) 393-4200
Milwaukee HE	Hawley Environmental School	5610 W Wisconsin Ave, Milwaukee WI 53213	(414) 256-8500
Milwaukee HP	Humboldt Park K-8 Charter School	3230 S Adams Ave, Milwaukee WI 53207	(414) 294-1700
Milwaukee M	Downtown Montessori Academy	2507 S Graham St, Milwaukee WI 53207	(414) 744-6005
Milwaukee ME	Milwaukee Environmental Sciences Charter School	6600 W. Melvina Street milwaukee, wi 53216	(414) 944-1240
Osceola OE	Osceola Elementary School	250 10th Ave E, Osceola WI 54020	715-294-3457
Osceola OI	Osceola Intermediate School	949 Education Ave, Osceola WI 54020	715-294-2800
Osceola OM	Osceola Middle School	1029 Oak Ridge Dr, Osceola WI 54020	715-294-4180
Oshkosh OW	Oakwood Environmental Education Charter School	1225 N Oakwood Rd , Oshkosh WI 54904	920.424.0315
Oshkosh S	Smith Elementary School	1745 Oregon St, Oshkosh WI 54902	(920) 424-0174
Racine RM	Racine Montessori School	2317 Howe St, Racine, WI 53402.	262 637 7892
Racine W	Walden III Middle and High School	1012 Center St, Racine WI 53403	(262) 664-6250
Sussex WS	Woodside Elementary School	W236 N7465 Woodside Rd, Sussex	(262) 664-6250