Arsenic and Old Graves

A Method for Testing Arsenic Contamination in Historic Cemeteries

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ABSTRACT

During the late nineteenth and early twentieth centuries, arsenic was used as an embalming agent in the United States. In 1996, Konefes and McGee brought the potential danger of arsenic poisoning during excavation to the attention of archaeologists. They developed methodology that was later refined by the present authors. This article discusses the history of arsenic as an embalming agent, explores socioeconomic and demographic factors that might suggest the presence of arsenic in certain burials, and presents methods for testing arsenic in archaeological contexts. We also discuss environmental impact mitigation considerations and review examples of arsenic testing in archaeological contexts.

Keywords: arsenic, excavation safety, nineteenth century, historic cemeteries, United States, excavation methods

A finales del siglo XIX y principios del XX, el arsénico se utilizó como agente de embalsamamiento en los Estados Unidos. En 1996, Konefes y McGee señalaron a los arqueólogos el peligro potencial de envenenamiento por arsénico durante la excavación. Desarrollaron una metodología que luego fue refinada por los autores actuales. Este artículo analiza la historia del arsénico como agente de embalsamamiento, factores socioeconómicos y demográficos que pueden sugerir la presencia de arsénico en ciertos entierros y presenta métodos para probar el arsénico en contextos arqueológicos. También discutimos consideraciones de mitigación del impacto ambiental y revisamos ejemplos de pruebas de arsénico en contextos arqueológicos.

Palabras clave: el arsenic, seguridad de la excavación, siglos XIX, hómetro shistóricos, Estados Unidos, todostos de excavación

Arsenic has been documented in groundwater, and it is cancer causing (Welch et al. 2000). At least some arsenic in groundwater comes from nineteenth-century cemeteries (Chiapelli and Chiapelli 2008; Stowe et al. 2001). The use of arsenic as an embalming agent during the latter half of the nineteenth century is well documented, as is the potentially harmful effects of arsenic on archaeologists who are required to excavate such graves (Konefes and McGee 1996; National Park Service 2000). In this article, we have updated the methods (Meyers et al. 1998) to test for arsenic in graves, and we include information about suggested environmental mitigation procedures if arsenic is present. In addition, we present a detailed history of the use of arsenic as an embalming agent during the late nineteenth and early twentieth centuries. We identify populations more likely to practice embalming, specifically arsenic embalming, as it was adopted at different rates by different populations. Finally, we present examples of arsenic testing at four sites in Kentucky as comparative examples of arsenic testing use and outcomes. We note that the recommendations provided in this article are specific to North American burial practices.

THE HISTORY OF THE USE OF ARSENIC

Arsenic oxide "is colorless, odorless, and tasteless, and dissolves readily in water and other liquids" (Parascandola 2012:1), and although recognized as a poison since Greco-Roman times, it was not commonly used as such until the fifteenth century. As a poison, it can cause death incrementally when administered in small doses (300 milligrams; Whorton 2010:10). In as little as 30 minutes after ingesting arsenic (usually in powder form), difficulty in swallowing, severe stomach pain, and nausea can occur, and within a few hours or days, vomiting, diarrhea, thirst, and death ensue (Whorton 2010:10–16). The use of arsenic as an embalming agent in the nineteenth century was an outgrowth of sixteenth-century embalming techniques that injected preservation chemicals into corpses and, in part, because doctors noted that individuals poisoned with arsenic decomposed more slowly. J. N. Gannal, a French chemist, was the first to include arsenic in embalming fluid. Because its presence could interfere in murder cases in which

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arsenic poisoning was suspected, its use as an embalming agent was outlawed in France as early as 1846 (Parascandola 2012:99–100). After this, it was primarily used to preserve medical specimens (Habenstein and Lamers 1962).

