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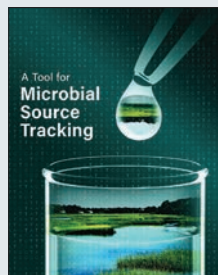
Shortcomings in traditional methods to understanding sources of bacterial contamination in water bodies limit the ability of public health officials to adequately protect public health and mitigate pollution sources. This month's cover article, "Microbial Source Tracking in the Sasco Brook, Lower Farm River, and Goodwives River Watersheds of Long Island Sound," used polymerase chain reaction (PCR) as a tool for microbial source tracking to attempt to identify host species contributing bacteria to three watersheds that flow into Long Island Sound. While the study had limitations and further research is needed, DNA analysis can be an effective public health tool toward bacterial source identification that can aid in determining if source bacteria are a potential threat to public health and to guide remediation efforts.

See page 8.

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▶ **PRESIDENT'S MESSAGE**

The Happiest Profession on Earth

D. Gary Brown,
DrPH, CIH, RS, DAAS

As I look back on the past year, words cannot express how grateful I am to be a part of this wild and wonderful environmental health field. Just like Henry David Thoreau said, "I am grateful for what I am and have. My thanksgiving is perpetual."

Over the past several years, environmental health professionals have been the unsung heroes of the COVID-19 pandemic. You have done as Abraham Lincoln said, "I do the very best I know how—the very best I can; and I mean to keep on doing so until the end." In this holiday season, we all have much to celebrate regarding environmental health along with the success of the National Environmental Health Association (NEHA). I want to extend my personal thanks to environmental health professionals, NEHA partners, students, and NEHA staff, regional vice-presidents, and board members.

As I stated in a previous column, we all are thankful for the ability to meet in person once again. I have been fortunate enough to attend several conferences that have allowed me to meet my fellow environmental health professionals and to learn new information. No matter what stage of our careers we are at, all environmental health professionals have unique knowledge and experiences. Environmental health professionals love to learn from each other because we have a shared passion.

I am thankful to be a part of a dynamic and constantly evolving field. When I started in the field 30 years ago, indoor air quality, emergency response, per- and polyfluoroalkyl substances (PFAS), nanomaterials, cyanobacteria (i.e., blue-green algae) blooms, and cli-

> *Environmental health professionals love to learn from each other because we have a shared passion.*

mate change were barely a blip on the radar, if on our radar at all. Learning about these areas along with other emerging challenges keeps me excited, engaged, and entertained.

Over the past several months I had the pleasure to attend the Yankee Conference in New England, the Canadian Institute of Public Health Inspectors National Conference, and the Jamaica Association of Public Health Inspectors Annual Educational Conference. Over the years I have learned that no matter where we hail from—even from a galaxy far, far away—we all speak the same environmental health language. Foundational principles of environmental health apply anywhere, irrespective of nuances in regulations.

Unlike many other professions, another magnificent aspect of our profession is the willingness and happiness to share information regarding similar challenges. In many professions, such as engineering, the free sharing of ideas is hindered by the fear of losing a competitive advantage. Environmental health professionals want to ensure people have a safe and healthy place in which to live, work, and play.

I am extremely grateful to have the privilege to teach this wild and wonderful environmental health field to future professionals. As Bob Phillips stated, "There are three stages of man: he believes in Santa Claus; he does not believe in Santa Claus; he is Santa Claus." Even though I am the Santa Claus (I still believe) of the Environmental Health Science Department at Eastern Kentucky University (EKU), my colleagues and the students help to keep me young at heart by educating me on new things. Today, students and early career professionals want a fulfilling career to help people and to make the world a better place. For younger individuals, environmental health checks off all of those career boxes along with many others.

As our EKU students say, the Environmental Health Science Department is the "happiest department on campus," not quite up to Disneyland's "The Happiest Place on Earth." Another slogan for environmental health could be the "happiest profession on Earth." Please volunteer to share the joy because all of the National Environmental Health Science and Protection Accreditation Council (EHAC) environmental health programs would love to have more environmental health professionals involved with and engaged in these programs. Let us all work to empower students for a bright future in a career with endless possibilities.

EHAC is the gold standard regarding environmental health science accreditation. EHAC requires a firm educational foundation in the natural sciences of biology, microbiology, chemistry, and physics. This

foundation—combined with a requirement for the completion of a practical, hands-on internship—results in graduates that are well prepared to immediately enter the environmental health workforce or to continue their academic journeys. Many environmental health professionals may not know that graduation from an EHAC-accredited program is required to enter U.S. Public Health Service, U.S. Army, and U.S. Navy environmental science and engineering careers. Graduates of EHAC-accredited programs meet the criteria to take the NEHA Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential examination after graduation. Please reach out to a program in your area. I know you will enjoy your time at your local college or university's "happiest department on campus" while sharing your experience about the "happiest profession on Earth."

If there are no EHAC-accredited program in your area, there are local colleges or universities that may be interested in starting an environmental health science program. Further, please reach out to the Association of Environmental Health Academic Programs (AEHAP). We need more environmental health science programs at the undergraduate and graduate levels both nationally and internationally. There are more jobs than graduates, which results in countless jobs being filled by those not possessing an environmental health science degree. Unlike many other fields, even if the number of environmental health science programs doubled or tripled and the number of graduates quadrupled or quintupled—which would be a wonderful thing—there would still be an abundance of jobs filled by those not possessing an environmental health science degree.

I want to provide a little background about an unsung organization in our field: AEHAP. In 1999, AEHAP volunteers and a small staff began working alongside EHAC volunteers to promote the value of environmental health education and degrees. The goal was to launch more environmental health professionals into careers of significance for the care, health, and protection of our communities. From then to now, the goal remains to encourage more students to pursue a science-based degree in environmental health. AEHAP and EHAC would love to have more environmental health professional involved—the more the merrier.

Hopefully, we will be able to enjoy some well-deserved time off during these holidays. I wish all of you the very best, along with health and happiness throughout the coming year. A little more sparkle, a little less stress. As environmental health science rings in the New Year, I leave you with a quote from David Bowie: "I don't know where I'm going from here, but I promise it won't be boring." �

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Microbial Source Tracking in the Sasco Brook, Lower Farm River, and Goodwives River Watersheds of Long Island Sound

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Abstract

Shortcomings in traditional methods for understanding sources of bacteriological contamination limit the ability of public health officials to adequately protect public health and mitigate pollution sources. This study used polymerase chain reaction (PCR) as a tool for microbial source tracking to attempt to identify host species contributing bacteria to three watersheds flowing into Long Island Sound. Samples were collected once a month near the mouth of each watershed and analyzed for other *E. coli* (a traditional fecal indicator) and genetic markers for members of the phylum *Bacteroidetes*. Genetic markers included host-specific markers that can be used to identify sources of contamination such as humans, domestic animals, and wildlife. Despite observing elevated *E. coli* levels in all three watersheds, we could not make a conclusive determination of actual sources using the available tools. Additionally, as there was disagreement between the *E. coli* levels and the presence of the general *Bacteroidetes* marker, it is important to evaluate the accuracy of this indicator with respect to recent fecal contamination and human health risks. Limitations posed by using indicator organisms, such as enterococci, illustrate the need to develop other methodologies for assessing actual sources of bacterial contamination.

Introduction

The presence of fecal matter is a cause of water body impairment in the U.S. and globally. Fecal contamination poses public health risks associated with pathogens (Cabral, 2010; Wade et al., 2010) as well as other concerns such as excess nutrients leading to eutrophication (Pinckney et al., 2001). Water bodies often are declared closed when impairment is suspected, causing loss of access by both recreational and commercial users, thereby resulting in economic damages in the community (Rabinovici et al., 2004). While proxy measures associated with impairment

(e.g., rainfall amount) often are used for such closures, a common means to trigger the closure of water bodies is the detection of fecal indicator bacteria (FIB) such as *E. coli* or enterococci that are found primarily or exclusively in feces, which can be easily quantified.

Although monitoring for FIB has been used to assess water quality for decades, there are many limitations of this method, including a poor correlation with health risks (Colford et al., 2007) and a lack of information regarding the source of the contamination. While point sources of fecal contamination have been addressed largely through improved infra-

structure, sites that continue having elevated bacterial counts (possibly due to fecal contamination) experience contribution from numerous and difficult-to-identify nonpoint sources of fecal matter or bacteria. An important first step in the process of source identification is the ability to identify the species contributing to elevated FIB counts.

Source identification is particularly relevant at the watershed scale where numerous sources likely contribute to contamination. Without being able to quickly identify fecal contamination sources via testing, water quality managers rely on time-consuming and costly surveys that are often unsuccessful at identifying the sources. Additionally, unknown sources limit the ability for mitigation and risk assessment in watersheds that experience contamination. Our project design was an attempt to remove proxy measures used to make public health decisions and use DNA source tracking to determine the sources of bacteria as a means of assessing risk levels.

To address the limitations of traditional FIB monitoring, a microbial source tracking toolbox has been developed that includes a range of methodologies (Scott et al., 2002). One promising option within this toolbox is the amplification of selected DNA fragments via polymerase chain reaction (PCR). PCR can be used to amplify a variety of markers including those found in fecal pathogens (Harwood et al., 2014; Korajkic et al., 2018) or the same FIB traditionally used for culture-based detection (Chern et al., 2011; Haugland et al., 2010; Kildare et al., 2007). By targeting genetic markers within the bacteria that are specific to a given host (i.e.,

Map of Connecticut Showing the Location of the Three Targeted Watersheds

Lower Farm River, Branford

Sasco Brook, Westport

Goodwives River, Darien
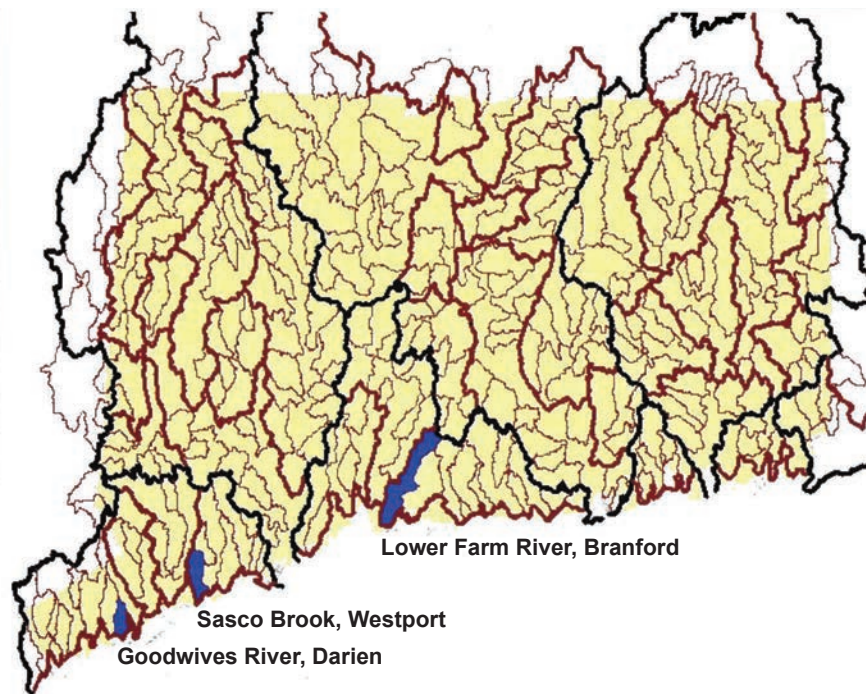
host-specific genetic markers), it is possible to identify species that contribute to fecal contamination in a body of water (Bernhard & Field, 2000). This approach could provide water quality managers with possible contamination sources, which is a valuable starting point to begin source tracking and eventual mitigation in a targeted way.

In our study, three local health departments in Connecticut collaborated to use host-specific genetic markers to provide information on possible contamination sources in three watersheds in coastal Connecticut. All three selected watersheds outlet into the Long Island Sound (LIS), an Atlantic Ocean tidal estuary that the U.S. Congress declared to be of national significance. Water quality in LIS is threatened by localized urbanization and the >9 million people who live within the watershed area (Save the Sound, 2022).

The LIS estuary has been the focus of many remediation efforts (Schimmel et al., 1999; State of Connecticut, 2020), yet still experiences frequent elevated fecal bacteria counts, especially after rainfall events. By analyz-

ing water samples from each watershed, we attempted to identify the sources of bacteria, evaluate the actual risk the bacteria pose to public health, better understand fluctuations in bacterial counts affecting the water quality of LIS, and establish mitigation programs based on these results.

Methods

Watershed Selection
The Sasco Brook (Westport), Lower Farm River (Branford), and Goodwives River (Darien) watersheds (Figure 1) all have experienced unexplained elevated bacterial counts that were especially pronounced after precipitation events. Both Sasco Brook and Goodwives River have been identified by the Connecticut Department of Energy and Environmental Protection (CT DEEP; State of Connecticut, 2019) as impaired water bodies for not meeting state water quality standards for fecal coliform bacteria (i.e., a class of FIB that includes *E. coli*). The Lower Farm River site has also experienced elevated FIB levels

and is of special interest because of recreational and commercial shellfishing. As all three watersheds feed into LIS, addressing impairments in water quality at these sites may also help to alleviate pressures on this estuary of national significance.

Standardized Sample Collection, Processing, and Monitoring of Traditional Fecal Indicator Bacteria
Sampling locations were selected near the mouth of each watershed. Water samples were collected once a month between January and December 2016 at low or ebbing tides to avoid tidal influence. For each sample, approximately 500 ml of water was collected in a sterile container from between 6 and 12 in. below the surface of the water. Samples were placed in an insulated cooler on ice for transport to the Harbor Watch Laboratory in Westport, Connecticut.

E. coli enumeration was conducted at the Harbor Watch Laboratory using m-FC media following standard method 9222D (National Environmental Methods Index, n.d.). Individual CFUs were counted to estimate bacterial abundance in the water samples.

For the genetic analysis, two independent 100-ml water subsamples were vacuum filtered on a 0.2-μm pore size polycarbonate filter (GE Osmotic 04CP04700) to concentrate bacterial cells. Following filtration, the filter was removed aseptically and placed into cryo-safe tubes with glass beads or in a sterile polypropylene tube with a screw cap. These filters were stored at -80 °C in the Connecticut Agricultural Experiment Station (CAES). DNA extractions were conducted on the first set of filters at CAES as previously described (Shanks et al., 2016).

Analysis With qPCR
Analysis for host-specific genetic markers was conducted at the Center for Genetic Analyses of Biodiversity in the Yale Institute for Biospheric Studies. Quantitative PCR (qPCR) was used (ABI 7500 Fast Real-Time PCR) to amplify all markers using either SYBR Green or TaqMan chemistry (Table 1).

TaqMan reactions were a total volume of 20 μl consisting of 10 μl of TaqMan Fast Universal Master Mix (ThermoFisher 4352042), 500 nmol/l of each primer, and 250 nmol/l of probe. SYBR Green assays were conducted similarly, with 20 μl reactions consisting of

TABLE **1**

List of Primers and Probes Used

Assay	Host Primer and Probe	Group	Reference
TaqMan			
GenBac3	General *Bacteroidetes*	F: GGGGTTCTGAGAGGAAGGT R: CCGTCATCCTTCACGCTACT P: [FAM]-CAATATTCCTCACTGCTGCCTCCCGTA-[TAMRA]	Dick & Field, 2004; Siefring et al., 2008
HF183	Human	F: ATCATGAGTTCACATGTCCG R: CTTCCTCTCAGAACCCCTATCC P1: [FAM]-CTAATGGAACGCATCCC-[MGB] P2: [VIC]-AACACGCCGTTGCTACA-[MGB]	Bernhard & Field, 2000; Seurinck et al., 2005
HumM2	Human	F: CGTCAGGTTTGTTTCGGTATTG R: TCATCACGTAACTTATTTATATGCATTAGC P1: [FAM]-TATCGAAAATCTCACGGATTAACTCTTGTGTACGC-[TAMRA] P2: [VIC]-CCTGCCGTCTCGTGCTCCTCA-[TAMRA]	Shanks et al., 2009
Rum2Bac	Ruminant	F: ACAGCCCGCGATTGATACTGGTAA R: CAATCGGAGTTCTTCGTGAT P: [FAM]-ATGAGGTGGATGGAATTCGTGGTGT-[BHQ-1]	Mieszkin et al., 2010
CowM2	Cattle	F: CGGCCAAATACTCCTGATCGT R: GCTTGTTGCGTTCCTTGAGATAAT P: [FAM]-AGGCACCTATGTCCTTTACCTCATCAACTACAGACA-[TAMRA]	Shanks et al., 2009
LA35	Poultry	F: ACCGGATACGACCATCTGC R: TCCCCAGTGTCAGTCACAGC P: [FAM]-CAGCAGGGAAGAAGCCTTC GGGTGACGGTA-[BHQ-1]	Nayak et al., 2015
DogBact	Canine	F: CGCTTGTATGTACCGGTACG R: CAATCGGAGTTCTTCGTG P: [6-FAM]-ATTCGTGGTGTAGC GGTGAAATGCTTAG-[BHQ-1]	Schriewer et al., 2015
Sketa22	Quality assurance	F: GGTTTCCGCAGCTGGG R: CCGAGCCGTCCTGGTCTA P: [FAM]-AGTCGCAGGCGGCCACCGT-[TAMRA]	Haugland et al., 2005
SYBR Green			
GFD *	General avian	F: TCGGCTGAGCACTCTAGGG R: GCGTCTCTTTGTACATCCCA	Green et al., 2012
GFC *	Gull	F: CCCTTGTCGTTAGTTGCCATCATTC R: GCCCTCGCGAGTTCGCTGC	Green et al., 2012

*Assays were not successfully optimized.

10 µl of Fast SYBR Green Master Mix (ThermoFisher 4309155) and 500 nmol/l of each primer. All reactions were performed in triplicate in MicroAmp optical 96-well plates with optical adhesive film. Cycling parameters included a 2-min start at 94 °C followed by 40 cycles of 15 s at 94 °C and 32 s at 60 °C. Cycle threshold for each run was determined by the instrument software.

Standards were constructed for each plate using synthetic plasmids consisting of sequences corresponding to the selected markers (Supplemental Table 1, www.neha.org/jeh-supplementals). Standards were diluted from a range of 10^5 to 10^1 markers per reaction and used to construct calibration curves for quantification for each run.

Troubleshooting to achieve amplification of the two SYBR Green assays was performed to reach specific and reliable amplification. These optimization steps included variations in melting temperature, magnesium chloride, and PCR additives such as bovine serum albumin.

Quality Assurance and Controls
For each round of sampling, one negative control filtration blank (i.e., sterile water known to contain no FIB or genetic markers) was processed following the same protocol as described above to detect contamination in the collection and processing steps. To ensure effective DNA extraction and detect inhibitors that could interfere with amplification, sample process controls consisting of salmon DNA were added into the extraction buffer as previously described (Shanks et al., 2016). Inhibition was measured by comparing the amplification efficiency (i.e., cycle threshold) of the blanks compared with the samples. Internal amplification controls (Supplemental Table 1) were used to detect inhibition by comparing the cycle threshold of no-template

Raw Counts Generated for the Two General Markers Quantified in the Three Targeted Watersheds

Date	Lower Farm River, Branford		Goodwives River, Darien		Sasco Brook, Westport	
	E. coli Levels (CFU/100 ml)	GenBac3 Counts (Markers/100 ml)	*E. coli* Levels (CFU/100 ml)	GenBac3 Counts (Markers/100 ml)	*E. coli* Levels (CFU/100 ml)	GenBac3 Counts (Markers/100 ml)
1/19/2016	12	346	14	320	54	3,024
2/16/2016	14	330	650	337	70	903
3/29/2016	190	1,568	38	153	52	558
4/26/2016	84	138	900	1,460	470	1,490
5/10/2016	80	94	82	47	74	455
6/23/2016	92	321	308	439	520	102
7/26/2016	168	369	22,000	1,248	1,100	401
8/22/2016	760	566	13,600	1,704	19,600	1,346
9/21/2016	140	208	1,200	301	300	194
10/18/2016	80	237	116	241	132	154
11/21/2016	350	490	138	133	350	1,940
12/19/2016	138	2,630	138	350	350	1,242

Note. The two general markers quantified in this study were not host associated.

control wells in each plate with those containing samples or standards.

Data Analysis and Interpretation

Each run was assessed visually for performance using ABI 7500 Fast software. Runs were screened for amplification in negative controls, high standard deviation among replicates, successful amplification in positive controls, and a standard curve constructed from plasmids. For each plate that was considered a successful run, results were exported into Excel using ABI 7500 Fast software. Analysis of the results and graphics were produced using RStudio (2015 version).

Results

Quality Assurance and Controls

Quality assurance and controls were implemented at various stages of the project to ensure the reliability of the data. Field blanks revealed no evidence of contamination at any stage of the sample handling process. The salmon DNA used as a control spike revealed environmental inhibition in all undiluted samples, which was addressed by a dilution factor of 5, after which no samples showed interference. Similarly, diluted samples showed no evidence of inhibition, as internal amplification controls were appropriately detected.

Two assays failed to pass the screening for successful runs and indicated nonspecific amplification. Steps taken to optimize both the GFC and GFD assays (Table 1) failed to improve performance, resulting in nonspecific amplification or no amplification. Due to these failings, we did not include these assays in further analyses.

General Indicators of Fecal Contamination

Traditional monitoring for *E. coli* at the three watershed sites revealed the occurrence of elevated bacterial counts as defined by the Connecticut bathing beach standard of 104 CFU/100 ml (Table 2). The Lower Farm River had lower *E. coli* levels relative to the other locations, but still had elevated levels in 50% of the samples. *E. coli* levels at the Goodwives River exceeded regulatory limits in 75% of samples, while samples collected in Sasco Brook suggested impairment 67% of the time. *E. coli* levels were higher at both the Goodwives River and Sasco Brook in summer months, with samples in July and August exceeding 10,000 CFU/100 ml at one or both sites.

The GenBac3 marker is found in members of the phylum *Bacteroidetes* but is not associated with a specific host. Organisms from the phylum *Bacteroidetes* such as *E. coli* are found in the gut of many animals, although the bacteria are also known to occur in the environment without contributions of fecal matter (Fiksdal et al., 1985). Like *E. coli*, the GenBac3 marker is an indicator of fecal contamination from multiple sources, and the two are often correlated (Bower et al., 2005; Savichtcheva et al., 2007). We found only a weak relationship, however, between *E. coli* and GenBac3 (Figure 2). We found a slightly higher correlation between the levels of *E. coli* and the general marker GenBac3 (R^2 = .44) at Goodwives River. This correlation, however, is largely influenced by the elevated GenBac3 counts and *E. coli* levels in July and August, whereas there is little to no correlation when considering other samples from the same sites (R^2 = .19) when high counts were removed from the analysis.

Host-Specific Markers

In addition to identifying general indicators of fecal bacteria, we also examined the presence of host-specific markers that provide information on the source of contamination

(Table 1). We found little evidence of chronic human contamination at any site, although human markers were detected sporadically below the lower limit for quantification but still above the limit of detection (Supplemental Table 2). The ruminant marker was also detected infrequently at the Lower Farm River and Sasco Brook, while there was no detection at Goodwives River (Supplemental Table 1). The sporadic detection of markers at these sites does little to explain the sources of contamination, as the detection of these markers did not correspond to elevated counts of *E. coli* (Figure 3). Markers associated with contamination by poultry, dogs, and cattle feces were not detected in any of the samples (Supplemental Table 2).

Discussion

The aim of this project was to develop a microbial source tracking program in coastal Connecticut and establish a scientific method for assessing the sources of fecal contamination that can lead to water body impairment. This study, however, did not detect significant human, domesticated animal, or wildlife contributions to the elevated bacteria levels in the three targeted watersheds. Our results suggest that the tested sources might not contribute to the observed elevated bacteria levels. This information is valuable considering the potential threat to public health that the discovery of human markers would have represented. Not finding a definitive answer on the contamination source, however, prevents the development of action-based remediation recommendations.

While genetic markers associated with human, poultry, dog, ruminant, and cattle feces were successfully implemented, the markers for avian (including seagull) contamination failed quality assurance procedures. At the time of this study, alternative markers for avian contamination had not yet been tested for use in studies of this type. A more consistent and reliable marker for geese is needed as well as additional markers to enable the detection of other potential sources of bacterial contamination such as rodents or other wildlife.

The U.S. Environmental Protection Agency, CT DEEP, and other agencies recognize that indicator bacteria are not the basis of a human health risk but rather a proxy for other more serious disease-causing organ-

FIGURE **2**

Relationship Between *E. coli* Levels and GenBac3 Counts in the Three Targeted Watersheds

A. Lower Farm River, Branford

B. Goodwives River, Darien

C. Sasco Brook, Westport
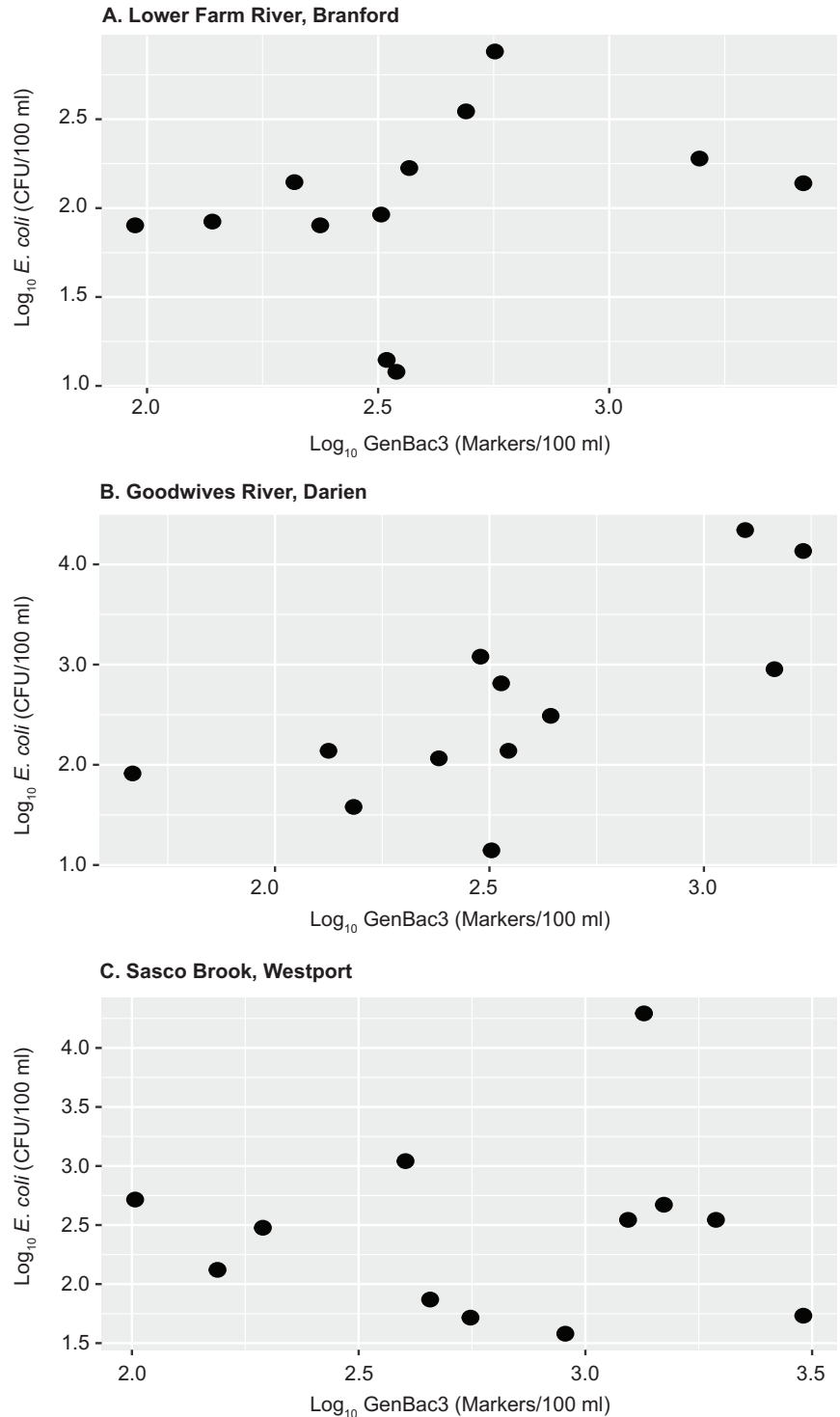
Note. The results demonstrate a weak correlation between *E. coli* levels and GenBac3 counts for any of the sampling sites.

FIGURE **3**

Absence and Presence of Human-Associated (A) and Ruminant-Associated (B) Markers in the Three Targeted Watersheds
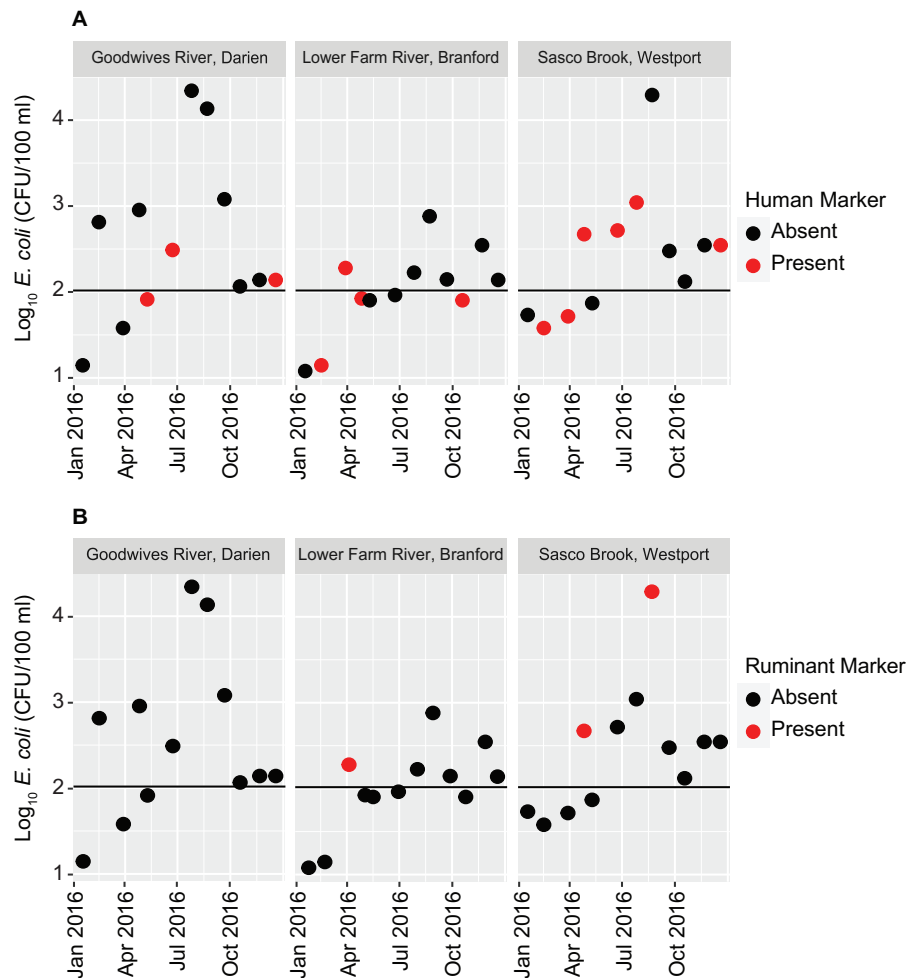
Note. The presence of the human-associated and ruminant-associated markers did not correlate with elevated *E. coli* levels.

isms that might be present when indicator bacteria are detected at concentrations above the water quality criteria.

While the results reported here support past findings by CT DEEP that all of these watersheds have had fecal contamination (State of Connecticut, 2022), the lack of correlation between *E. coli* levels and GenBac3 counts presents challenges in identifying sources of *E. coli*. As the elevated *E. coli* levels were predominantly in the summer, one possibility is that the *E. coli* originated from avian sources, particularly geese, which are known to have gut microbiota fluctuations

resulting in elevated *E. coli* levels in summer months (Alderisio & DeLuca, 1999). Additionally, birds are known to have low levels of *Bacteroidetes*, further supporting the hypothesis that geese or other birds could have contributed *E. coli* while not adding to the levels of *Bacteroidetes* detected.

Another possible explanation for the lack of correlation is that conditions were more favorable to support *E. coli* persistence outside of the gut environment in summer months when the water is warmer (Korajkic et al., 2019). While *Bacteroidetes* are anaerobic and thus do not survive outside the host

gut for long regardless of the season (Ahmed et al., 2014; Ballesté & Blanch, 2010; Kreader, 1998), *E. coli* can persist outside the host for longer periods in specific environments (Ishii & Sadowsky, 2008).

Limitations

Our findings serve to not only advance the understanding of water quality in coastal Connecticut but also help to highlight the limitations of using molecular markers to identify sources of fecal contamination. Major limitations include the lack of correlation between indicators and pathogens (Korajkic et al., 2018) and an inadequate understanding of the persistence of traditional and newer fecal indicators (Korajkic et al., 2019).

We also acknowledge the limitations of the tested DNA sources. The tested bird sources did not pass quality assurance, which—along with the fact that other nontested bacteria sources (e.g., rodents, etc.) might have been present in the sample—means that at this time it is not possible to correlate *E. coli* with bacteria-specific sources of bacterial contamination. Further research into source tracking as a means of determining public health risk is warranted.

An additional or alternate direction for future studies could be to employ next-generation sequencing technologies to assess likely sources of bacteria and to detect actual pathogens rather than focusing on surrogate indicators. Moreover, a series of sampling points along each river in conjunction with a more aggressive sampling schedule that included precipitation events would have been the preferred collection methodology. Due to limited project resources, however, a single sample location was selected for each targeted watershed, with collections conducted in such a way as to avoid tidal influence.

Conclusion

This study confirmed past findings that the targeted watersheds were consistently affected by elevated levels of fecal contamination after a rainfall event as detected by the indicators *E. coli* and GenBac3. In addition, through the use of host-associated molecular markers used for microbial source tracking, we found no evidence to support the hypothesis that any of the sites were chronically impacted by human, ruminant (including cattle), poultry, or canine feces.

As more evidence mounts that *E. coli* levels are not necessarily associated with human health risks (Colford et al., 2007; Wade et al., 2010), it is important to bear in mind that elevated *E. coli* levels might not actually mean higher amounts of pathogens or feces. Future studies are necessary to address if the observed levels are associated with higher health risks and other indicators for fecal contamination. Additionally, other approaches to microbial source tracking—such as detecting viral markers through PCR amplification (Elkayam et al., 2018) or identifying chemical tracers (González-Fernández et al., 2021; Paruch & Paruch, 2021)—have been developed and could be used to complement the tools used in this study. More data regarding specific components of fecal contamination could provide additional information that would help determine sources that contribute to contamination and also assess the potential for human health risk.

In addition to needing more reliable markers, this study highlights the importance of considering the properties of indicators when designing exploratory studies such as this one. As we used both live-culture and genetic markers to identify contamination, counts between these two different methods might have been more similar if samples had targeted flushes of fresh fecal contamination (e.g., after storm events). Collecting samples after a storm event could increase the chance of detecting fresh fecal matter, which would likely improve both the finding of a correlation between the general indicators and the detection of host-specific genetic markers that decay rapidly in the environment.