In America, it was widely adopted during the Civil War so that dead soldiers could be shipped home (Faust 2008; Habenstein and Lamers 1962; Laderman 1996). Around 1861, J. Holmes, one of the first embalmers, created a formula that was a mixture of arsenic and other materials (Hickman 2002). He embalmed Elmer Ellsworth, a friend of President Lincoln and the first Union soldier to die in the Civil War (Leepson 2011), and this successful embalming popularized its use during the war. Embalming became more widespread after Lincoln was killed and embalmed as "his body also toured the country to be viewed with great publicity before the funeral" (Elite 2020:86). Although Holmes later stated that he embalmed more than 4,000 individuals during the war at the Washington DC Military Hospital, Habenstein and Lamers (1962:325–327) cast doubts on Holmes's medical degree, his military service, and his work at the hospital. Holmes trained others in embalming, and within a short time, the practice was widespread. For example, Daniel Prunk "set up locations in Tennessee, Georgia, and Alabama" (Elite 2020:87). By 1865, multiple embalmers were charging high rates for poor service, which spurred General Grant to forbid embalmers from military areas (Faust 2008:96–97; Habenstein and Lamers 1962:334–335). This move eventually led to the licensing of embalmers.

Pallardy (2018) estimates that 40,000 soldiers were embalmed. Faust (2008:88) notes the Chattanooga office of the Sanitary Commission had 34 requests for embalming during a six-month period and that "embalming was much rarer in the Confederacy than in the North . . . but embalmers advertised throughout the war in the Richmond press" and one funeral home in Lynchburg, Virginia, "handled 1,251 soldiers in 1862, including both Union and Confederate" (Faust 2008:94–95). The evidence suggests that it was more common for officers from the North, but it did occur among the rank-and-file and among Confederates. Embalming was expensive—Holmes charged $100 per body (Habenstein and Lamers 1962:324), although Faust (2008:94) suggests that the cost could vary based on rank. She cites a Pennsylvania soldier who wrote in 1862 that he and his comrades "had contributed $140 to embalm and ship the bodies of two soldiers killed in his company" (Faust 2008:82). Embalming stations were common among battle sites in both the North and South. The Sanitary Commission of the North played an important role in enabling embalming by sending agents south to return Union soldiers to their homes (Faust 2008:87). In addition, embalmed individuals were more likely to be placed in steel coffins (Faust 2008:92).

Following the Civil War, "several of the best known undertakers of the late nineteenth century established themselves in the business of caring for the dead directly as a result of receiving army contracts for soldier burial" (Habenstein and Lamers 1962:333) in such places as Chicago, Boston, Cincinnati, and Washington, DC. Holmes created an embalming fluid, Innominata, which he subsequently sold to other embalmers. About a dozen formulas were patented between 1855 and 1870 (Habenstein and Lamers 1962:339). Most fluids contained arsenic, although the amount varied. One source (Parascandola 2012:102) cites between 110 g and 6 kg per individual. One archaeological excavation of the Court Street Cemetery in Arizona notes that in "testimony from a 1901 coroner's inquest case for Pima County, two quarts of embalming fluid were used to prepare an adult male" (Thiel et al. 2013:45). By 1886, there were 10 companies producing fluid that was sold by traveling salesmen. As Habenstein and Lamers state, "Selling fluids and patenting them was tied closely to teaching embalming techniques" (1962:344), and multiple embalming schools were founded. The Cincinnati School of Embalming, founded in 1881, was one of the largest, with classes in four cities, where over 100 students were trained yearly (Habenstein and Lamers 1962:347).

During the postbellum era, as embalming practices spread, there are some data to suggest differences in the use of embalming in terms of location, race, class, ethnicity, and gender. Urban areas appear more likely than rural areas to have used embalming during the late nineteenth century. Rural-area data are known from Pennsylvania (Weaver 2016) and Appalachia (Bettis et al. 1978; Crissman 1994). Crissman notes that "embalming was first used in the mountains around the turn of the century, although most residents did not practice it until the thirties" (1994:35). He states that unlike urban areas, embalming was often done in the home, usually by hardware store owners as well as employees of harness shops and department stores. Because most clients were poor, embalming was less likely to occur. There was also a hesitancy about the practice in rural areas. By contrast, embalming may have been more common in cities regardless of class. DiGirolamo (2002:5) documents newsboys who pooled their resources to pay for services to embalm their dead comrades.

Among African American communities of the late nineteenth century, funeral directing was seen as a way into the middle class and espoused by Booker T. Washington as a good career (Smith 2010). By 1890, there were 231 African American funeral homes nationwide (Bunch-Lyons 2015; U.S. Bureau of the Census 1918). African American funeral directors "were particularly well positioned to capitalize on its business potential through the exponential growth of their own mutual aid societies, secret societies, and burial leagues" (Smith 2010:40). Such societies offered life insurance and burial costs, for a small annual fee, and Smith notes that the aid given for burials was "the most significant aspect of black benevolent societies" (2010:41), which were most popular from the 1880s to the 1890s—the period when arsenic was the most common embalming fluid.

Embalming was adopted at different rates by different ethnic and religious groups. Embalming was espoused as a way to limit disease, particularly during the wave of immigration during the late nineteenth century. Mitford, however, argues that embalming has no efficacy in preventing disease (1963:82–89). Amanek notes that Jewish groups in New York City also relied on benevolent societies, which "oversaw all responsibilities, from administering last offices to overseeing funerals and expenses" (Amanek 2017:93). Regardless, "the Jewish custom of washing the dead was one of the last 'ceded' to undertakers" (Amanek 2017:94), and "the benefits of embalming services that might have outweighed its stigma or hastened its professional inroads had little appeal to most Jewish New Yorkers" (Amanek 2017:97). By the 1920s, embalming was more common. Among Italians in South Philadelphia, where benevolent societies were also common, traditional funeral customs persisted until the mid-twentieth century, when embalming became more common (Mathias 1974). Heilen (2012), in a comprehensive study of seven different groups

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buried in the nineteenth-century Alameda-Stone Cemetery in Tucson, does not discuss evidence for embalming other than to suggest that Protestants and members of the military were more likely to be embalmed than Hispanic Catholics, Jews, Apache, O'odham, or Yaqui (see also Sewell et al. 2012).

There is little information on differences between men and women and embalming, although Smith (2010) states that African American women were employed as embalmers for women. Rundblad (1995:183) cites advertisements for embalming fluids that emphasize women's beauty even in death, which suggests that women were commonly embalmed. It is likely that children were also commonly embalmed, such as Abraham Lincoln's son William and newsboys discussed above (DiGirolamo 2002).

Embalming resulted in a change in the way death is experienced in America. Aries notes that the American way of death, including embalming, is a "denial of the absolute finality of death and the repugnance of physical destruction" (Aries 1974:154). As such, it is likely that it was adopted relatively quickly and used on most individuals.

The use of arsenic began to decline by the end of the nineteenth century. Formaldehyde was discovered in 1867, and it became cheaper and more widely used over time. More importantly, the dangers of arsenic became known. Arsenic was commonly used as a poison from the sixteenth through the eighteenth centuries. But by 1851, there were legal restrictions on its sale—about the same time tests were developed to identify arsenic (Parascandola 2012:15). Arsenic was widely used in many industries: a by-product of mining and smelting, it was used in green paint and wallpaper, artificial flowers, and taxidermy. It was found in pesticides, playing cards, green candy, postage stamps (Hawksley 2016; Whorton 2010), iron tablets, flypapers, and cosmetics. One estimate given of the amount of arsenic powder in green-dyed gowns was 900 grains, or 2 oz (Whorton 2010:101). Its excessive use caused multiple deaths, particularly in children.