Future studies should include more frequent water sampling associated with precipitation events and a more comprehensive sampling scheme to evaluate each watershed at multiple locations to pinpoint sources of contamination so that effective mitigation strategies can be instituted. DNA analysis can be an effective public health tool toward bacterial source identification that can aid in determining if source bacteria are a potential threat to public health and to guide remediation efforts. Further use of this technology should be evaluated, and its use considered by regulatory agencies as the DNA laboratory methodology is refined. ❧

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References

Ahmed, W., Gyawali, P., Sidhu, J.P.S., & Toze, S. (2014). Relative inactivation of faecal indicator bacteria and sewage markers in freshwater and seawater microcosms. *Letters in Applied Microbiology*, *59*(3), 348–354. https://doi.org/10.1111/lam.12285

Alderisio, K.A., & DeLuca, N. (1999). Seasonal enumeration of fecal coliform bacteria from the feces of ring-billed gulls *(Larus delawarensis)* and Canada geese *(Branta canadensis)*. *Applied and Environmental Microbiology*, *65*(12), 5628–5630. https://doi.org/10.1128/AEM.65.12.5628-5630.1999

Ballesté, E., & Blanch, A.R. (2010). Persistence of *Bacteroides* species populations in a river as measured by molecular and culture techniques. *Applied and Environmental Microbiology*, *76*(22), 7608–7616. https://doi.org/10.1128/AEM.00883-10

Bernhard, A.E., & Field, K.G. (2000). A PCR assay to discriminate human and ruminant feces on the basis of host differences in *Bacteroides-Prevotella* genes encoding 16S rRNA. *Applied and Environmental Microbiology*, *66*(10), 4571–4574. https://doi.org/10.1128/AEM.66.10.4571-4574.2000

Bower, P.A., Scopel, C.O., Jensen, E.T., Depas, M.M., & McLellan, S.L. (2005). Detection of genetic markers of fecal indicator bacteria in Lake Michigan and determination of their relationship to *Escherichia coli* densities using standard microbiological methods. *Applied and Environmental Microbiology*, *71*(12), 8305–8313. https://doi.org/10.1128/AEM.71.12.8305-8313.2005

Cabral, J.P.S. (2010). Water microbiology. Bacterial pathogens and water. *International Journal of Environmental Research and Public Health*, *7*(10), 3657–3703. https://doi.org/10.3390/ijerph7103657

Chern, E.C., Siefring, S., Paar, J., Doolittle, M., & Haugland, R.A. (2011). Comparison of quantitative PCR assays for *Escherichia coli* targeting ribosomal RNA and single copy genes. *Letters in Applied Microbiology*, *52*(3), 298–306. https://doi.org/10.1111/j.1472-765X.2010.03001.x

Colford, J.M., Jr., Wade, T.J., Schiff, K.C., Wright, C.C., Griffith, J.F., Sandhu, S.K., Burns, S., Sobsey, M., Lovelace, G., & Weisberg, S.B. (2007). Water quality indicators and the risk of illness at beaches with nonpoint sources of fecal contamination. *Epidemiology*, *18*(1), 27–35. https://doi.org/10.1097/01.ede.0000249425.32990.b9

Dick, L.K., & Field, K. (2004). Rapid estimation of numbers of fecal *Bacteroidetes* by use of a quantitative PCR assay for 16S rRNA genes. *Applied and Environmental Microbiology*, *70*(9), 5695–5697. https://doi.org/10.1128/AEM.70.9.5695-5697.2004

Elkayam, R., Aharoni, A., Vaizel-Ohayon, D., Sued, O., Katz, Y., Negev, I., Marano, R.B.M., Cytryn, E., Shtrasler, L., & Lev, O. (2018). Viral and microbial pathogens, indicator microorganisms, microbial source tracking indicators, and antibiotic resistance genes in a confined managed effluent recharge system. *Journal of Environmental Engineering*, *144*(3), Article 05017011. https://doi.org/10.1061/(ASCE)EE.1943-7870.0001334
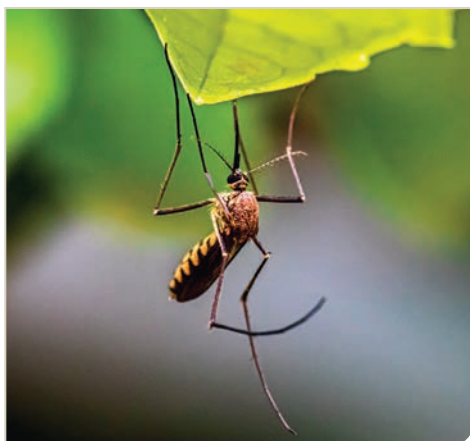
References

Fiksdal, L., Maki, J.S., LaCroix, S.J., & Staley, J.T. (1985). Survival and detection of *Bacteroides* spp., prospective indicator bacteria. *Applied and Environmental Microbiology*, *49*(1), 148–150. https://doi.org/10.1128/aem.49.1.148-150.1985

González-Fernández, A., Symonds, E.M., Gallard-Gongora, J.F., Mull, B., Lukasik, J.O., Rivera Navarro, P., Badilla-Aguilar, A., Peraud, J., Brown, M.L., Mora Alvarado, D., Breitbart, M., Cairns, M.R., & Harwood, V.J. (2021). Relationships among microbial indicators of fecal pollution, microbial source tracking markers, and pathogens in Costa Rican coastal waters. *Water Research*, *188*, Article 116507. https://doi.org/10.1016/j.watres.2020.116507

Green, H.C., Dick, L.K., Gilpin, B., Samadpour, M., & Field, K.G. (2012). Genetic markers for rapid PCR-based identification of gull, Canada goose, duck, and chicken fecal contamination in water. *Applied and Environmental Microbiology*, *78*(2), 503–510. https://doi.org/10.1128/AEM.05734-11

Harwood, V.J., Staley, C., Badgley, B.D., Borges, K., & Korajkic, A. (2014). Microbial source tracking markers for detection of fecal contamination in environmental waters: Relationships between pathogens and human health outcomes. *FEMS Microbiology Reviews*, *38*(1), 1–40. https://doi.org/10.1111/1574-6976.12031

Haugland, R.A., Siefring, S.C., Wymer, L.J., Brenner, K.P., & Dufour, A.P. (2005). Comparison of *Enterococcus* measurements in freshwater at two recreational beaches by quantitative polymerase chain reaction and membrane filter culture analysis. *Water Research*, *39*(4), 559–568. https://doi.org/10.1016/j.watres.2004.11.011

Haugland, R.A., Varma, M., Sivaganesan, M., Kelty, C., Peed, L., & Shanks, O.C. (2010). Evaluation of genetic markers from the 16S rRNA gene V2 region for use in quantitative detection of selected *Bacteroidales* species and human fecal waste by qPCR. *Systematic and Applied Microbiology, 33*(6), 348–357. https://doi.org/10.1016/j.syapm.2010.06.001

Ishii, S., & Sadowsky, M.J. (2008). *Escherichia coli* in the environment: Implications for water quality and human health. *Microbes and Environments*, *23*(2), 101–108. https://doi.org/10.1264/jsme2.23.101

Kildare, B.J., Leutenegger, C.M., McSwain, B.S., Bambic, D.G., Rajal, V.B., & Wuertz, S. (2007). 16S rRNA-based assays for quantitative detection of universal, human-, cow-, and dog-specific fecal *Bacteroidales*: A Bayesian approach. *Water Research*, *41*(16), 3701–3715. https://doi.org/10.1016/j.watres.2007.06.037

Korajkic, A., McMinn, B.R., & Harwood, V.J. (2018). Relationships between microbial indicators and pathogens in recreational water settings. *International Journal of Environmental Research and Public Health*, *15*(12), Article 2842. https://doi.org/10.3390/ijerph15122842

Korajkic, A., Wanjugi, P., Brooks, L., Cao, Y., & Harwood, V.J. (2019). Persistence and decay of fecal microbiota in aquatic habitats. *Microbiology and Molecular Biology Reviews*, *83*(4), e00005-19. https://doi.org/10.1128/MMBR.00005-19

Kreader, C.A. (1998). Persistence of PCR-detectable *Bacteroides distasonis* from human feces in river water. *Applied and Environmental Microbiology*, *64*(10), 4103–4105. https://doi.org/10.1128/AEM.64.10.4103-4105.1998

Mieszkin, S., Yala, J.-F., Joubrel, R., & Gourmelon, M. (2010). Phylogenetic analysis of *Bacteroidales* 16S rRNA gene sequences from human and animal effluents and assessment of ruminant faecal pollution by real-time PCR. *Journal of Applied Microbiology*, *108*(3), 974–984. https://doi.org/10.1111/j.1365-2672.2009.04499.x

National Environmental Methods Index. (n.d.). *Standard methods: 9222D: Membrane filtration test for fecal coliforms.* https://www.nemi.gov/methods/method_summary/5587/

Nayak, B., Weidhaas, J., & Harwood, V.J. (2015). LA35 poultry fecal marker persistence is correlated with that of indicators and pathogens in environmental waters. *Applied and Environmental Microbiology*, *81*(14), 4616–4625. https://doi.org/10.1128/AEM.00444-15

Paruch, L., & Paruch, A.M. (2021). Cross-tracking of faecal pollution origins, macronutrients, pharmaceuticals and personal care products in rural and urban watercourses. *Water Science & Technology*, *83*(3), 610–621. https://doi.org/10.2166/wst.2020.603

Pinckney, J.L., Paerl, H.W., Tester, P., & Richardson, T.L. (2001). The role of nutrient loading and eutrophication in estuarine ecology. *Environmental Health Perspectives*, *109*(Suppl. 5), 699–706. https://doi.org/10.1289/ehp.01109s5699

Rabinovici, S.J.M., Bernknopf, R.L., Wein, A.M., Coursey, D.L., & Whitman, R.L. (2004). Economic and health risk trade-offs of swim closures at a Lake Michigan beach. *Environmental Science & Technology*, *38*(10), 2737–2745. https://doi.org/10.1021/es034905z

Save the Sound. (2022). *Long Island Sound report card.* https://www.savethesound.org/report-card

Savichtcheva, O., Okayama, N., & Okabe, S. (2007). Relationships between *Bacteroides* 16S rRNA genetic markers and presence of bacterial enteric pathogens and conventional fecal indicators. *Water Research*, *41*(16), 3615–3628. https://doi.org/10.1016/j.watres.2007.03.028

Schimmel, S.C., Benyi, S.J., & Strobel, C.J. (1999). An assessment of the ecological condition of Long Island Sound, 1990–1993. *Environmental Monitoring and Assessment*, *56*(1), 27–49. https://doi.org/10.1023/A:1005967923353

Schriewer, A., Odagiri, M., Wuertz, S., Misra, P.R., Panigrahi, P., Clasen, T., & Jenkins, M.W. (2015). Human and animal fecal contamination of community water sources, stored drinking water and hands in rural India measured with validated microbial source tracking assays. *The American Journal of Tropical Medicine and Hygiene*, *93*(3), 509–516. https://doi.org/10.4269/ajtmh.14-0824

Scott, T.M., Rose, J.B., Jenkins, T.M., Farrah, S.R., & Lukasik, J. (2002). Microbial source tracking: Current methodology and future directions. *Applied and Environmental Microbiology*, *68*(12), 5796–5803. https://doi.org/10.1128/AEM.68.12.5796-5803.2002

References *continued from page 15*

Seurinck, S., Defoirdt, T., Verstraete, W., & Siciliano, S.D. (2005). Detection and quantification of the human-specific HF183 *Bacteroides* 16S rRNA genetic marker with real-time PCR for assessment of human faecal pollution in freshwater. *Environmental Microbiology*, 7(2), 249–259. https://doi.org/10.1111/j.1462-2920.2004.00702.x

Shanks, O.C., Kelty, C.A., Oshiro, R., Haugland, R.A., Madi, T., Brooks, L., Field, K.G., & Sivaganesan, M. (2016). Data acceptance criteria for standardized human-associated fecal source identification quantitative real-time PCR methods. *Applied and Environmental Microbiology*, 82(9), 2773–2782. https://doi.org/10.1128/AEM.03661-15

Shanks, O.C., Kelty, C.A., Sivaganesan, M., Varma, M., & Haugland, R.A. (2009). Quantitative PCR for genetic markers of human fecal pollution. *Applied and Environmental Microbiology*, 75(17), 5507–5513. https://doi.org/10.1128/AEM.00305-09

Siefring, S., Varma, M., Atikovic, E., Wymer, L., & Haugland, R.A. (2008). Improved real-time PCR assays for the detection of fecal indicator bacteria in surface waters with different instrument and reagent systems. *Journal of Water & Health*, 6(2), 225–237. https://doi.org/10.2166/wh.2008.022

State of Connecticut, Department of Energy and Environmental Protection. (2019). *Connecticut nonpoint source management 2018 annual report.* https://portal.ct.gov/-/media/DEEP/water/nps/annualreports/CT3192018AnnRptpdf.pdf

State of Connecticut, Department of Energy and Environmental Protection. (2020). *2020 integrated water quality report.* https://www.epa.gov/sites/default/files/2020-11/documents/2020-ct-integrated-rpt.pdf

State of Connecticut, Department of Energy and Environmental Protection. (2022). *Integrated water quality report to Congress.* https://portal.ct.gov/DEEP/Water/Water-Quality/Water-Quality-305b-Report-to-Congress

Wade, T.J., Sams, E., Brenner, K.P., Haugland, R., Chern, E., Beach, M., Wymer, L., Rankin, C.C., Love, D., Li, Q., Noble, R., & Dufour, A.P. (2010). Rapidly measured indicators of recreational water quality and swimming-associated illness at marine beaches: A prospective cohort study. *Environmental Health*, 9(1), Article 66. https://doi.org/10.1186/1476-069X-9-66

▶ **SPECIAL REPORT**

Biological Factors That Impact Variability of Lead Absorption and Blood Lead Level Estimation in Children: Implications for Child Blood Lead Level Testing Practices

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A b s t r a c t   **Childhood lead poisoning in the U.S. continues to be a major unresolved child public health issue. One barrier to solving the problem of lead poisoning concerns current child blood lead level (BLL) monitoring practices. In most states, one or two BLL tests administered in early childhood are used to rule out lead exposure. Current knowledge, however, regarding the multiple, complex biological mechanisms that underlie lead absorption and distribution during development suggests that child BLLs should be assumed to be an informative but necessarily fluctuating metric of current child lead exposure. We review some key mechanisms and pathways that influence lead absorption, lead distribution, and the stability of lead in red blood cells. We also consider how each of these factors and their development are likely to drive fluctuations in child BLLs over time. The goal of this special report is to provide a starting point for change in current child BLL testing practices. Solving the problem of child lead exposure will require new approaches to child BLL testing that take into account likely fluctuations in child BLLs.**

Introduction

Lead poisoning in U.S. children continues at staggering rates in selected sectors, particularly among those living in under-resourced communities where older unrenovated housing and lead paint are still major sources of exposure. In over 3,000 U.S. cities, child lead poisoning rates exceed those found in Flint, Michigan, at the height of the crisis (Pell & Schneyer, 2016, 2017). Solving the problem of lead poisoning in U.S. children will require accurate detection of exposed children. In many states, child BLL testing practices rely on single tests among only the youngest children (i.e., 0–5 years) to rule out lead exposure, implicitly assuming that one or two tests in early childhood can accurately reflect a child's ongoing exposure risk.

Lead exposure occurs via inhalation or ingestion. Among children, when exposure is chronic, 99% of absorbed lead is taken up by red blood cells (RBCs) (Agency for Toxic Substances and Disease Registry [ATSDR], 2017; deSilva, 1981) and child lead exposure is most commonly determined from whole blood samples. BLLs reflect circulating lead and, in many cases, exposure occurring in the preceding 28 to 40 days (Griffin et al., 1975; Rabinowitz et al., 1973).

The potent toxicity of lead during development has been attributed to many factors but in particular, lead structurally mimics calcium and causes multitiered damage in calcium-channel dependent pathways, systems, and organ mechanisms (Lidsky & Schneider, 2003). More specifically, Pb^{2+} readily enters RBCs because its radius is slightly smaller than that of Ca^{2+} (Kirberger & Yang, 2008; Simons, 1986a, 1986b). Lead also gains entry to RBCs when the permeability of cell walls shift the processes that are dependent on developmental and individual differences as well as exigencies in the child's environment (Hasan et al., 1967; Riordan & Passow, 1971; Vincent, 1958).

Once absorbed, Pb^{2+} binds to delta-amino-laevulinic acid dehydratase enzyme (ALAD), specifically the three-cysteine site of ALAD, replacing Zn^{2+} and interrupting the second step in heme synthesis (Gonick, 2011; Sakai et al., 1983). The binding affinity of Pb^{2+} is, in fact, greater than that of Zn^{2+} (Boudene et al., 1984; Gonick, 2011).

With regard to individual variability in these processes, there are three *ALAD* common genetic variants (*ALAD-1*, *ALAD-1-2*, and *ALAD-2-2*) that vary in their binding properties and thus their affinity for lead. *ALAD-2-2* has the highest affinity for lead (Gonick, 2011; Pérez-Bravo et al., 2004; Scinicariello et al., 2007) and is associated with higher BLLs in children (Kim et al., 2004; Pérez-Bravo et al., 2004; Scinicariello et al., 2007; Sobin et al., 2009, 2011, 2015; Wetmur et al., 1991). It is logical to suggest that the stability of BLLs over time in children with each of these genetic variants would be expected to differ.

Some key absorption mechanisms and their development throughout childhood suggest additional sources of variability and

Summary of Developmental Influences on Lead Absorption and Re-Release Variability Throughout Childhood

Body System	Mechanism	Source of Variability
Respiratory (lungs)	Lead in gases and particles <100 nm enters via diffusion in alveoli (limited evidence for absorption of particles >100 nm); particles not expelled or ingested are absorbed into the bloodstream	Alveoli densities reach 93% by age 8 (Ahlfeld & Conway, 2014; Dunnill, 1962); full density not reached until approximately age 18 (Narayanan et al., 2012)
Digestive (liver)	Soluble and insoluble lead stored in hepatocytes via metallothionein binding reduces lead in blood	Decreased capacity to metabolize, detoxify, and excrete lead in newborns (Beath, 2003; Gow et al., 2001; Wells, 2017); liver does not fully mature until age 5
Circulatory (red blood cells)	Blood nutrient deficiencies allow lead binding to calcium, iron, and zinc sites	Malnutrition and genetic polymorphisms (*ALAD*) directly impact lead absorption by red blood cells, suggesting variability in lead absorption during childhood (Sobin et al., 2009, 2011, 2015)
Excretory (kidneys)	Metallothionein-bound lead is retained in nephron cell walls; active or passive transport along the nephron can re-release lead into the bloodstream	Mechanisms for filtration and excretion mature at age 2, while full kidney function is not reached until young adulthood (Blane et al., 1985; Čukuranović & Vlajković, 2005)
Endocrine (fat cells)	Initial evidence that lead is stored in fat; fasting, starvation, and exercise can trigger fat metabolism and re-release lead	Initial data suggest insecure food access, irregular eating habits, and/or empty gut can increase vulnerability to lead re-release
Skeletal (bone)	Accumulation in the inert and labile components of cortical and trabecular bone via binding to hydroxyapatite; low calcium blood levels break down hydroxyapatite and lead is re-released from bone into bloodstream	Broken bones, growth spurts during puberty, and deficiencies in bone nutrients can re-release lead into the bloodstream (Janz, 2002; Jones, 2011)
Central nervous system (brain)	Mimics calcium and activates calcium-dependent protein kinase (CDPK), crossing the blood-brain barrier (BBB), possibly disrupting the cohesiveness of the BBB and ability for astrocytes to maintain BBB integrity; inability to regulate the integrity of the BBB may allow for lead to be exchanged more easily between the brain and bloodstream	Nutrient deficiencies and stress can affect BBB integrity (Kadry et al., 2020), suggesting fluctuations in lead absorption through childhood

instability in child BLLs over time. Tables 1 and 2 provide an overview of the detailed information discussed in this special report.

Absorption of Inhaled Lead
Inhaled lead particles follow respiratory system pathways that are relatively well defined. Approximately 30–50% of inhaled lead is retained in the lungs (Chamberlain, 1983; Geiser & Kreyling, 2010) and the duration of respiratory exposure appears to increase absorption (Kastury et al., 2019).

Inhaled lead particles are drawn into the windpipe and bronchi, which have mucus-producing cells where cilia attempt to move dust-laden mucus upward and out of the lungs (Bailey et al., 2007). When trapping fails, dust is absorbed directly by the lung alveoli, a thin barrier of cells between air and blood capillaries (Bailey et al., 2007). In the alveoli, activated macrophages can engulf dust particles, preventing dust from reaching the bloodstream (Hamilton et al., 2008; James et al., 1994).

Absorption of remaining dust depends on particle size and shape; the distribution of particles is determined by air direction and air force. Ultrafine particles (<100 nm) quickly enter the bloodstream via alveoli. Mechanisms by which larger lead particles enter the bloodstream are not well understood, however, particularly in children. Larger lead particles (100 nm–5 μm) are deposited and can remain in different regions of the lungs from months to years before they are eventually absorbed, filtrating from the lungs to the heart and into the bloodstream, or expelled from the lungs and then ingested (Bailey et al., 2007; James et al., 1994; Kastury et al., 2019).

During development, absorption is also influenced by lung growth rate and maturity of alveoli. Lungs of children develop throughout childhood up until age 18 (Ahlfeld & Conway, 2014; Narayanan et al., 2012). It is estimated that by age 8 years, only 63% of alveoli have developed (Ahlfeld & Conway, 2014; Dunnill, 1962; Ochs et al., 2004). Fewer alveoli would be expected to result in poorer filtering capacity and higher absorbed lead. Coupled with relatively high respiratory rates, children at different ages have the potential to retain substantial amounts of inhaled lead, especially in the tracheobronchial and alveolar regions (Asgharian et al., 2004). Individual differences in lung development further complicate how and when lead absorption occurs at different ages.