By the early twentieth century, moves were made to ban or more strongly control its use. Although some reports suggest that embalmers were dying because of exposure, Parascandola (2012) found little evidence to support this. More likely "it would appear that concern over the interference of this practice with murder investigations involving arsenic poisoning was at least as important a reason for the abandonment of arsenic embalming" (Parascandola 2012:103) Eventually, a doctor's certificate noting there was no poison present in bodies was required before embalming. Arsenic was outlawed in Illinois by 1907, and by 1920, it was illegal for embalming purposes nationwide.

This history of arsenic suggests that some individuals may have been more likely to have been embalmed with arsenic than others, depending on factors such as location and socioeconomic status. First, Union soldiers were more likely to be embalmed, but many Confederate soldiers were also embalmed. The presence of steel coffins is an indicator of embalming for any Civil War grave. Second, after 1880, embalming became widespread in urban areas, both North and South, but it was less common in rural areas such as Appalachia until after arsenic was outlawed. Third, both African Americans and whites were embalmed in large numbers, and for African Americans, this was particularly true during the period when arsenic was most used (1880s–1890s). Being a member of a lower class did not necessarily mean embalming did not occur, particularly among groups with benevolent societies, individuals buried in pauper fields, and residents of mental asylums and prisons (see below). In urban areas with dense immigrant populations, where benevolent societies were more common, embalming should be expected. Among Jewish populations, however, embalming was adopted more slowly, in many cases until after arsenic became outlawed. Finally, both women and men appear to have been embalmed, and it is likely that children were too. The amount of arsenic varied by embalmer, and probably by source. More data are needed, however, on the differences in embalming fluids by company and the popularity of some over others.

METHODS FOR IDENTIFYING ARSENIC ARCHAEOLOGICALLY

The potential for environmental impacts from the use of arsenic as an embalming agent is clear, and the amounts of arsenic that may be involved are substantial. Konefes and McGee (1996:16) estimate there was up to 12 lb per interment and up to a ton of arsenic total in a modest-sized town cemetery. These estimates form a stark contrast to the comparatively low Environmental Protection Agency (EPA) safe limit of 10 parts per billion (ppb) of arsenic in drinking water. Arsenic is environmentally persistent and can remain concentrated over time. Its transmissibility into the environment, however, depends on multiple factors, including soil type, groundwater, and rainfall. Consequently, archaeologists must be prepared to both manage the occupational hazard posed by arsenic exposure that could occur with investigators working in a cemetery environment (Meyers et al 1998:1–2) and to advise landowners and clients as to how the contamination may affect future land-use options and what environmental impact mitigations may be required by state regulations.

Research

Prior to any archaeological excavations on any cemetery dating between 1860 and 1920, the history of the cemetery should be thoroughly researched to determine age and use. This history should focus on what types of individuals were buried there in terms of ethnicity, race, and other factors discussed above. Even though an archaeologist is less likely to excavate a public cemetery than a private one, the arsenic problem exists in either situation. It is unlikely that municipalities or local governments are aware of the use of arsenic as an embalming fluid during the nineteenth century, although some publications have drawn attention to its use (e.g., Chiapelli and Chiapelli 2008). Small cemeteries are more likely to be excavated than larger, public cemeteries, and if families were of modest or low income, those buried are less likely to have been embalmed. Large city cemeteries that have been excavated—including Snake Hill Cemetery (also known as Laurel Hill; late nineteenth through mid-twentieth century), associated with a public poor house cemetery in Secaucus, New Jersey; the poorhouse Milwaukee County Poor Farm Cemetery in Milwaukee, Wisconsin (mid-nineteenth through early twentieth century); and the Old Frankfort Cemetery in Frankfort, Kentucky (mid-nineteenth century)—did contain some arsenic in the burials. Another cemetery in Indianapolis had the potential to contain embalmed individuals, but they were encased in concrete vaults, which were usually not opened. At Snake Hill,

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some embalming fluid was found in some coffins, which was surprising because it was a pauper cemetery associated with medical facilities and a prison. At the Court Street Cemetery in Arizona, eight complete and three broken bottles of embalming fluid were recovered (Thiel et al. 2013:45–47). The presence of these types of bottles at a historic cemetery is a strong indication of the presence of arsenic.

Based on these limited examples, the presence or absence of arsenic or other embalming fluids cannot be known until soil samples are obtained. Archaeologists should proceed with caution: seemingly poor cemeteries may have individuals whose wealthy relatives paid for embalming, and, conversely, large public cemeteries may contain burials from medical facilities or prisons. If archaeologists are excavating cemeteries as part of mitigation of inadvertent discovery, historical research may be occurring during excavation. In the absence of historic research prior to excavation, archaeologists should assume contamination and proceed in a manner that protects all workers.

Personal Protective Equipment (PPE)

Individuals collecting samples should wear Tyvek coveralls and latex gloves. Nitrile gloves can be used in cases of latex allergies. After collection of samples, the coveralls and gloves should be placed in a common trash bag and disposed of. Individuals taking samples should wash their hands and face before eating or performing other work.

If the cemetery is determined to have the potential of containing arsenic, the following steps should be taken. First, identify the grave shafts on the site, and take soil samples from each before excavation. Using a small bucket auger, obtain one sample from the base of the center of the shaft and from approximately 1 ft. below the base. Before initial sampling and between samples, decontaminate the bucket auger with soap and water, followed by a distilled-water wash. We note that arsenic leaves a telltale signature on bones—a turquoise crystal that is evident on both bones and the soil immediately surrounding them. Store samples in clean containers on ice in coolers. Data designated by the testing laboratory should be recorded on each sample container, as well as on the chain-of-custody form and in a field notebook. These data should include sample number, provenience, and depth of sample.

Soil Testing

Samples should also be collected in off-site areas because, as stated above, environmental factors such as soil and groundwater can affect how far arsenic can travel into the surrounding environment. The sampling area should be as similar as possible to the soil anomaly site in soil type, land use, drainage, and vegetation, but it must be located outside the area where contamination may be present. If possible, off-site samples should be collected uphill or to the side of the site rather than downhill from the site. Off-site samples need to be decontaminated between collections using the same methods described above. Two aggregated samples should be collected from an off-site location. Each sample should consist of soil from five or six separate auger holes taken at the approximate depth of the on-site samples. In unmarked cemeteries, a sufficient amount of topsoil needs to be removed to identify grave shafts prior to sampling. We recognize that soil sampling creates a necessary disturbance. If minor sampling disturbance is necessary to provide a safe work environment, however, then sampling takes precedence and outweighs the risk of damage to the resource. Arsenic is an acute toxin and employers are required to provide workers with a safe work environment.

After collection, send all samples to a testing laboratory. We strongly recommend the use of a qualified environmental testing laboratory. Note that different labs may be used to analyze the samples collected. Once identified, follow the lab's sampling protocols and chain-of-custody procedures. Because many archaeological projects are time sensitive, we suggest immediately sending the first samples collected from the feature to the laboratory. Additional soil samples from other features can be collected while the initial samples are being tested. It is recommended that between five and 10 samples be tested. Standard testing costs for arsenic is about $60/sample, with a usual turnaround time of three weeks.

If the arsenic level in the sample is less than 20 parts per million (ppm), arsenic contamination is likely absent, and excavation can proceed using standard health and safety procedures. For comparison, the average U.S. soil contains about 5 ppm (Lindsay 1979). Although states set their own threshold limits, the typical threshold is around 20 ppm (Teaf et al. 2010). This threshold applies to both residential and nonresidential sites and takes into account "natural background" levels. It is a good idea, however, to check with your state EPA office. If arsenic in the samples is greater than 20 ppm but less than 100 ppm, arsenic contamination is likely present. The level of arsenic needs to be verified. Once verified, dust control measures and thorough excavator hygiene must be used. If arsenic in fill is present at levels greater than 100 ppm, arsenic contamination is probable. The arsenic level should be confirmed through additional testing. No excavation of grave shafts should be undertaken until further expert assessment is completed. Expert assessment refers to qualified personnel working under a detailed health and safety plan. This is discussed in greater detail in the following section.