Absorption of Ingested Lead
Compared with inhalation, ingested lead is influenced by relatively more complex and interacting factors including, for example, the bioaccessibility of the lead source, particulate size, site of absorption, individual differences in physiological and molecular lead-uptake processes, lead–nutrient interactions, whether ingestion occurs in an empty or full gut, and developmental and individual differences in the maturity of the gastrointestinal (GI) tract.

The bioaccessibility of a given lead source depends on its chemical form (Deshommes & Prévost, 2012); the chemical form determines the rate of absorption in the GI tract by altering how digestive proteins, gastric fluid pH, and other ions interact with lead (Deshommes et al., 2012). The chemical forms of lead that exist in non-nutritive substances—such as in leaded paint chips, paint dust, and in some contaminated soils—are far more bioaccessible than

the forms of lead commonly found in foods. In vitro digestion models have shown that the bioaccessibility of lead-contaminated soil from pottery industries typically ranges from 28% to 73% (Oomen et al., 2003). In contrast, the bioaccessibility of lead-contaminated soil at mining sites ranges from 2% to 33% (Ruby et al., 1992; von Lindern et al., 2016). The bioaccessibility of lead in water ranges broadly from 1.5% to 100% (Deshommes & Prévost, 2012), while the bioaccessibility of lead-contaminated household dust is from 28% to 100% (Sowers et al., 2021; von Lindern et al., 2016).

Many chemical forms of ingested lead have been identified and include sulfide, chloride, acetate, carbonate, chromate, monoxide, tetroxide, phosphate, and nitrate, all of which are found in the most common child lead hazard sources, but the bioaccessibility will vary depending on their form (speciation) as well as what matrix they are in (ATSDR, 2017) and goes directly into the stomach where multiple internal mechanisms influence both dissolution and speed of absorption. Gastric acid breaks down lead into more soluble forms. Human intestinal fluid studies and animal models have shown that an interacting complex series of chemical, biological, and biophysicochemical factors directly affect absorption of ingested lead, which creates the potential for broad fluctuation of lead in whole blood samples (Liu et al., 2021; Mushak, 1991). Importantly, lead can transform into different lead species in the gut during the digestion process when interactions with native stomach acids increase the lead solubility (Mushak, 1991).

Interestingly, the electrical charge associated with lead influences its diffusion rate in intestinal cells. Ionized forms of lead have higher affinity for intestinal cell junctions that rely on ionic mechanisms for the transport of essential cations including Ca^{2+}, Mg^{2+}, Fe^{2+}, and Na^+ (Jaishankar et al., 2014). For example, lead–bile complexes convert to ionized lead and transport lead into intestinal cells—a process not yet well understood (Oomen et al., 2003).

Lead absorption in the small intestine occurs primarily in the duodenum (upper first sections) via passive diffusion and active transport (Mushak, 1991). In the ileum (third section), micelles form, capture lead in the spaces of the intestines, and are absorbed through the intestinal walls via pinocytosis (Teichmann & Stremmel, 1990). Lead can also pass

TABLE 2

Sources of Variability in Key Lead Absorption Mechanisms by Body System

Body System	Absorption Mechanism	Factors Contributing to Blood Lead Level Variability
Respiratory	• Particles >5.0 µm mainly deposit in the nasopharyngeal region • Particles 2.0–5.0 µm can penetrate the tracheobronchial region • Small particles <0.5 µm and very small particles <1.0 µm can penetrate deep into the alveoli, remaining for months to years • Soluble gases and particles <100 nm enter directly into the bloodstream via diffusion in alveoli	• Lead particulate size • Duration of inhalation • Frequency of exposure • Respiratory rate • Alveoli density • Individual respiratory system differences
Digestive	• Passive and active transport via enterocytes in the gut and small intestine	• Bioaccessibility of lead hazard source • Lead particulate size • Lead chemical form • Absorption site • Lead–nutrient interactions and nutrient deficiencies • Maturity of the gastrointestinal tract • Individual differences in physiological and molecular lead uptake • Food intake variability
Blood	• Active transportation in red blood cells via using calcium- and zinc-activated proteins	• Oxidation stage of lead • Concentration of lead • Nutrient deficiencies • Genetic (*ALAD*) predisposition influencing lead absorption

through the tight spaces between the enterocytes that line the stomach, small intestines, and colon (Kiela & Ghishan, 2016; Mushak, 1991) or can be engulfed by macrophages and/or micelles from the cell membrane of enterocytes. Via these mechanisms, lead can then travel into the bloodstream. While any of these mechanisms can deliver lead into the circulatory system via the liver (Liu et al., 2021; Mushak, 1991), most ingested lead (70–90%) is excreted in urine or feces; sequestered lead can be retained in cells for varying periods of time (Leggett, 1993; O'Flaherty, 1998). Age and maturity of the GI tract influence the functioning of these mechanisms and thus affect lead absorption and excretion.

Eating patterns also affect absorption. Absorption is substantially greater when the stomach is empty (Blake et al., 1983; Blake & Mann, 1983; Heard & Chamberlain, 1982; James et al., 1985), thus the timing of meal and dietary nutrient intake can block

or enhance lead absorption. In children 3–5 years, those who ate breakfast compared with those who did not had lower BLLs after controlling for nutritional and demographic variables (Liu et al., 2011). If a child's stomach is near empty, Pb^{2+} absorption can be as high as 100% (ATSDR, 2017; Heard & Chamberlain, 1982; Rabinowitz et al., 1980). High gut absorption in children has been attributed to developmental and individual differences in calcium-binding proteins and gut acid (Deren, 1971; Mushak, 1991). Also, the risk of exposure from tap water can be increased when children with empty stomachs drink more due to hunger (Heard & Chamberlain, 1982).

Lead in combination with another ion and/or vitamin can facilitate or block absorption of lead in the GI tract. One obvious critical lead–nutrient interaction is with calcium (Blake & Mann, 1983; Elias et al., 2007; Heard & Chamberlain, 1982; Schell et al., 2004; Ziegler et al., 1978). Another critical

interaction is with iron. Similar to calcium, iron deficiencies in children are associated with higher BLLs (Marcus & Schwartz, 1987; Schell et al., 2004; Wolf et al., 2003) and animal studies have shown that lead competes with iron absorption in the intestines (Bannon et al., 2003; Morrison & Quarterman, 1987). Thus, more lead is absorbed when a child is iron deficient, when lead replaces iron in the receptors and/or binding proteins found in the intestines.

With regard to individual differences, there are at least two inherited conditions that directly impact iron metabolism: hemochromatosis and transferrin genes (Hopkins et al., 2008), both of which have been associated with higher BLLs in children. With regard to four clinically recommended nutrients to reduce lead absorption (calcium, iron, vitamin C, and zinc), there is limited evidence that the supplementation of these nutrients prevents lead absorption in nutritionally robust children (Kordas, 2017).

Post-Absorption Mechanisms and Potential for Re-Release

Once in the bloodstream, lead is passed between blood and organs via carrier-mediated transportation (active transport) and diffusion (Leggett, 1993; O'Flaherty, 1998). Absorbed lead is transported via RBCs to soft tissue organs (liver, kidneys, lungs, brain, spleen, muscles, and heart) and exchanged, filtered, and/or trapped to differing degrees, depending on the organ. Ultimately, lead that is not excreted is stored in mineralized tissues (bone and teeth). The amount of lead that remains in the blood rather than transferring to organ tissues depends on multiple shifting factors.

Lead elimination occurs primarily via the kidneys (Lentini et al., 2017). The remaining lead, referred to as total lead body burden, is transported back and forth between the blood system, soft tissue, and mineralizing tissues in a continual process of lead concentration equilibrium (Marcus, 1985; Rabinowitz et al., 1973; Smith et al., 1996). Total lead body burden is dependent on the frequency of lead exposure, concentration, distribution, metabolism, and ability to eliminate lead from the body through urine or feces, as well as developmental and individual differences in the implicated body systems of children.

Furthermore, several mechanisms facilitate or oppose the distribution of lead into tissues. Simple diffusion and carrier proteins for calcium facilitate the transfer of lead into soft tissues (Rădulescu & Lundgren, 2019). In contrast, plasma proteins such as albumin, transferrin, globulin, and lipoproteins oppose and limit distribution by binding to lead molecules (Gonick, 2011). Unbound lead passes through capillary endothelial cells into the extravascular space for tissue storage. Of note, the immaturity of this mechanism in young children does not allow tissue absorption and reabsorption, leaving greater amounts of lead in circulating blood. Site-specific proteins and interstitial conditions can also contribute to BLLs (Table 1).

Two mechanisms in the liver act simultaneously to remove lead from blood and retain lead in hepatocytes (Braet & Wisse, 2002). Inorganic lead, the most common form absorbed by children, is stored in the liver via the fenestrate, a layer of endothelial cells with scattered small and large pores lining the liver sinusoids (ATSDR, 2017; Beath, 2003). A second retention mechanism involves metallothionein, an intracellular protein that, once bound to lead, ensures that the lead does not exit hepatocytes (Gonick, 2011). The hepatocytes, submucosal and mucosal layers, and bile duct size do not mature in young children until the age of 2 years (Gow et al., 2001; Wells, 2017); the transition to a single cell wall of hepatocytes is not complete until age 5 years (Morgan & Hartroft, 1961). Thus, depending on the age of the child and individual differences in development, these mechanisms might or might not be mature enough to consistently metabolize, detoxify, and/or excrete lead, contributing to increased or fluctuating BLLs (Allegaert et al., 2007; Gow et al., 2001; Wells, 2017).

Reabsorption of lead into the kidney is another mechanism that influences BLLs. Lead is reabsorbed through active or passive transport mechanisms along three main sections of the nephron: the proximal convoluted tubule (via both passive and active transportation), predominately in the ascending limb of the loop of Henle (mainly via active transportation), and the distal convoluted tubule (mainly via passive transportation) (Fowler & DuVal, 1991; Kwon et al., 2015). When lead binds to metallothionein, it is retained in the cell wall of the nephron (Fowler & DuVal, 1991). Another pathway for reabsorption of lead is by erythrophagocytosis effected via macrophages in the epithelial cells that line the proximal convoluted tubule (Kwon et al., 2015). Thus, lead in degrading RBCs is engulfed and removed; reabsorbed lead is then transported to the peritubular capillary network, eventually leading into the bloodstream. Lead that is not reabsorbed exits the nephron as urine.

The mechanisms responsible for kidney filtration and excretion mature at different ages. Nephrons and tubular structures continue to grow until approximately 1 year; kidney excretion mechanisms (via the parenchyma) mature when the child is approximately 7 months (Čukuranović & Vlajković, 2005; Weinstein & Anderson, 2010). Kidney perfusion and glomerular filtration rates reach full capacity by approximately 2 years; urine concentration capacity matures by 18 months; and renal blood flow by 1 year. Importantly however, full renal function is not complete until young adulthood (approximately 25 years) (Čukuranović & Vlajković, 2005; Davies & Shock, 1950; Levey et al., 2003; Weinstein & Anderson, 2010). The kidneys do not reach maximum functional capacity until early to middle adulthood (between 20 and 30 years) (Blane et al., 1985; Čukuranović & Vlajković, 2005). These age-related factors necessarily influence the amount of lead detectable in circulating whole blood.

Individual differences in children are also important to consider. For example, lead can be stored in body fat. While lead concentrations in fat might be lower than in other types of tissues initially, with chronic exposure they can begin to equal BLL concentrations (Mikalsen et al., 2019; Riedt et al., 2009). Lead stored in fat can be re-released into the bloodstream when fat reserves are mobilized, such as during fasting, hunger, starvation, or exercise (Mikalsen et al., 2019; Riedt et al., 2009). Thus, children with insecure food access or irregular eating habits, who are likely to be at highest environmental risk of lead exposure, might mobilize fat stores more frequently (Dhurandhar, 2016; Pan et al., 2012; Tester et al., 2020).

Approximately one half of the lead that the body absorbs is stored in bone/mineralized tissues, accounting for an estimated 74% of the total lead body burden in children (Barry, 1975, 1981). The storage is relatively temporary, however, because bone tissue re-releases lead via different types of biological processes. Depending on the type and duration of expo-

sure, from 40–70% of circulating lead can come from stores in the bones (Smith et al., 1996).

How and when lead is re-released into the bloodstream depends on the concentration of lead in the outer layers of the bone and the body's demand for calcium (Dowd et al., 2001; Stojsavljević et al., 2019). Lead accumulates in the inert and labile components of cortical and trabecular bone. The inert component is closer to the center of the bone, which can store lead for decades. The labile component is located toward the outer layers of the bone and can easily exchange lead from bone to blood (Stojsavljević et al., 2019). Lead stored in the inert component can mobilize to the labile component with time or in situations where the body releases calcium from the bone, such as when a child suffers a broken bone.

The mechanism by which lead is exchanged between blood and bone mimics that of calcium exchange. Lead can bind to hydroxyapatite (a calcium phosphate mineral that serves as a calcium reserve for the body) and fluctuates according to the concentration of calcium found in the blood (Dowd et al., 2001; Pounds et al., 1991; Saisa-ard et al., 2014). Deficiencies in calcium, phosphorus, and vitamin D result in higher lead bone storage and more frequent re-release (Jones, 2011).

Bone growth in children creates multiple opportunities for lead to be reintroduced into the bloodstream. The largest growth spurt occurs during puberty when there is a greater demand for hydroxyapatite formation (Stagi et al., 2013). Females reach full height at approximately 15 years and continue to build bone mass until 21 years. Males grow until approximately 18 years and build bone mass up to 12 months after reaching full height (Jones, 2011). Also, lead is released during states of high bone turnover such as following bone fractures or in children with conditions that prevent bone mass formation (e.g., osteoporosis, conditions that limit physical activity) (Janz, 2002). Age-based differences, individual differences in stored bone-forming nutrients, and bone injuries can all explain BLL spikes in some older children.

Summary

Current practices for BLL testing in children that rely on one or two BLL tests administered to only the youngest children (i.e., 0–5 years) are not aligned with knowledge regarding the complexity of lead absorption, transport, and disposition in the body throughout childhood and adolescence. In the respiratory system, lead deposition and absorption rates are complex and depend on many changing factors, including lead particulate size, length, frequency of exposure, respiratory rate, where in the lungs lead particulates are deposited, and importantly, individual differences in the development of the lungs and alveoli.

Ingested lead is influenced by complex interactions of chemical, biological, biophysicochemical, and behavioral factors related to dietary intake, dietary deficiencies, and maturity of the GI tract. These interactions of factors can be additive, antagonistic, or synergistic. Once in the bloodstream, lead absorption by RBCs is influenced by common (*ALAD*) genetic variants and by ongoing fluctuations in calcium, iron, and zinc levels. Additional age-dependent factors facilitate and oppose the distribution of lead into tissues and re-release of lead into the circulatory system.

Current approaches for BLL testing in children inadvertently do not take into account the likely fluctuations in child BLLs described previously in this article. As Sobin et al. (2022) discussed, a revision of current practices is needed to ensure feasibility for monitoring highest-risk children. Suggested revisions include:

- Acceptance of capillary samples for final determination of lead poisoning, with electronic documentation of "clean" collection methods submitted by workers.
- New guidance specifying analysis of capillary samples by inductively coupled plasma mass spectrometry or graphite furnace atomic absorption spectrometry with documented level of detection ≤0.2 µg/dL.
- Adaptation of universal testing and monitoring guidance that is census tract-specific for children from birth to 10 years.

These changes to current practices can immediately increase our national capacity for inclusive and equitable detection and monitoring of BLLs, particularly for dangerous lower-range BLLs in children in the U.S. ❧

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References

Agency for Toxic Substances and Disease Registry. (2017). *Lead (Pb) toxicity: Who is at risk of lead exposure?* https://www.atsdr.cdc.gov/csem/leadtoxicity/who_at_risk.html

Ahlfeld, S.K., & Conway, S.J. (2014). Assessment of inhibited alveolar-capillary membrane structural development and function in bronchopulmonary dysplasia. *Birth Defects Research. Part A, Clinical and Molecular Teratology*, *100*(3), 168–179. https://doi.org/10.1002/bdra.23226

Allegaert, K., van den Anker, J.N., Naulaers, G., & de Hoon, J. (2007). Determinants of drug metabolism in early neonatal life. *Current Clinical Pharmacology*, *2*(1), 23–29. https://doi.org/10.2174/157488407779422294

Asgharian, B., Ménache, M.G., & Miller, F.J. (2004). Modeling age-related particle deposition in humans. *Journal of Aerosol Medicine*, *17*(3), 213–224. https://doi.org/10.1089/jam.2004.17.213

Bailey, M.R., Ansoborlo, E., Guilmette, R.A., & Paquet, F. (2007). Updating the ICRP human respiratory tract model. *Radiation Protection Dosimetry*, *127*(1–4), 31–34. https://doi.org/10.1093/rpd/ncm249

Bannon, D.I., Abounader, R., Lees, P.S., & Bressler, J.P. (2003). Effect of DMT1 knockdown on iron, cadmium, and lead uptake in Caco-2 cells. *American Journal of Physiology–Cell Physiology*, *284*(1), C44–50. https://doi.org/10.1152/ajpcell.00184.2002

Barry, P.S. (1975). A comparison of concentrations of lead in human tissues. *Occupational and Environmental Medicine*, *32*(2), 119–139. https://doi.org/10.1136/oem.32.2.119

References *continued from page 22*

Barry, P.S. (1981). Concentrations of lead in the tissues of children. *Occupational and Environmental Medicine*, *38*(1), 61–71. https://doi.org/10.1136/oem.38.1.61

Beath, S.V. (2003). Hepatic function and physiology in the newborn. *Seminars in Fetal & Neonatal Medicine*, *8*(5), 337–346. https://doi.org/10.1016/S1084-2756(03)00066-6

Blake, K.C.H., Barbezat, G.O., & Mann, M. (1983). Effect of dietary constituents on the gastrointestinal absorption of ^{203}Pb in man. *Environmental Research*, *30*(1), 182–187. https://doi.org/10.1016/0013-9351(83)90178-0

Blake, K.C.H., & Mann, M. (1983). Effect of calcium and phosphorus on the gastrointestinal absorption of ^{203}Pb in man. *Environmental Research*, *30*(1), 188–194. https://doi.org/10.1016/0013-9351(83)90179-2

Blane, C.E., Bookstein, F.L., DiPietro, M.A., & Kelsch, R.C. (1985). Sonographic standards for normal infant kidney length. *American Journal of Roentgenology*, *145*(6), 1289–1291. https://doi.org/10.2214/ajr.145.6.1289

Boudene, C., Despaux-Pages, N., Comoy, E., & Bohuon, C.I. (1984). Immunological and enzymatic studies of erythrocytic delta-aminolevulinate dehydratase. Comparison of results obtained in normal and lead-exposed subjects. *International Archives of Occupational and Environmental Health*, *55*(1), 87–96. https://doi.org/10.1007/BF00378071

Braet, F., & Wisse, E. (2002). Structural and functional aspects of liver sinusoidal endothelial cell fenestrae: A review. *Comparative Hepatology*, *1*, Article 1. https://doi.org/10.1186/1476-5926-1-1

Chamberlain, A.C. (1983). Effect of airborne lead on blood lead. *Atmospheric Environment (1967)*, *17*(4), 677–692. https://doi.org/10.1016/0004-6981(83)90415-8

Čukuranović, R., & Vlajković, S. (2005). Age related anatomical and functional characteristics of human kidney. *Medicine and Biology*, *12*(2), 61–69.