ENVIRONMENTAL IMPACT MITIGATION

Arsenic testing is part of the regulatory framework of both the Occupational Safety and Hazards Administration (OSHA) and the EPA, and depending on individual circumstances, mitigation of these hazards is mandatory under both agencies. The guidance and procedures that could be required on a site contaminated with arsenic will vary from state to state. We recognize that cultural resource management firms not part of larger engineering or environmental firms are at a disadvantage here, and we suggest that they begin by contacting their state EPA office. Those that are affiliated with firms that have broad expertise in environmental regulation should be consulted as needed. We use the Illinois EPA as an example (Chris Cahnovsky, Environmental Health and Safety Manager, Southern Illinois University, Edwardsville, personal communication 2020) to show that although this is complex from a regulatory standpoint, it is a process that has achievable remediation goals. Initially, the management of a site with known arsenic contamination in Illinois could be subject to one of two

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procedures. A site remediation could be voluntary and administered through the Illinois Site Remediation Program (SRP). In a worst-case scenario, however, it could be brought involuntarily through an enforcement action. Here, we focus on a brief description of the voluntary process, with the goal of advising and expediting the process for a landowner or client.

The Illinois SRP is designed to be flexible to meet the needs of the voluntary site-remediation applicant. Future land-use goals are determined by the SRP applicant, and they play a critical role in determining the extent of the remediation. This is accomplished by following action levels outlined in the state's Tiered Approach to Corrective Action Objectives (TACO). As the SRP applicant works through the remediation process, the state EPA provides expertise, technical assistance, plan review, and action evaluation, along with a "No Further Remediation" determination once the corrective action objectives are complete.

Subsequent to enrolling in the Illinois SRP, the landowner would—in the case of a cemetery with known contaminants—conduct a focused investigation to determine the extent of the contamination and then develop a corrective action plan that would meet one of the three tiers in the TACO guidelines. Depending on the site's geomorphology and hydrology, this could be a plan to "dig and haul" with the goal of meeting the strictest Tier 1 TACO objective. From an engineering and cost-estimate perspective, this would be similar to the "tank yank" methodology employed to mitigate a leaking underground storage tank. Meeting the Tier 2 and 3 TACO objectives, however, might involve forms of mitigation in place as well as ongoing institutional or engineered controls. Examples of these include groundwater use restrictions or engineered barriers to control the future movement of arsenic to groundwater.

Last, the landowner would address soil disposal management issues if it were determined that the site's soils constituted a hazardous waste according to the Resource Conservation and Recovery Act (RCRA). For example, if a dig and haul remediation was employed, the soil would have to pass a Toxicity Characteristic Leaching Procedure test (TCLP) before it could be landfilled. Soils with a TCLP result higher than 5 ppm would be subject to EPA Land Disposal Restrictions (LDRs) and might require application of treatment standards.

EXAMPLES OF ARSENIC TESTING IN ARCHAEOLOGICAL CONTEXTS

Four reports were examined from the Kentucky Office of State Archaeology for testing strategies and the presence of arsenic during cemetery excavations, specifically where their presence would necessitate modifications to the excavation methods if high levels of these elements were found. For each of the cemetery excavations examined, similar techniques were used. Soil samples were removed from known locations of burials and control soil samples were taken from an area outside of the cemetery. Often, the samples were removed from above (higher elevation) the cemetery, outside of the cemetery limits, as well as from below (lower elevation) the cemetery, outside of the cemetery limits. In some cases, however, only one control soil sample was removed from outside of the cemetery limits.