Davies, D.F., & Shock, N.W. (1950). Age changes in glomerular filtration rate, effective renal plasma flow, and tubular excretory capacity in adult males. *The Journal of Clinical Investigation*, *29*(5), 496–507. https://doi.org/10.1172/JCI102286

Deren, J.S. (1971). Development of structure and function in the fetal and newborn stomach. *The American Journal of Clinical Nutrition*, *24*(1), 144–159. https://doi.org/10.1093/ajcn/24.1.144

Deshommes, E., & Prévost, M. (2012). Pb particles from tap water: Bioaccessibility and contribution to child exposure. *Environmental Science & Technology*, *46*(11), 6269–6277. https://doi.org/10.1021/es2045585

Deshommes, E., Tardif, R., Edwards, M., Sauvé, S., & Prévost, M. (2012). Experimental determination of the oral bioavailability and bioaccessibility of lead particles. *Chemistry Central Journal*, *6*, 138. https://doi.org/10.1186/1752-153X-6-138

deSilva, P.E. (1981). Determination of lead in plasma and studies on its relationship to lead in erythrocytes. *Occupational and Environmental Medicine*, *38*(3), 209–217. https://doi.org/10.1136/oem.38.3.209

Dhurandhar, E.J. (2016). The food-insecurity obesity paradox: A resource scarcity hypothesis. *Physiology & Behavior*, *162*, 88–92. https://doi.org/10.1016/j.physbeh.2016.04.025

Dowd, T.L., Rosen, J.F., Mints, L., & Gundberg, C.M. (2001). The effect of Pb^{2+} on the structure and hydroxyapatite binding properties of osteocalcin. *Biochimica et Biophysica Acta*, *1535*(2), 153–163. https://doi.org/10.1016/s0925-4439(00)00094-6

Dunnill, M.S. (1962). Postnatal growth of the lung. *Thorax*, *17*(4), 329–333. https://doi.org/10.1136/thx.17.4.329

Elias, S., Hashim, Z., Marjan, Z., Abdullah, A., & Hashim, J. (2007). Relationship between blood lead concentration and nutritional status among Malay primary school children in Kuala Lumpur, Malaysia. *Asia Pacific Journal of Public Health*, *19*(3), 29–37. https://doi.org/10.1177/101053950701900306

Fowler, B.A., & DuVal, G. (1991). Effects of lead on the kidney: Roles of high-affinity lead-binding proteins. *Environmental Health Perspectives*, *91*, 77–80. https://doi.org/10.1289/ehp.919177

Geiser, M., & Kreyling, W.G. (2010). Deposition and biokinetics of inhaled nanoparticles. *Particle and Fibre Toxicology*, *7*(1), Article 2. https://doi.org/10.1186/1743-8977-7-2

Gonick, H.C. (2011). Lead-binding proteins: A review. *Journal of Toxicology*, *2011*, Article 686050. https://doi.org/10.1155/2011/686050

Gow, P.J., Ghabrial, H., Smallwood, R.A., Morgan, D.J., & Ching, M.S. (2001). Neonatal hepatic drug elimination. *Pharmacology & Toxicology*, *88*(1), 3–15. https://doi.org/10.1034/j.1600-0773.2001.088001003.x

Griffin, T.B., Coulston, F., & Wills, H. (1975). Biological and clinical effects of continuous exposure to airborne particulate lead. *Archives of Industrial Hygiene and Toxicology*, *26*(Suppl.), 191–208. https://hrcak.srce.hr/167410

Hamilton, R.F., Jr., Thakur, S.A., & Holian, A. (2008). Silica binding and toxicity in alveolar macrophages. *Free Radical Biology and Medicine*, *44*(7), 1246–1258. https://doi.org/10.1016/j.freeradbiomed.2007.12.027

Hasan, J., Hernberg, S., Metsälä, P., & Vihko, V. (1967). Enhanced potassium loss in blood cells from men exposed to lead. *Archives of Environmental Health*, *14*(2), 309–312. https://doi.org/10.1080/00039896.1967.10664737

Heard, M.J., & Chamberlain, A.C. (1982). Effect of minerals and food on uptake of lead from the gastrointestinal tract in humans. *Human & Experimental Toxicology*, *1*(4), 411–415. https://doi.org/10.1177/096032718200100407

Hopkins, M.R., Ettinger, A.S., Hernández-Avila, M., Schwartz, J., Téllez-Rojo, M.M., Lamadrid-Figueroa, H., Bellinger, D., Hu, H., & Wright, R.O. (2008). Variants in iron metabolism genes predict higher blood lead levels in young children. *Environmental Health Perspectives*, *116*(9), 1261–1266. https://doi.org/10.1289/ehp.11233

References *continued from page 23*

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B.B., & Beeregowda, K.N. (2014). Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary Toxicology*, 7(2), 60–72. https://doi.org/10.2478/intox-2014-0009

James, A.C., Stahlhofen, W., Rudolf, G., Köbrich, R., Briant, J.K., Egan, M.J., Nixon, W., & Birchall, A. (1994). Annexe D. Deposition of inhaled particles. *Annals of the ICRP*, 24(1–3), 231–299. https://doi.org/10.1016/0146-6453(94)90042-6

James, H.M., Hilburn, M.E., & Blair, J.A. (1985). Effects of meals and meal times on uptake of lead from the gastrointestinal tract in humans. *Human Toxicology*, 4(4), 401–407. https://doi.org/10.1177/096032718500400406

Janz, K. (2002). Physical activity and bone development during childhood and adolescence. Implications for the prevention of osteoporosis. *Minerva Pediatrica*, 54(2), 93–104.

Jones, G. (2011). Early life nutrition and bone development in children. *Nestle Nutrition Workshop Series. Paediatric Programme*, 68, 227–233. https://doi.org/10.1159/000325910

Kadry, H., Noorani, B., & Cucullo, L. (2020). A blood-brain barrier overview on structure, function, impairment, and biomarkers of integrity. *Fluids and Barriers of the CNS*, 17, Article 69. https://doi.org/10.1186/s12987-020-00230-3

Kastury, F., Smith, E., Lombi, E., Donnelley, M.W., Cmielewski, P.L., Parsons, D.W., Noerpel, M., Scheckel, K.G., Kingston, A.M., Myers, G.R., Paterson, D., de Jonge, M.D., & Juhasz, A.L. (2019). Dynamics of lead bioavailability and speciation in indoor dust and X-ray spectroscopic investigation of the link between ingestion and inhalation pathways. *Environmental Science & Technology*, 53(19), 11486–11495. https://doi.org/10.1021/acs.est.9b03249

Kiela, P.R., & Ghishan, F.K. (2016). Physiology of intestinal absorption and secretion. *Best Practice & Research Clinical Gastroenterology*, 30(2), 145–159. https://doi.org/10.1016/j.bpg.2016.02.007

Kim, H.-S., Lee, S.-S., Lee, G.-S., Hwangbo, Y., Ahn, K.-D., & Lee, B.-K. (2004). The protective effect of delta-aminolevulinic acid dehydratase 1-2 and 2-2 isozymes against blood lead with higher hematologic parameters. *Environmental Health Perspectives*, 112(5), 538–541.

Kirberger, M., & Yang, J.J. (2008). Structural differences between Pb^{2+}- and Ca^{2+}-binding sites in proteins: Implications with respect to toxicity. *Journal of Inorganic Biochemistry*, 102(10), 1901–1909. https://doi.org/10.1016/j.jinorgbio.2008.06.014

Kordas, K. (2017). The "lead diet": Can dietary approaches prevent or treat lead exposure? *The Journal of Pediatrics*, 185, 224–231.E1. https://doi.org/10.1016/j.jpeds.2017.01.069

Kwon, S.-Y., Bae, O.-N., Noh, J.-Y., Kim, K., Kang, S., Shin, Y.-J., Lim, K.-M., & Chung, J.-H. (2015). Erythrophagocytosis of lead-exposed erythrocytes by renal tubular cells: Possible role in lead-induced nephrotoxicity. *Environmental Health Perspectives*, 123(2), 120–127. https://doi.org/10.1289/ehp.1408094

Leggett, R.W. (1993). An age-specific kinetic model of lead metabolism in humans. *Environmental Health Perspectives*, 101(7), 598–616. https://doi.org/10.1289/ehp.93101598

Lentini, P., Zanoli, L., Granata, A., Signorelli, S.S., Castellino, P., & Dell'Aquila, R. (2017). Kidney and heavy metals—The role of environmental exposure (review). *Molecular Medicine Reports*, 15(5), 3413–3419. https://doi.org/10.3892/mmr.2017.6389

Levey, A.S., Coresh, J., Balk, E., Kausz, A.T., Levin, A., Steffes, M.W., Hogg, R.J., Perrone, R.D., Lau, J., Eknoyan, G., & National Kidney Foundation. (2003). National Kidney Foundation practice guidelines for chronic kidney disease: Evaluation, classification, and stratification. *Annals of Internal Medicine*, 139(2), 137–147. https://doi.org/10.7326/0003-4819-139-2-200307150-00013

Lidsky, T.I., & Schneider, J.S. (2003). Lead neurotoxicity in children: Basic mechanisms and clinical correlates. *Brain*, 126(1), 5–19. https://doi.org/10.1093/brain/awg014

Liu, J., McCauley, L., Compher, C., Yan, C., Shen, X., Needleman, H., & Pinto-Martin, J.A. (2011). Regular breakfast and blood lead levels among preschool children. *Environmental Health*, 10, 28. https://doi.org/10.1186/1476-069X-10-28

Liu, W., Feng, H., Zheng, S., Xu, S., Massey, I.Y., Zhang, C., Wang, X., & Yang, F. (2021). Pb toxicity on gut physiology and microbiota. *Frontiers in Physiology*, 12, Article 574913. https://doi.org/10.3389/fphys.2021.574913

Marcus, A.H. (1985). Multicompartment kinetic models for lead: II. Linear kinetics and variable absorption in humans without excessive lead exposures. *Environmental Research*, 36(2), 459–472. https://doi.org/10.1016/0013-9351(85)90038-6

Marcus, A.H., & Schwartz, J. (1987). Dose–response curves for erythrocyte protoporphyrin vs blood lead: Effects of iron status. *Environmental Research*, 44(2), 221–227. https://doi.org/10.1016/S0013-9351(87)80230-X

Mikalsen, S.M., Bjørk-Monsen, A.-L., Flaten, T.P., Whist, J.E., & Aaseth, J. (2019). Cadmium, lead and mercury in Norwegian obese patients before and 12 months after bariatric surgery. *Journal of Trace Elements in Medicine and Biology*, 54, 150–155. https://doi.org/10.1016/j.jtemb.2019.04.008

Morgan, J.D., & Hartroft, W.S. (1961). Juvenile liver. Age at which one-cell-thick plates predominate in the human liver. *Archives of Pathology*, 71, 86–88.

Morrison, J.N., & Quarterman, J. (1987). The relationship between iron status and lead absorption in rats. *Biological Trace Element Research*, 14(1), 115–126. https://doi.org/10.1007/BF02795602

Mushak, P. (1991). Gastro-intestinal absorption of lead in children and adults: Overview of biological and biophysicochemical aspects. *Chemical Speciation & Bioavailability*, 3(3–4), 87–104. https://doi.org/10.1080/09542299.1991.11083160

Narayanan, M., Owers-Bradley, J., Beardsmore, C.S., Mada, M., Ball, I., Garipov, R., Panesar, K.S., Kuehni, C.E., Spycher, B.D., Williams, S.E., & Silverman, M. (2012). Alveolarization continues during childhood and adolescence: New evidence from

References

Helium-3 magnetic resonance. *American Journal of Respiratory and Critical Care Medicine*, *185*(2), 186–191. https://doi.org/10.1164/rccm.201107-1348OC

Ochs, M., Nyengaard, J.R., Jung, A., Knudsen, L., Voigt, M., Wahlers, T., Richter, J., & Gundersen, H.J. (2004). The number of alveoli in the human lung. *American Journal of Respiratory and Critical Care Medicine*, *169*(1), 120–124. https://doi.org/10.1164/rccm.200308-1107OC

O'Flaherty, E.J. (1998). A physiologically based kinetic model for lead in children and adults. *Environmental Health Perspectives*, *106*(Suppl. 6), 1495–1503. https://doi.org/10.1289/ehp.98106s61495

Oomen, A.G., Rompelberg, C.J.M., Bruil, M.A., Dobbe, C.J.G., Pereboom, D.P.K.H., & Sips, A.J.A.M. (2003). Development of an in vitro digestion model for estimating the bioaccessibility of soil contaminants. *Archives of Environmental Contamination and Toxicology*, *44*(3), 0281–0287. https://doi.org/10.1007/s00244-002-1278-0

Pan, L., Sherry, B., Njai, R., & Blanck, H.M. (2012). Food insecurity is associated with obesity among U.S. adults in 12 states. *Journal of the Academy of Nutrition and Dietetics*, *112*(9), 1403–1409. https://doi.org/10.1016/j.jand.2012.06.011

Pell, M.B., & Schneyer, J. (2016, December 19). The thousands of U.S. locales where lead poisoning is worse than in Flint. *Reuters*. https://www.reuters.com/investigates/special-report/usa-lead-testing/

Pell, M.B., & Schneyer, J. (2017, November 14). Reuters finds 3,810 U.S. areas with lead poisoning double Flint's. *Reuters*. https://www.reuters.com/article/us-usa-lead-map-idUSKBN1DE1H2

Pérez-Bravo, F., Ruz, M., Morán-Jiménez, M.J., Olivares, M., Rebolledo, A., Codoceo, J., Sepúlveda, V., Jenkin, A., Santos, J.L., & Fontanellas, A. (2004). Association between aminolevulinate dehydrase genotypes and blood lead levels in children from a lead-contaminated area in Antofagasta, Chile. *Archives of Environmental Contamination and Toxicology*, *47*(2), 276–280. https://doi.org/10.1007/s00244-004-2215-1

Pounds, J.G., Long, G.J., & Rosen, J.F. (1991). Cellular and molecular toxicity of lead in bone. *Environmental Health Perspectives*, *91*, 17–32. https://doi.org/10.1289/ehp.919117

Rabinowitz, M.B., Kopple, J.D., & Wetherill, G.W. (1980). Effect of food intake and fasting on gastrointestinal lead absorption in humans. *The American Journal of Clinical Nutrition, 33*(8), 1784–1788. https://doi.org/10.1093/ajcn/33.8.1784

Rabinowitz, M.B., Wetherill, G.W., & Kopple, J.D. (1973). Lead metabolism in the normal human: Stable isotope studies. *Science*, *182*(4113), 725–727. https://doi.org/10.1126/science.182.4113.725

Rădulescu, A., & Lundgren, S. (2019). A pharmacokinetic model of lead absorption and calcium competitive dynamics. *Scientific Reports, 9*(1), Article 14225. https://doi.org/10.1038/s41598-019-50654-7

Riedt, C.S., Buckley, B.T., Brolin, R.E., Ambia-Sobhan, H., Rhoads, G.G., & Shapses, S.A. (2009). Blood lead levels and bone turnover with weight reduction in women. *Journal of Exposure Science & Environmental Epidemiology, 19*(1), 90–96. https://doi.org/10.1038/jes.2008.5

Riordan, J.R., & Passow, H. (1971). Effects of calcium and lead on potassium permeability of human erythrocyte ghosts. *Biochimica et Biophysica Acta*, *249*(2), 601–605. https://doi.org/10.1016/0005-2736(71)90139-8

Ruby, M.V., Davis, A., Kempton, J.H., Drexler, J.W., & Bergstrom, P.D. (1992). Lead bioavailability—Dissolution kinetics under simulated gastric conditions. *Environmental Science & Technology*, *26*(6), 1242–1248. https://doi.org/10.1021/es50002a614

Saisa-ard, O., Somphon, W., Dungkaew, W., & Haller, K.J. (2014). Evidence of a lead metathesis product from calcium hydroxyapatite dissolution in lead nitrate solution. *Advances in Materials Science and Engineering*, *2014*, Article 273632. https://doi.org/10.1155/2014/273632

Sakai, T., Yanagihara, S., Kunugi, Y., & Ushio, K. (1983). Mechanisms of ALA-D inhibition by lead and of its restoration by zinc and dithiothreitol. *British Journal of Industrial Medicine*, *40*(1), 61–66. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1009119/pdf/

Schell, L.M., Denham, M., Stark, A.D., Ravenscroft, J., Parsons, P., & Schulte, E. (2004). Relationship between blood lead concentration and dietary intakes of infants from 3 to 12 months of age. *Environmental Research*, *96*(3), 264–273. https://doi.org/10.1016/j.envres.2004.02.008

Scinicariello, F., Murray, H.E., Moffett, D.B., Abadin, H.G., Sexton, M.J., & Fowler, B.A. (2007). Lead and δ-aminolevulinic acid dehydratase polymorphism: Where does it lead? A meta-analysis. *Environmental Health Perspectives*, *115*(1), 35–41. https://doi.org/10.1289/ehp.9448

Simons, T.J. (1986a). The role of anion transport in the passive movement of lead across the human red cell membrane. *The Journal of Physiology*, *378*(1), 287–312. https://doi.org/10.1113/jphysiol.1986.sp016220

Simons, T.J. (1986b). Passive transport and binding of lead by human red blood cells. *The Journal of Physiology*, *378*(1), 267–286. https://doi.org/10.1113/jphysiol.1986.sp016219

Smith, D.R., Osterloh, J.D., & Flegal, A.R. (1996). Use of endogenous, stable lead isotopes to determine release of lead from the skeleton. *Environmental Health Perspectives*, *104*(1), 60–66. https://doi.org/10.1289/ehp.9610460

Sobin, C., Flores-Montoya, M.G., Gutierrez, M., Parisi, N., & Schaub, T. (2015). δ-Aminolevulinic acid dehydratase single nucleotide polymorphism 2 (*ALAD*₂) and peptide transporter 2*2 haplotype (*hPEPT2*2) differently influence neurobehavior in low-level lead exposed children. *Neurotoxicology and Teratology*, *47*, 137–145. https://doi.org/10.1016/j.ntt.2014.12.001

References *continued from page 25*

Sobin, C., Gutierrez, M., & Alterio, H. (2009). Polymorphisms of delta-aminolevulinic acid dehydratase (*ALAD*) and peptide transporter 2 (*PEPT2*) genes in children with low-level lead exposure. *NeuroToxicology*, *30*(6), 881–887. https://doi.org/10.1016/j.neuro.2009.08.006

Sobin, C., Guitierrez-Vega, M., Flores-Montoya, G., Del Rio, M., Alvarez, J., Obeng, A., Avila, J., & Hettiarachchi, G. (2022). *Improving equitability and inclusion for testing and detection of lead poisoning in U.S. children* [Manuscript submitted for publication].

Sobin, C., Parisi, N., Schaub, T., Gutierrez, M., & Ortega, A.X. (2011). δ-Aminolevulinic acid dehydratase single nucleotide polymorphism 2 and peptide transporter 2*2 haplotype may differentially mediate lead exposure in male children. *Archives of Environmental Contamination and Toxicology*, *61*(3), 521–529. https://doi.org/10.1007/s00244-011-9645-3

Sowers, T.D., Nelson, C.M., Diamond, G.L., Blackmon, M.D., Jerden, M.L., Kirby, A.M., Noerpel, M.R., Scheckel, K.G., Thomas, D.J., & Bradham, K.D. (2021). High lead bioavailability of indoor dust contaminated with paint lead species. *Environmental Science & Technology*, *55*(1), 402–411. https://doi.org/10.1021/acs.est.0c06908

Stagi, S., Cavalli, L., Iurato, C., Seminara, S., Brandi, M.L., & de Martino, M. (2013). Bone metabolism in children and adolescents: Main characteristics of the determinants of peak bone mass. *Clinical Cases in Mineral and Bone Metabolism*, *10*(3), 172–179.

Stojsavljević, A., Škrivanj, S., Trifković, J., Djoković, N., Trifunović, S.R., Borković-Mitić, S., & Manojlović, D. (2019). The content of toxic and essential elements in trabecular and cortical femoral neck: A correlation with whole blood samples. *Environmental Science and Pollution Research*, *26*(16), 16577–16587. https://doi.org/10.1007/s11356-019-04796-w

Teichmann, R., & Stremmel, W. (1990). Iron uptake by human upper small intestine microvillous membrane vesicles. Indication for a facilitated transport mechanism mediated by a membrane iron-binding protein. *The Journal of Clinical Investigation*, *86*(6), 2145–2153. https://doi.org/10.1172/JCI114953

Tester, J.M., Rosas, L.G., & Leung, C.W. (2020). Food insecurity and pediatric obesity: A double whammy in the era of COVID-19. *Current Obesity Reports*, *9*, 442–450. https://doi.org/10.1007/s13679-020-00413-x

Vincent, P.C. (1958). The effects of heavy metal ions on the human erythrocyte. II. The effects of lead and mercury. *The Australian Journal of Experimental Biology and Medical Science*, *36*(6), 589–602. https://doi.org/10.1038/icb.1958.64

von Lindern, I., Spalinger, S., Stifelman, M.L., Stanek, L.W., & Bartrem, C. (2016). Estimating children's soil/dust ingestion rates through retrospective analyses of blood lead biomonitoring from the Bunker Hill Superfund Site in Idaho. *Environmental Health Perspectives*, *124*(9), 1462–1470. https://doi.org/10.1289/ehp.1510144

Weinstein, J.R., & Anderson, S. (2010). The aging kidney: Physiological changes. *Advances in Chronic Kidney Disease*, *17*(4), 302–307. https://doi.org/10.1053/j.ackd.2010.05.002

Wells, R.G. (2017). Hepatic fibrosis in children and adults. *Clinical Liver Disease*, *9*(4), 99–101. https://doi.org/10.1002/cld.623

Wetmur, J.G., Lehnert, G., & Desnick, R.J. (1991). The δ-aminolevulinate dehydratase polymorphism: Higher blood lead levels in lead workers and environmentally exposed children with the 1–2 and 2-2 isozymes. *Environmental Research*, *56*(2), 109–119. https://doi.org/10.1016/S0013-9351(05)80001-5

Wolf, A.W., Jimenez, E., & Lozoff, B. (2003). Effects of iron therapy on infant blood lead levels. *The Journal of Pediatrics*, *143*(6), 789–795. https://doi.org/10.1067/S0022-3476(03)00540-7

Ziegler, E.E., Edwards, B.B., Jensen, R.L., Mahaffey, K.R., & Fomon, S.J. (1978). Absorption and retention of lead by infants. *Pediatric Research*, *12*(1), 29–34. https://doi.org/10.1203/00006450-197801000-00008

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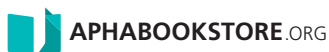
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Brownfields in Romania and the United States: A Visual Tour

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Abstract This third article in a series of three on land reuse describes brownfield sites in Romania and the U.S. In 2018 and 2019, four of the authors toured brownfield areas in Romania (including Bucharest, southern Transylvania, and Oradea) and the U.S. (Southeast Missouri [called the Missouri Bootheel], Northern Arizona and Navajo Nation, and Northwest Indiana). We were interested in similarities and differences among brownfields in various urban and rural settings in both countries. This article describes these sites through a visual perspective as well as site characteristics and commonalities. Ultimately, potentially contaminated or land reuse sites such as brownfields are common in many parts of the world. We hope to advance the understanding of brownfields and site transformation options through our collaboration.

Introduction

We authors are members of the Brownfields & Reuse Opportunity Working Network (BROWN), a consultative collaboration that provides free assistance related to land reuse and public health concerns (Agency for Toxic Substances and Disease Registry [ATSDR], 2020). BROWN was created and is facilitated by the National Land Reuse Health Program within the Agency for Toxic Substances and Disease Registry (ATSDR, 2022). We are also part of the North American European Brownfields Working Group, a special initiative of BROWN.

In the U.S., brownfields are defined as property where the expansion, redevelopment, or reuse can be complicated by the presence of hazardous substances, pollutants, or contaminants (U.S. Environmental Protection Agency [U.S. EPA], 2022a). While Europe does not have a common definition of brownfields, the concept generally is associated with land contamination (Cobârzan, 2007; Grimski & Ferber, 2001). Brownfields reuse and redevelopment in Europe and the U.S. present many opportunities for com-

munity design, reduction of sprawl, taking pressures off green or undeveloped land, and improving community and environmental health outcomes through safe and sustainable reuse practices and community design.

To enhance our collaborative research on brownfields redevelopment practices, regulations, and policies in Europe and the U.S., we examined the nature and type of a number of brownfield case study sites in Romania and the U.S. During the summers of 2018 and 2019, our team toured brownfield sites in both countries. Through our intercontinental collaboration, we intend to broaden the technical and policy knowledge related to brownfields redevelopment and restoration. Further, we plan to disseminate best practices among policy makers and the various stakeholders including developers, regulatory personnel, academicians, and the public.

Brownfields in Romania

Bucharest

Romania is the 12th-largest country in Europe, with a population of approximately

22 million, and is the 6th-most populous member state of the European Union. Our brownfields tour commenced in the capital city of Bucharest. Located in Southern Romania, Bucharest (population of 2,143,132) is the nation's economic, political, administrative, and cultural center. As shown in Table 1, the city of Bucharest has an unemployment rate of 0.7%, approximately one half that of the country of Romania; employed people make up 45.9% of the population, which is approximately double the percentage of employed people in the country (Romanian National Institute of Statistics, 2020).

The development and planning of this urban and densely populated capital city was strongly influenced by various historical periods. At the end of the 19th century and beginning of the 20th century, Bucharest was known as the Little Paris because of its unique and extravagant architecture. During this period, the National Theater, Bucharest Academic Society, Bucharest Philharmonic Orchestra, University of Bucharest, Grand Hotel du Boulevard, Romanian Athenaeum, and National Bank of Romania were constructed.

After World War II, Romania became a communist country. For almost one half a century, industrialization was the most important episode in the economic and political history of the country, aiming to transform the mainly agrarian state in to an industrial one. The city of Bucharest grew rapidly and became the national center of economic production and population growth. In addition to industrial expansion, the communist regime designed large, imposing buildings to project a sense of its power. Many of these buildings

TABLE 1

Demographic Indicators for Romania and Select Cities

Indicator	Romania	Bucharest	Oradea
Population (total)	22,193,286	2,143,132	221,473
Employed (total)	5,164,471	984,014	94,612
Unemployed (total)	257,865	15,248	629
Employed (%)	23.3	45.9	42.7
Unemployed (%)	1.2	0.7	0.3

Source: Romanian National Institute of Statistics, 2019.

FIGURE 1

Radio House in Bucharest

FIGURE 2

Dunărea Hotel in Bucharest

FIGURE 3

Old Farm Buildings in the Historical Region of Transylvania Bounded by the Carpathian Mountain Range

are now vacant and deteriorated, leaving a trail of brownfields across the country.

Our tour of brownfields in Bucharest included former communist-era sites and other historical buildings. Sites featured in this article include a former communist-era Romanian museum and a former mid-20th century hotel.

The Radio House (or the Dâmbovița Center) is an example of a typical communist-era building (Figure 1). It was built in the late 1980s as a Romanian Communist Party museum. From one of the building's balconies on August 23, 1989, former Romanian dictator Nicolae Ceaușescu watched the last communist-style parade in Romania, dedicated to Romania's National Day. Currently the unfinished building is abandoned, but there are plans for converting it in to a large residential and commercial center (OfficeRentInfo.RO, 2022). The contaminants of concern are lead-based paint and asbestos.

The second featured site is the former Dunărea Hotel (Figure 2). It was built in the interwar period (1935–1940) and for several decades was one of the most famous hotels in Bucharest. An earthquake in 1977 severely damaged the building—it is now in an advanced stage of decay and has been vacant for over 30 years. As the hotel is in a prominent location in the city, it is a priority for redevelopment. Plans for rehabilitation and transformation of this historical building exist, but no project has been implemented yet (Neagu, 2018). Contaminants of concern include lead-based paint and asbestos.

Transylvania and Oradea
Prior to a tour of Oradea, coauthors Dr. Laurel Berman and photojournalist Lloyd DeGrane independently hiked over 50 miles through the Carpathian Mountains in Southern Transylvania. Brownfields there were primarily rural and consisted largely of abandoned and deteriorated former farmhouses (a typical rural site is shown in Figure 3), which based on their age could have lead-based paint, asbestos, and mold contamination. In some of the villages, former communist-era vacant factories loom over the landscape.

During our visit in Oradea, our tour included historical military brownfields and com-

munist-era industrial sites. Sites included a former fortress and a former aluminum production industrial site. The city of Oradea is in Northwest Romania and has an approximate population of 221,473 (Romanian National Institute of Statistics, 2019). Because of its geostrategic importance (a combination of political and geographic locations that are primed for strategic planning on various levels), Oradea played a significant historical role in its 1,000-year history as a bridge between the West and East in Europe. Oradea declined, however, during the 20th century. In the last 10 years, Oradea has received $150 million Euros from the European Union (EU) to improve urban infrastructure and increase the quality of life for its residents (Simic, 2018). Although the city has begun a revitalization process with EU funds (Morar, Lukić, et al., 2021), many brownfield sites remain that need remediation and restoration, similar to many other cities in Romania.

Like Bucharest, Oradea has a low unemployment rate of 0.3%, approximately one quarter that of Romania. Employed people make up 42.7% of the population, which is approximately double the percentage of employed people in the country (Table 1; Romanian National Institute of Statistics, 2019). The city of Oradea had its greatest urban transformation and economic growth during the communist period (1948–1989), with the implementation of the central planning and economic development model, primarily based on heavy industry (Morar et al., 2019). Over time, this model proved to be economically inefficient. The political and

economic changes during the last decades of the 20th century led to the transition to the free market economy that is currently in place. Many communist-era industries could not adjust to the new economic environment, however, leaving behind large urban areas of derelict, abandoned, and underused brownfields (Morar et al., 2016).

One of the brownfields case studies in Oradea is the Fortress of Oradea (Figure 4), which represents the initial medieval urban nucleus of Oradea. It was built as early as the 11th century under the rule of King Ladislaus I. The medieval fortress consisted of a circular inner castle, highlighted by a pentagonal outer castle. The fortress was rebuilt in the 16th century to represent Renaissance architecture and center-oriented urban planning. Military use of the fortress ended by the middle of the 19th century, after which it served only as auxiliary facilities. Between 1947 and 1952, the northern section of the fortress was used by the former Romanian Secret Police (i.e., the Securitate). The fortress also housed military units between 1945 and 1989, but after 1975 the structure entered a deterioration phase and was used mainly as military warehouses.

Renovation work on the fortress occurred between 2010 and 2021 to remove lead-based paint and mold and to redevelop the site. Now the renovation efforts are focused on the surrounding defensive walls, which are scheduled to be done during the next 2 years. The fortress currently functions as a multicultural place for the city, offering tourist sights, cultural programs, concerts, festivals, and various events. As a traditional military site incorporated in a city's urban architecture, this site's heritage as a Renaissance structure in Transylvania is a valuable regional asset.

In Oradea, industry began to develop after 1950. During the communist era, large industrial areas were developed, many of which are now brownfields. The former aluminum factory in Oradea that began operating in 1965 is part of a typical communist-era site (Figure 5). For several decades, the factory was one of the first nonferrous metallurgy sites in Romania. This industrial development was based on the availability of local bauxite deposits (Brejea et al., 2019).

The reduced demand for raw material in the 1990s led to closure of the bauxite mining unit in 1999, leaving behind contaminated

land including an open pit mine and abandoned processing facilities (Dragastan et al., 2009). The factory was permanently closed in 2006. The massive amounts of bauxite residue saturated with caustic soda resulted in an 800,000 m^2 surface of "red mud" from decades of aluminum processing. The historical operations at this site released highly alkaline compounds including trace amounts of toxic compounds, heavy metals, and radioactive materials that produce radon, which resulted in environmental pollution of air, groundwater, and soil. Such pollutant exposures potentially can result in adverse population health impacts such as respiratory illness (Economic Commission for Europe, 2001; Kovacs et al., 2017; Totorean, 2019). The aluminum factory and other industrial sites from the communist era left a landscape of large, abandoned, and contaminated sites throughout Romania. Often, these sites are contiguous, which complicates the contamination profile.

Brownfields in the United States

The Missouri Bootheel
Our first U.S. brownfields tour was the Missouri Bootheel. The Bootheel is in the far southeast corner of the state, which looks like the heel of a boot, hence the name "Bootheel." It is a largely rural area that is bisected by Interstate 55 and Highways 60 and 61. Historically, the Bootheel was a swampy wetland area formed by flooding from the Mississippi and Ohio Rivers. The area is referred to as the Mississippi Alluvial Basin (Missouri Department of Conservation, 2005). The five primary counties within the heel shape of the boot include Dunklin, Mississippi, New Madrid, Pemiscot, and Scott counties. These Bootheel counties have the lowest health rankings among all 115 Missouri counties (Missouri Bootheel Regional Consortium Inc., 2019).

Howardville, in New Madrid County, was founded by Travis Howard in 1953, who

FIGURE **6**

Exterior of Howardville High School (Left) and Interior of the Howardville High School Gymnasium (Right) in Howardville, Missouri

FIGURE **7**

Inactive Cotton Gin in the Missouri Bootheel (Left) and Drums Stored Outside an Inactive Cotton Gin Undergoing Demolition (Right) in the Missouri Bootheel

FIGURE **8**

Active Gas Station With Old Fuel Tanker Trucks in Portageville, Missouri

FIGURE **9**

Vacant Historic Sharecropper Home in Homestown, Missouri

established an African American community and a school to provide a higher-quality education for African Americans than what was available at the time. Howardville is centrally located in the Bootheel, with a reported census population of 346 that is 96.2% Black or African American (U.S. Census Bureau, 2020a). The household median income for Howardville residents is $30,577 and 14.5% of the population is below 100% of the poverty level (U.S. Census Bureau, 2020a). In contrast, the total population of New Madrid County is 17,275, of which 81.0% of the population is White and 15.8% is Black or African American. The household median income in New Madrid County is $40,129 and 20.7% of the population is below 100% of the poverty level (U.S. Census Bureau, 2020b).

In the 1930s, cotton was the primary cash crop in the Bootheel and many of the farmers were renters or sharecroppers (i.e., farmers who rented land and paid in shares of crops). Many of these farmers were Black who, in the post-slavery times, were paid much less than other farmworkers (Cantor, 1969). In the late 1930s, landowners did not want to share government subsidies with sharecroppers and planned a mass eviction. A local minister, Owen Whitfield, protested the ongoing evictions and organized the Sharecroppers Roadside Demonstration of 1939. Hundreds of sharecroppers camped along the main highways of the Bootheel, drawing national attention to their plight. Ultimately the Farm Security Administration created low-rent housing developments, known as the Delmo Homes, for 500 sharecropper families (Cantor, 1969). Many of these housing developments currently are occupied by family members descended from the sharecroppers. Some of the homes that might have asbestos-containing material and lead-based paint have become abandoned and deteriorated.

The Bootheel area is littered with petroleum brownfields, abandoned cotton gins, and boarded or vacant commercial and residential buildings. While many suspected brownfields and land reuse sites have not yet received assessment or cleanup funding, the U.S. Environmental Protection Agency's (U.S. EPA) My Environment website search of Bootheel counties lists one Superfund (National Priorities List) site in Sikeston (New Madrid County) and 11 brownfields that have received U.S. EPA funding throughout the Bootheel (U.S. EPA, 2020a).

A review of Bootheel brownfields in the U.S. EPA database Cleanups in My Community indicates that contaminants of concern include petroleum, solvents (e.g., volatile organic compounds), lead, and asbestos (U.S. EPA, 2021). The websites My Environment and Cleanups in My Community only list sites that have received funding from U.S. EPA for assessment or cleanup, including Superfund or National Priorities List sites, or sites that are required to report emissions into the environment (e.g., emit permitted amounts of hazardous waste). Sites featured

TABLE **2**

Demographic Indicators for Navajo Nation and Holbrook Areas of Arizona and New Mexico

Indicator	Chinle, Arizona	Apache County, Arizona	Holbrook, Arizona	Navajo County, Arizona	Navajo, New Mexico	McKinley County, New Mexico
Population	4,291	65,623	5,073	108,147	1,818	71,780
Median household income (in 2020 dollars)	$30,667	$33,967	$45,106	$43,140	$25,323	$36,179
Persons in poverty (%, below 100% of poverty level)	53.5	32.4	20.9	23.3	60.5	32.0
Race (%)						
White	3.5	22.6	50.6	51.1	0.6	15.7
Black or African American	0.7	0.6	7.1	1.1	0.1	0.6
American Indian and Alaska Native	91.8	74.5	27.9	44.6	95.4	79.9
Hispanic or Latino	0.4	7.1	30.0	12.1	1.3	14.6

Source: U.S. Census Bureau, 2020c, 2020d, 2020e, 2021a.

in this article include the old Howardville High School (Figure 6); an inactive cotton gin (Figure 7); an active auto gasoline and service station with old fuel tank trucks stored behind the facility (Figure 8); and a vacant historic sharecropper home that is typical of many abandoned residential structures in the Bootheel (Figure 9).

Brownfields in Navajo Nation and Northern Arizona

Our second U.S. brownfields tour was in the Navajo Nation Chapters of Chinle and Red Lake and in Holbrook, in Northern Arizona. Navajo Nation extends across the Four Corners region of Arizona, New Mexico, Utah, and Colorado and encompasses 27,000 mi². Also known as Diné Bikéyah, or Navajoland, the Navajo Nation reservation is larger than 10 of the 50 states in the U.S. (Navajo Nation Government, 2022). Demographic information for the Navajo Nation and Holbrook communities is summarized in Table 2.