The Old Branham Cemetery (15FD94) dates from the first quarter of the nineteenth century through approximately AD 1900 (Bybee 2004:40–43). Six soil samples from graves and two soil control samples were removed. Sampling showed no significant elevations in the amounts of arsenic or mercury within graves when compared to the control samples. For arsenic, samples remained between <4.28 ppm to 6.76 ppm, which is well below the 20–100 ppm considered hazardous. At the Mosley Cemetery (1830–1920)—a family cemetery in Campbell County, Kentucky (Bybee 2016:56)—four soil samples from graves and two soil control samples were removed. Sampling showed no significant elevations in the amounts of arsenic or mercury within graves when compared to the control samples. For arsenic, samples remained between 1.9 mg/kg and 6.8 mg/kg (or less than 1.9–6.8 ppm), also well below the 20–100 ppm considered hazardous. For another cemetery in Campbell County, Kentucky (15Cp61; 1830–1900), a probable family or local area cemetery (Bybee 2003:42–43), three soil samples from graves and one soil control sample were removed. Sampling showed no significant elevations in the amounts of arsenic within graves when compared to the control samples. For arsenic, samples remained between 8.9 ppm and 15 ppm—again, below the 20–100 ppm considered hazardous. Work completed at the post-1840s public Rudy Cemetery consisted of the monitoring of a utility trench (McBride and Beverley 2010:6.1–6.3). A variety of human skeletal materials was recovered from disturbed contexts associated with the cemetery. The Kentucky Transportation Cabinet (KYTC) informed Wilber Smith Associates (WBA) that a bluish-green substance was noted on at least one long bone, and it was suspected that the bone was contaminated with arsenic. A sample of the substance was removed and sent for analysis. The results indicated that the level of arsenic was low (less than 49 ppm). No control samples were removed from this cemetery for comparison. McBride and Beverley surmised that the

> bluish-green substance was probably associated with the position of a cupreous metal item or items on or very near the skeleton after interment of the body. Many items made from cupreous metals (i.e. copper and copper alloys) corrode to blue or green over time and with exposure to elements [2010:6.3].

A relatively new device can be used for rapid detection of arsenic in soil in the field. A handheld portable X-ray fluorescence spectrometry instrument (pXRF) can provide immediate results of suspicious soil stains noticed during cemetery excavations. Although effective, the tool is used only when a suspicious soil stain is observed—that is, one could have already been exposed to contaminated soil before using the pXRF analyzer. For a Niton pXRF, the limit of detection for arsenic in soil ranges from 10 to 15 ppm depending on the type of filter used (Thermo Scientific 2020). For liability reasons, elevated field test results obtained with a pXRF analyzer should be confirmed with a certified environmental testing lab.

During excavations at the Milwaukee County Poor Farm Cemetery (Richards et al. 2016:90–91), a Bruker Tracer IIIv+ pXRF was used in the field to test for suspected contaminants after a coffin was located in association with a bright-blue soil deposit. Additionally, a Niton XLT pXRF was used in the lab for artifact analysis, specifically with a set of vulcanite dentures that contained elevated levels of mercury, demonstrating the versatility of this type of pXRF

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instrumentation. The field analysis of the coffin and associated blue staining did, in fact, yield very elevated levels of arsenic in samples from the pelvic region. Richards and colleagues state that "the genesis of this deposit remains unknown" (2016:91), but the authors of this article believe that it is highly likely that the discovered contamination is the result of arsenic used in embalming.

LAST WORDS

Arsenic is one of many threats to archaeologists' health during excavation. It can be safely mitigated, however. Additional research on arsenic, using both historic and archaeological resources, are recommended to better identify the different ways in which populations adopted the practice of embalming and exemplified changing ideas of death in nineteenth-century America. Historians and social scientists have used documentary sources to identify this change, but this work could be supplemented by additional archaeological cases, especially those tested in the process of archaeological identification, testing, and mitigation.

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Data Availability Statement

No original data were presented in this article.

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