Chinle, Arizona
The Chinle Chapter is a small city in Apache County that is home to Canyon de Chelly. The canyon historically was home to Puebloan and Hopi before Navajo settled there (National Park Service, 2021). As shown in Table 2, approximately 54% of Chinle residents are in poverty (U.S. Census Bureau, 2020c) compared with 32% of Apache County resi-

dents (U.S. Census Bureau, 2021a). Chinle residents have a median household income of $30,667 (U.S. Census Bureau, 2020c), which is comparable to that for Apache County ($33,967) (U.S. Census Bureau, 2021a).

The My Environment website from U.S. EPA for Chinle, Arizona, in Apache County did not indicate any known land reuse or brownfields sites (U.S. EPA, 2020b). As previously discussed, however, the My Environment website only lists sites that have received funding from U.S. EPA for assessment or cleanup. Navajo tribal officials are aware of several brownfields in Chinle that have not received funding to perform assessments or cleanup (A. McCabe, personal communication, June 19, 2019). Sites we visited in Chinle included vacant residential and commercial properties, two petroleum leak sites, and a vacant fast-food restaurant. Chinle sites included in this article include vacant parcels that are under consideration for redevelopment as a crafts village for artist vendors (Figure 10).

Navajo, New Mexico
The Red Lake Chapter is in Navajo, New Mexico, in McKinley County. It is rural and was developed as a company town around the now-defunct 103-acre Navajo Forest Products Industry (NFPI) site. Approximately 60.5% of Navajo residents are in poverty (U.S. Census Bureau, 2020e), compared with

32.0% of McKinley County residents (U.S. Census Bureau, 2021a; Table 2).

The My Environment website indicated two brownfields in the city of Navajo, New Mexico, including the NFPI site that is featured in this article (U.S. EPA, 2020c; Figure 11). The NFPI site currently is undergoing extensive site assessment by the Navajo Nation Environmental Protection Agency. Debris has been removed from the site, but there are large areas in and around the site that have wood chip fill that could be contaminated with asbestos. Much of the soil is also contaminated with benzene and naphthalene (P. Maples, personal communication, June 19, 2019).

Holbrook, Arizona
The City of Holbrook, Arizona, in Navajo County is along Route 66 and is considered the gateway to the Petrified Forest (City of Holbrook, n.d.). Holbrook is a former tourist town that has a large corridor of vacant gasoline and automobile service stations, along with old residential and commercial buildings. As shown in Table 2, Holbrook's median household income is $45,106—slightly higher than the overall Navajo County median ($43,140)—and 20.9% of residents are in poverty, which is slightly lower than the rest of Navajo County (23.3%). Sites that we visited in Holbrook included petroleum brownfields and vacant commercial and residential buildings, including an old automo-

FIGURE **10**

Fenced Structure Within Proposed Vendor Village Site (Left) and Proposed Vendor Village Site Tour and Phase I Environmental Site Assessment Conducted by Licensed Environmental Professional Dave Laney (Right) in Chinle, Arizona

FIGURE **11**

Landscape of the 103-Acre Navajo Forest Products Industry Site in Navajo, New Mexico

FIGURE **12**

Vacant Automobile Service and Repair Station in Holbrook, Arizona

FIGURE **13**

Vacant and Deteriorated Hotel in Holbrook, Arizona

bile gas and service station and a vacant, deteriorated hotel (Figures 12 and 13).

The My Environment website indicated three brownfields in Holbrook (U.S. EPA, 2020d). Our tour host in Holbrook was Dave Laney, an experienced licensed environmental professional. Laney indicated that the city has been unsuccessful in securing U.S. EPA brownfields funding to clean up significant petroleum contamination in the groundwater from numerous automobile service and gasoline stations that are vacant. Laney also relayed that there are numerous vacant commercial and residential properties suspected to have lead-based paint and vapor intrusion issues due to the petroleum plume at a shallow depth below ground level (D. Laney, personal communication, June 18, 2019).

Holbrook is one of the communities in the Route 66 Partnership organized by the Arizona Department of Environmental Quality.

Launched in 2004, the partnership is a network of local, state, and federal agencies and organizations that helps communities identify resources for assessment, cleanup, and redevelopment at current and former leaking underground storage tank sites, abandoned gas stations, and other underutilized sites along Route 66 in Northern Arizona (U.S. EPA, 2011).

Brownfields in Northwest Indiana

We concluded our U.S. brownfields tour in Northwest Indiana, visiting the former industrial cities of Gary and East Chicago in what is known as the Calumet Region in Lake County, Indiana (Figures 14 and 15). Despite its industrial past that was heavily focused on steel production and chemical plants, the Calumet Region is home to the Indiana Dunes National Shoreline, several wetlands, and rare natural areas (Calumet Heritage Partnership, 2022).

Demographic indicators for Gary, East Chicago, and Lake County are summarized in Table 3. Gary is nearly 3 times the size of East Chicago. Both cities are racially diverse. Gary's majority population is 78% Black, and East Chicago's majority population is 58% Hispanic or Latino and 36% Black. In contrast, the population of Lake County is primarily White (71%). The median household income in Gary and East Chicago is approximately $35,000 and $31,000, respectively, which is below the county's median household income of approximately $57,000. In Gary, 33% of the population is in poverty; in East Chicago, 31% of the population is in poverty. In Lake County, 16% of the population is in poverty (U.S. Census Bureau, 2021b).

The Grand Calumet River runs throughout the Calumet Region. It is one of the Great Lakes Areas of Concern (AOC) under the Great Lakes National Program Office within U.S. EPA (U.E. EPA, 2022b). AOCs have experienced significant environmental degradation. The Grand Calumet AOC has legacy contamination that includes polychlorinated biphenyls (PCBs); polycyclic aromatic hydrocarbons (PAHs); heavy metals including but not limited to mercury, cadmium, chromium, and lead; and oil and grease (U.S. EPA, 2022c).

The My Environment website indicated 2 Superfund and 34 known brownfield sites in Gary and 1 Superfund and 16 known brownfield sites in East Chicago (U.S. EPA, 2020e, 2020f). There are, however, additional numerous vacant sites, including old gas stations, multiunit residential buildings, schools, parking structures, and homes in both cities.

Coauthor Lloyd DeGrane began photographing land reuse sites in the region in 2009 and continues to document and archive the

TABLE **3**

Demographic Indicators for Gary, East Chicago, and Lake County in Indiana

Indicator	Gary, Indiana	East Chicago, Indiana	Lake County, Indiana
Population	68,325	26,099	498,558
Median household income (in 2020 dollars)	$31,315	$35,396	$57,530
Persons in poverty (%, below 100% of poverty level)	33.1	30.6	15.8
Race (%)			
White	14.5	24.5	71.0
Black or African American	77.9	36.0	24.5
American Indian and Alaska Native	0.1	0.1	0.6
Hispanic or Latino	8.9	57.5	20.4

Source: U.S. Census Bureau, 2021b.

FIGURE **14**

Marktown in East Chicago, Indiana

area for brownfield sites. In July 2019, we revisited several sites he documented. There had been few to no environmental improvements at these sites in the last decade. Sites we visited in Gary included old schools, churches, businesses, and residential areas. Photos include a vacant multiunit apartment building (Figure 16) and two vacant businesses including a dry cleaner and an old tire facility (Figure 17).

Discussion: Brownfields in Romania and the United States

Brownfield sites can occur in any location in the world where people have conducted work that involves use or storage of hazardous materials. As illustrated in this article, sites can be in the middle of a bustling metropolis such as Bucharest or quietly situated along a forgotten highway such as Route 66, or they can be in rural or remote areas. While it is easy to point to abandoned industrial sites as potential areas of concern, it is often more difficult to identify and document old, abandoned farmhouses—such as those in the Missouri Bootheel or the Carpathian Mountain—as sites with the potential to pose health risks. Many of the same hazards, however, can exist in both locations due to sources of environmental pollution and the similar fingerprinting of chemical constituents in the polluted environment.

When specifically comparing Eastern European brownfields with those in the U.S.,

urban areas in Romania such as Bucharest and Oradea have high employment rates and nearly all-White populations. These demographics are very different from the urban areas with the heaviest brownfields burden in the U.S., mainly those with predominant populations of color or lower socioeconomic status (e.g., Gary and East Chicago, Indiana). Often, many of the brownfield sites in the U.S. are more isolated geographically (e.g., Chinle, Arizona, and the Missouri Bootheel), lessening the visual exposure of the sites to larger numbers of people. The rural, mountainous areas of Transylvania in Romania are similarly isolated, bringing the saying "out of sight, out of mind" to consciousness.

This varied landscape of geographic locations of brownfields, the environmental impacts of pollution at the sites, and their proximity to human populations play a significant role in the source-to-receptor paradigm and the extent and scope of potential adverse public health effects associated with exposure to pollutants emanating from brownfield sites. These factors necessitate proper training of local scientists, policy makers, and the public about brownfield issues from a local perspective to advance a successful brownfields restoration program that is responsive to local, ecological, and public health concerns of all stakeholders.

We should note that when examining contaminants at brownfield sites, many

similar contaminants of public health concern exist regardless of geographical location—these contaminants include mold, lead, asbestos, petroleum products, solvents, volatile organic compounds, PCBs, PAHs, and heavy metals. The industrial sites often have a more complex pollution profile that includes various pollutants in air, water, and soil. The sites visited, whether the communist-era factories in Oradea compared to industrial sites in Gary and East Chicago, or the old farm buildings in the Carpathian Mountains compared to sharecropper cottages in the Bootheel, told similar stories regardless of their country of origin. Similar human industrial activity conducted around comparable areas can produce similar contaminants of concern that threaten human health across the globe.

Once the source and constituents of environmental pollution are identified via initial site investigation of brownfields, site remediation alternatives can be developed to clean up the site per health-based cleanup standards and return it to productive use. The entire process requires expertise from different disciplines including engineers, geologists, hydrogeologists, chemists, statisticians, toxicologists, public health professionals, and risk assessment experts. In the U.S., under the U.S. EPA Brownfields Program, this process is well-developed, implemented, and administered by state and local agencies from administrative, legal, technical, and financial perspectives. In Romania, however, there is a less developed and formally adopted process that is practiced, serving as a potential impediment to the

FIGURE 15

Calumet Industrial Canal in East Chicago, Indiana

FIGURE 16

Vacant and Deteriorated Multiunit Residential Building in Gary, Indiana

FIGURE 18

Historic Sharecropper Home Being Rehabilitated by Owner Robert Robinson in North Lilbourn, Missouri

Note. Robert Robinson died in 2020 due to COVID-19.

FIGURE 17

Vacant Dry Cleaning Facility (Left) and Vacant Tire Facility (Right) in Gary, Indiana

development of brownfield sites. Instituting a robust brownfields revitalization program nationally, regionally, and locally may be essential to the successful return of sites to productive use, elimination or reduction of potential adverse ecological and public health impacts, and simultaneous revitalization of the economy.

In Romanian brownfields areas, the unemployment and poverty level are low, and the population is primarily White. In the U.S., brownfields areas we visited were characterized by high unemployment, high poverty rates, and racial and ethnic variability. In the U.S., a high prevalence of predominantly Black, Hispanic, and Native American populations reside within or near brownfield case study sites.

The U.S. brownfields areas we visited could be considered to be environmental justice communities. Environmental justice emphasizes that all people have an equal opportunity to live, work, and play in a healthy environment. Communities with a high percentage of brownfields and hazardous waste sites often have a disproportionate burden of environmental and health hazards. In the U.S., many of these areas are lower income and historically marginalized communities. These factors highlight significant environmental justice concerns regarding the prevalence of brownfield sites in the U.S. being overwhelmingly situated in similarly low-socioeconomic regions with heavier pollution and health-risk burden for the populations living there.

Our ability to use U.S. EPA-developed tools such as My Environment and Cleanups in My Community facilitated our mapping of locations and identifying source profiles and other critical information for brownfield sites and/or other hazardous waste sites within the inventory of the U.S. EPA across the case study areas. These tools are available to the public and not only empower communities about the potential hazards in their own neighborhoods but also allow tracking of improvements in environmental and public health conditions over time in a specific locality. Similar tools are not available in Romania. We suggest the development of similar tools in Europe to share information with the public transparently, to empower communities, and to foster brownfields development and restoration.

Conclusion

While brownfields can lead to poor environmental conditions and disinvestment in the communities in which they are located, they exist throughout the world. Brownfields provide a rich global laboratory to study and comprehensively advance the science and practice of site investigation, remediation, and restoration with stakeholder input from various perspectives: administrative, legal, environmental, public health, economic, and sustainability. Thus, brownfields can be treated as opportunities to foster and re-create communities to improve overall community health—physical, economic, environmental, and public health.

We suggest an international action and global cooperation to adopt similar frameworks and practices for the evaluation and remediation of brownfield sites. Similar environmental pollution profiles and associated hazards and health risks govern the environmental fate of pollutants and their intrinsic toxicity, regardless of country of origin. Further, we suggest an international training and mentoring program to educate the next generation of scientists, scholars, and prac-

titioners who serve as agents of change for community revitalization. This program can incorporate public health and environmental sustainability principles in brownfields development in public agencies and nonprofit organizations such as community advocacy and environmental justice organizations.

Brownfields can be personal. Our team not only explored brownfields in Romania and the U.S. but also shared the historical and current conditions that touch on impacts that go beyond contamination, gaining a small glimpse of the lives of community members burdened by these sites. We met people who are directly working to improve their community and environment by remediating brownfields. We dedicate this article to the memory of one of these local champions, Robert Robinson, a North Lilbourn resident of the Missouri Bootheel, who was passionate about redeveloping his family's sharecropper home (Figure 18). ❧

Editor's Note: This review article is the third in a series of three that examine brownfields redevelopment as a subset of overall land use and reuse practices in Europe and the U.S. These articles are a result of a collaboration of the North American European Brownfields Working Group, a subgroup of the Brownfields & Reuse Opportunity Working Network (ATSDR, 2020). The working group aims to share and highlight best practices to promote healthy, sustainable redevelopment globally. The first article presented the European landscape of brownfields redevelopment through policy and funding frameworks (Morar, Berman, et al., 2021). The second article examined brownfields redevelopment in the U.S. through regulatory, public health, and sustainability lenses (Berman et al., 2022). This third article presents a comparative analysis of brownfields in the U.S. and Romania.

Photo Credits: The photos in Figures 1 and 2 are courtesy of R.D. Pintilii. The photos in Figures 3, 4, and 6–18 are courtesy of Lloyd DeGrane. The photo in Figure 4 (Oradea Fortress) is courtesy of the World Monuments Fund. The photos in Figure 5 are courtesy of Cezar Morar.

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References

Agency for Toxic Substances and Disease Registry. (2020). *Brownfields & Reuse Opportunity Working Network (BROWN)*. https://www.atsdr.cdc.gov/sites/brownfields/stakeholders.html

Agency for Toxic Substances and Disease Registry. (2022). *ATSDR Land Reuse Health Program: Overview*. https://www.atsdr.cdc.gov/sites/brownfields/overview.html

Berman, L., Morar, C., Unkart, S., & Erdal, S. (2022). An overview of brownfields redevelopment in the United States through regulatory, public health, and sustainability lenses. *Journal of Environmental Health*, *84*(9), 8–14.

Brejea, R., Domuta, C.G., Jude, E. & Nistor, A. (2019). Exploitation of bauxite from Padurea Craiului Mountains and the impact on environmental factors. *Annals of the Academy of Romanian Scientists Series on Agriculture, Silviculture and Veterinary Medicine Sciences*, *8*(1), 46–53.

Calumet Heritage Partnership. (2022). *Calumet National Heritage Area Initiative*. https://calumetheritage.org/heritage/calumet-national-heritage-area-feasibility-study/

Cantor, L. (1969). A prologue to the protest movement: The Missouri Sharecropper Roadside Demonstration of 1939. *Journal of American History*, *55*(4), 804–822. https://doi.org/10.2307/1900154

City of Holbrook, Arizona. (n.d.). *Home page*. https://www.holbrookaz.gov/

Cobârzan, B. (2007). Brownfield redevelopment in Romania. *Transylvanian Review of Administrative Sciences*, *21*, 28–46. https://rtsa.ro/tras/index.php/tras/article/view/370/360

Dragastan, O., Damian, R., Csiki, Z., Lazăr, I., & Marinescu, M. (2009). Review of the bauxite-bearing formations in the Northern Apuseni Mts. Area (Romania) and some aspects of the environmental impact of the mining activities. *Carpathian Journal of Earth and Environmental Sciences*, *4*(2), 5–24. https://www.cjees.ro/viewIssue.php?issueId=8

Economic Commission for Europe, Committee on Environmental Policy. (2001). *Environmental performance reviews: Romania*. United Nations. https://unece.org/fileadmin/DAM/env/epr/epr_studies/romania.pdf

Grimski, D., & Ferber, U. (2001). Urban brownfields in Europe. *Land Contamination & Reclamation*, *9*(1), 143–148. https://hero.epa.gov/hero/index.cfm/reference/details/reference_id/8748548

Kovacs, T., Bator, G., Schroeyers, W., Labrincha, J., Puertas, F., Hegedus, M., Nicolaides, D., Sanjuán, M.A., Krivenko, P., Grubeša, I.N., Sas, Z., Michalik, B., Anagnostakis, M., Barisic, I., Nuccetelli, C., Trevisi, R., Croymans, T., Schreurs, S., Todorović, N, . . . Doherty, R. (2017). From raw materials to NORM by-products. In W. Schroeyers (Ed.), *Naturally occurring radioactive materials in construction: Integrating radiation protection in reuse* (1st ed., pp. 135–182). Woodhead Publishing. https://doi.org/10.1016/B978-0-08-102009-8.00006-2

Missouri Bootheel Regional Consortium Inc. (2019). *Data reports*. https://www.mbrcinc.org/resources/data-reports/

Missouri Department of Conservation. (2005, October 2). *Bootheel Wetlands*. https://mdc.mo.gov/magazines/conservationist/2005-10/bootheel-wetlands

Morar, C., Berman, L., Unkart, S., & Erdal, S. (2021). Sustainable brownfields redevelopment in the European Union: An overview of policy and funding frameworks. *Journal of Environmental Health*, *84*(4), 24–31.

References

Morar, C., Dulca, M., & Nagy, G. (2016). Brownfields regeneration, between sustainable urban development and cultural heritage. The former military sites in Oradea, Romania. *Journal of Urban and Regional Analysis*, *8*(1), 75–84. https://bit.ly/3SkGFrY

Morar, C., Lukić, T., Basarin, B., Valjarević, A., Vujićić, M., Niemets, L., Telebienieva, I., Boros, L., & Nagy, G. (2021). Shaping sustainable urban environments by addressing the hydro-meteorological factors in landslide occurrence: Ciuperca Hill (Oradea, Romania). *International Journal of Environmental Research and Public Health*, *18*(9), Article 5022. https://doi.org/10.3390/ijerph18095022

Morar, C., Nagy, G., Dulca, M., Boros, L., & Sehida, K. (2019). Aspects regarding the military cultural-historical heritage in the City of Oradea (Romania). *ANNALES–Annals for Istrian and Mediterranean Studies, Series Historia et Sociologia*, *29*(2), 303–322. https://doi.org/10.19233/ASHS.2019.21

National Park Service. (2021). *Canyon de Chelly: National monument, Arizona*. https://www.nps.gov/cach/learn/historyculture/index.htm

Navajo Nation Government. (2022). *History*. https://www.navajo-nsn.gov/History

Neagu, A. (2018, May 4). Bucharest: The former Dunărea hotel, which will be transformed into an apartment building, has been waiting for two years for the start of the rehabilitation works. *PRESShub*. https://presshub.ro/bucuresti-fostul-hotel-dunarea-care-va-fi-transformat-in-bloc-de-apartamente-asteapta-de-doi-ani-ince perea-lucrarilor-de-reabilitare-1315/

OfficeRentInfo.RO. (2022). *Plaza Centers investigates several issues regarding Casa Radio project in Bucharest*. https://www.office rentinfo.ro/article/officemarket-news/plaza-centers-investigates-several-issues-regarding-casa-radio-project-in-bucharest

Romanian National Institute of Statistics. (2019). [Website in Romanian]. https://insse.ro/cms/

Romanian National Institute of Statistics. (2020). [Website in Romanian]. https://insse.ro/cms/

Simic, N. (2018, September 14). How a city can benefit from EU funds. *European Investment Bank*. https://www.eib.org/en/stories/romania-oradea-urban-development

Totorean, A. (2019, February 1). Poisonous legacy: On the outskirts of Oradea lie huge quantities of hazardous waste, abandoned from the glory years of the Alumina and Sinteza factories [Article in Romanian]. *Bihoreanul*. https://bit.ly/3S6dsRM

U.S. Census Bureau. (2020a). *Howardville, Missouri: American Community Survey, S0601: Selected characteristics of the total and native populations in the United States; S1901: Income in the past 12 months (in 2020 inflation-adjusted dollars)*. Retrieved October 19, 2022, from https://data.census.gov/cedsci/table?q=Howardville,%20Missouri

U.S. Census Bureau. (2020b). *New Madrid County, Missouri: American Community Survey, S0601: Selected characteristics of the total and native populations in the United States; S1901: Income in the past 12 months (in 2020 inflation-adjusted dollars)*. Retrieved October 19, 2022, from https://data.census.gov/cedsci/table?q=New%20Madrid%20County,%20Missouri&tid=ACSST5Y2020.S0601

U.S. Census Bureau. (2020c). *Chinle CDP, Arizona: American Community Survey, S0601: Selected characteristics of the total and native populations in the United States; S1901: Income in the past twelve months (in 2020 inflation-adjusted dollars)*. Retrieved October 19, 2022, from https://data.census.gov/cedsci/table?q=Chinle%20CDP,%20Arizona

U.S. Census Bureau. (2020d). *Holbrook, Arizona: American Community Survey, S0601: Selected characteristics of the total and native populations in the United States; S1901: Income in the past twelve months (in 2020 inflation-adjusted dollars)*. Retrieved October 19, 2022, from https://data.census.gov/cedsci/table?q=Holbrook%20city,%20Arizona

U.S. Census Bureau. (2020e). *Navajo, New Mexico: American Community Survey, S0601: Selected characteristics of the total and native populations in the United States; S1901: Income in the past twelve months (in 2020 inflation-adjusted dollars)*. Retrieved October 19, 2022, from https://data.census.gov/cedsci/table?q=Navajo,%20New%20Mexico

U.S. Census Bureau. (2021a). *QuickFacts: Navajo County, Arizona; McKinley County, New Mexico; Apache County, Arizona*. Retrieved October 19, 2022, from https://www.census.gov/quickfacts/fact/table/holbrookcityarizona,navajocountyarizona,mckinleycountyn ewmexico,apachecountyarizona/PST045219

U.S. Census Bureau. (2021b). *QuickFacts: Lake County, Indiana; East Chicago city, Indiana; Gary city, Indiana*. Retrieved October 19, 2022, from https://www.census.gov/quickfacts/fact/table/lakecoun tyindiana,eastchicagocityindiana,garycityindiana/PST045221

U.S. Environmental Protection Agency. (2011). *The Arizona Route 66 Partnership: Westward expansion from Holbrook to Kingman* (909-R-10-001). https://archive.epa.gov/region9/brownfields/archive/web/pdf/az-route-66-partnership.pdf

U.S. Environmental Protection Agency. (2020a). *My Environment. New Madrid County, Missouri*. Retrieved January 9, 2020, from https://bit.ly/3E0QeZ5

U.S. Environmental Protection Agency. (2020b). *My Environment. Chinle, Arizona*. Retrieved January 9, 2020, from https://bit.ly/3SCPrS6

U.S. Environmental Protection Agency. (2020c). *My Environment. Navajo, New Mexico*. Retrieved January 9, 2020, from https://bit.ly/3CeLAoU

U.S. Environmental Protection Agency. (2020d). *My Environment. Holbrook, Arizona*. Retrieved January 9, 2020, from https://bit.ly/3RhBiJh

U.S. Environmental Protection Agency. (2020e). *My Environment. Gary, Indiana*. Retrieved January 9, 2020, from https://bit.ly/3LL4Mhc

U.S. Environmental Protection Agency. (2020f). *My Environment. East Chicago, Indiana*. Retrieved January 9, 2020, from https://bit.ly/3Cck8Z2

References *continued from page 37*

U.S. Environmental Protection Agency. (2021). *Cleanups in My Community*. Retrieved August 11, 2021, from https://www.epa.gov/cleanups/cleanups-my-community

U.S. Environmental Protection Agency. (2022a). *Overview of EPA's Brownfields Program*. https://www.epa.gov/brownfields/overview-epas-brownfields-program

U.S. Environmental Protection Agency. (2022b). *Great Lakes Areas of Concern*. https://www.epa.gov/great-lakes-aocs

U.S. Environmental Protection Agency. (2022c). *Grand Calumet River AOC*. https://www.epa.gov/great-lakes-aocs/grand-calumet-river-aoc

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The Ethics of Professionalism in Environmental Health

Daniel B. Oerther, PhD, CEHS, DAAS, PE, BCEE, FCIEH, FAAN

Editor's Note: In an effort to provide environmental health professionals with relevant information and tools to further the profession, their careers, and themselves, the National Environmental Health Association (NEHA) has teamed up with the American Academy of Sanitarians (AAS) to publish two columns a year in the *Journal*. AAS is an organization that "elevates the standards, improves the practice, advances the professional proficiency, and promotes the highest levels of ethical conduct among professional sanitarians in every field of environmental health." Membership with AAS is based upon meeting certain high standards and criteria, and AAS members represent a prestigious list of environmental health professionals from across the country.

Through the column, information from different AAS members who are subject-matter expects with knowledge and experience in a multitude of environmental health topics will be presented to the *Journal's* readership. The conclusions and opinions of this column are those of the author(s) and do not necessarily represent the views of NEHA.

Professor Daniel Oerther is a leader who promotes transdisciplinary environmental health practice, teaching, research, and policy. He is a diplomate with AAS, executive director of the American Academy of Environmental Engineers and Scientists, chair of the Chartered Institute of Environmental Health, and a lifetime honorary fellow of the American Academy of Nursing.

Previously, I discussed the importance of a global outlook—including the United Nations Sustainable Development Goals—to meet the ethical obligations shared among environmental health professionals such as sanitarians, engineers, and community health nurses (Oerther, 2021). The constitution of the American Academy of Sanitarians (AAS, 2006a) notes that the purposes and objectives of AAS include, "promoting the highest levels of ethical conduct among professional sanitarians in every field of environmental health." But what is ethical conduct and what are the ethical obligations shared among environmental health professionals?

In Table 1, I provide the current code of ethics for professionals with a credential from the National Environmental Health Association (NEHA, 2022). The NEHA code identifies two areas of required action, namely: 1) keeping up-to-date on knowledge and 2) acting professionally. The code forbids behaviors that undermine the credential or impair the ability of a credentialled professional to discharge their duties. Further, the code promotes the credential through raising awareness within the public sphere. The NEHA code does not include details to define the meaning of professional manner (i.e., what to do) and it does not include examples of behaviors that undermine the credential (i.e., what not to do).

Terms such as professionalism simultaneously seem to be important and yet often are poorly understood by the very individuals who have an obligation to apply their meaning. One readily available, free resource that may be useful to environmental health professions trying to understand these terms is the Internet Encyclopedia of Philosophy (IEP, https://iep.utm.edu). Important, yet often confusing terms such as ethics, morals, principles, values, and virtues are carefully described in detailed articles in the IEP, written by and reviewed by a group of volunteers with earned doctorates in philosophy.

Alternatively, the meaning of professionalism for environmental health professionals may be gleaned from a comparative reading of the code of ethics from sister organizations of similar stature. For example, the Chartered Institute of Environmental Health (CIEH, 2022) maintains a code of ethics for members and fitness to practice rules. Section 4 of the CIEH code notes four main domains of ethics: 1) integrity, 2) competence, 3) respon-

TABLE 1

Code of Ethics for Professionals Credentialed Through the National Environmental Health Association

Code of Conduct and Ethics
I shall endeavor to keep myself current and informed and satisfy any continuing education requirements that may be in effect for my credential.
I shall conduct myself in a professional manner befitting of my credentialed status.
I shall proudly represent my credentialed status to the public I serve.
I shall do nothing to undermine, detract from, or otherwise cause to develop any damaging associations with respect to this credential. I accept that any activity on my part that will cause this credential any measure of injury serves as a breach and a failure on my part to uphold this code of ethics. Moreover, I accept that such actions for which I might be responsible could result in the revocation of my credential.
I shall do nothing to impair my ability to discharge any administrative or regulatory duty related to my professional credential that may also be required under federal, state, or local law as a part of the position I hold.

Source: National Environmental Health Association, 2022.

TABLE 2

Select Articles From the 2022 Update of the American Academy of Sanitarians Bylaws

Article	Description
2. Purpose and Objectives, Section 3, Diversity, Equity, and Inclusion	The Academy accepts [any] qualified member … does not discriminate … and strives to create an inclusive environment.
6. Committees, Section 3, Ad Hoc Committees	Ad hoc committees shall assist the Academy in creating, adopting, and implementing a diversity, equity, and inclusion (DE&I) policy that guides Academy employment, governance, and membership.
10. Code of Conduct	No officer or director shall: … 3) publicly utilize any Academy affiliation in connection with the promotion of partisan politics, religious matters, or positions on any issues not in conformity with the official position or policies of the Academy … 5) knowingly take any action or make any statements (written or oral) intended to influence the conduct of the Academy in such a way as to confer any financial benefit on any person, corporation, or entity in which the individual has an interest of affiliation.

Source: American Academy of Sanitarians, 2022.

sibility, and 4) respect. Section 5 of the CIEH codes provides examples of the behaviors CIEH expects of its members.

For example, integrity means that an environmental health professional holds the health and the protection of the public as their prime concern. With regard to integrity, the behaviors include: 1) providing prompt, clear, and accurate information; 2) seeking advice from colleagues when unsure how to act in a particular situation; and 3) always placing the interests of the communities served above self-interest, the interest of colleagues, and the interest of any organization. In my personal opinion, I believe these examples of behaviors described by CIEH are entirely consistent with NEHA's expectation that I conduct myself in a professional manner. Furthermore, I believe these examples help to give

life to the CIEH code, which is not present in the NEHA code.

One domain where the CIEH code is particularly useful is the term respect. According to CIEH, respect includes recognizing the dignity of individuals, treating everyone fairly, and cooperating with others. Examples of respectful behaviors include: 1) ensuring an effective procedure exists to raise, investigate, and adjudicate complaints in the workplace; 2) assisting colleagues in complying with requirements for continuing professional development; and 3) recognizing differences among individuals and groups while avoiding stereotyping. I want to focus on this third example of respectful behavior.

In the July/August 2020 issue of the *Journal of Environmental Health*, Brian Collins, past president of NEHA and past chair of AAS, and Wendell Moore, past chair of AAS, described the formation of the AAS Respect, Integrity, Service, and Equality (RISE) Task Force (Collins & Moore, 2020). RISE was envisioned to ask, "Who are we? What do we look like? What do we represent? What are our perceptions and priorities versus our realities?" (Collins & Moore, 2020).

In June 2022, the bylaws of AAS were updated to incorporate the early efforts of RISE. In Table 2, I provide a selection from the updated bylaws. For more information, I encourage you to review the AAS website at www.sanitarians.org.

The prior bylaws of AAS were adopted in 2006 and included a total of 7 pages of text (AAS, 2006b). The updated bylaws of AAS, adopted in 2022, include a total of 15 pages of text (AAS, 2022). Among the changes adopted in 2022, a statement on diversity, equity, and inclusion was added to the bylaws (a similar statement already exists in the AAS constitution). Furthermore, the updated bylaws call for the formation of an ad hoc committee to develop a policy on diversity, equity, and inclusion. In my personal opinion, a major improvement to the bylaws was the inclusion of a code of conduct.

Although the bylaws state that the AAS code of conduct applies to officers and directors, the list of seven behaviors helps to give life to our efforts to promote "the highest levels of ethical conduct among professional sanitarians in every field of environmental health" (AAS, 2006a). For example, as described in Table 2, using an affiliation with

AAS to advance a political or religious cause could seem to fall outside of the requirement in the NEHA code to "conduct myself in a professional manner befitting of my credentialed status."

I interpret the AAS code of conduct to mean that I should strongly consider removing my CEHS credential and my DAAS designation from my signature when authoring a newspaper editorial on a political or religious cause. And I am okay with striking that balance. AAS is not placing a limitation on my choice of free speech, rather the requirements of professional conduct limit me from potentially confusing the public by misrepresenting that AAS has an official position on a religious or political cause.

For environmental health professionals, one area where we need to be especially mindful in our ethical behavior is the polarization often observed in the public around the meaning of human-induced climate change. In my opinion, our ethical approach to this challenge needs to consider four items. First, we need to stick to the best available science while acknowledging the inherent skepticism that is part of any good application of the scientific method. Second, we need to avoid confusing the public by associating our profession with a particular political position or religious view. And third, we need to remember that the ethics of environmental health include caring for human welfare and planetary health from local to global (Oerther, 2022).

Fourth, and perhaps most important in my opinion, environmental health professionals need to help to create inclusive spaces for engagement where diverse views can be shared and true listening can occur. Past injustices have left a legacy of pain and disadvantage among many communities. These communities need to be heard and past injustices need to be addressed in the present so that the public can come together to tackle the shared challenges that face all of humanity. The resources of our shared planet are being stretched and the distribution of those resources among 8 billion humans is an opportunity for environmental health professionals to ensure the health and the protection of the public about whom we care deeply (Oerther et al., 2022). ✻

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References

American Academy of Sanitarians. (2006a). *American Academy of Sanitarians: Constitution.* http://www.sanitarians.org/Resources/Documents/Constitution1.pdf

American Academy of Sanitarians. (2006b). *American Academy of Sanitarians: Bylaws.* http://www.sanitarians.org/Resources/Documents/bylaws1.pdf

American Academy of Sanitarians. (2022). *American Academy of Sanitarians: Bylaws.*

Chartered Institute of Environmental Health. (2022). *Code of ethics for members and fitness to practise rules.* https://www.cieh.org/media/3973/code-of-ethics-for-members-and-ftp.pdf

Collins, B., & Moore, W.A. (2020). RISE to the call: Nondiscrimination, diversity, and inclusion. *Journal of Environmental Health*, *83*(1), 32–33.

National Environmental Health Association. (2022). *Code of ethics for credentialed professionals.* https://www.neha.org/credential-code-of-ethics

Oerther, D.B. (2021). Environmental health professionals: Local interprofessional collaborations require global thinking to meet shared ethical obligations. *Journal of Environmental Health*, *84*(5), 26–28.

Oerther, D.B. (2022). Is it time to decenter humans in our discussion of sustainable development? *Environmental Engineering Science*. Advanced online publication. https://doi.org/10.1089/ees.2022.0239

Oerther, D.B., Gautham, L., & Folbre, N. (2022). Environmental engineering as care for human welfare and planetary health. *Journal of Environmental Engineering*, *148*(6), Article 04022029. https://doi.org/10.1061/(ASCE)EE.1943-7870.0002013

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Using Effective Communication Strategies to Help Teens Manage Stress After Natural Disasters

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Editor's Note: The National Environmental Health Association (NEHA) strives to provide up-to-date and relevant information on environmental health and to build partnerships in the profession. In pursuit of these goals, NEHA features this column on environmental health services from the Centers for Disease Control and Prevention (CDC) in every issue of the *Journal*.

In these columns, authors from CDC's Water, Food, and Environmental Health Services Branch, as well as guest authors, will share tools, resources, and guidance for environmental health practitioners. The conclusions in these columns are those of the author(s) and do not necessarily represent the official position of CDC.

Traci Augustosky leads a team of writer-editors within the National Center for Environmental Health at CDC. Katherine MacKay is a health communication and research manager who leads CommunicateHealth teams in creating inclusive products that educate, inform, and empower various audiences. Sabrina Riera is a health communications specialist and Vivi Siegel is the lead for the emergency communications team within the National Center for Environmental Health at CDC. Kathleen Walker is a senior content strategist with CommunicateHealth who creates plain language health content that educates and inspires behavior change.

Creating Resources to Support Teens After Natural Disasters

According to a 2020 report published by the Society for Research in Child Development, each year more than 175 million children experience natural disasters like floods, severe storms, and earthquakes (Lai & La Greca, 2020). This problem has been compounded by the COVID-19 pandemic (U.S. Government Accountability Office, 2020), which has made it even more difficult for local governments, schools, and families to plan for and recover from emergency situations.

In the months following natural disasters, many teens struggle with stress, depression, and anxiety (National Child Traumatic Stress Network, n.d.). Yet few resources address the emotional challenges that teens can face in the aftermath of a disaster.

To fill this gap, the Centers for Disease Control and Prevention (CDC) National Center for Environmental Health (NCEH) and CommunicateHealth (CH), an independent health communication and research agency, set out to develop materials that

- encourage teens to use healthy strategies to cope after experiencing a natural disaster and

- improve perceptions of social support and solidarity among teens who have experienced natural disasters.

NCEH and CH wanted to create resources that reflect teen experiences with natural disasters and promote healthy coping skills. Using clear writing best practices, we developed materials that resonate with teens, including relatable stories and simple coping strategies to help teens manage stress in the aftermath of a disaster.

Taking a Human-Centered Design Approach

NCEH and CH wanted to create materials that put teens front and center, highlighting real-life stories of teens who have been through natural disasters. To achieve this goal, we applied a human-centered design approach that involved teens throughout the creative process.

Step 1: Conduct Formative Research

We conducted formative research with teens to inform the key messages, creative direction, and format of our materials. We used an interactive research platform called Aha! to gain insight into teen communication preferences and experiences with natural disasters. From our formative research, we learned that teens gravitate to real-life, first-person stories.

Step 2: Interview Teens

We interviewed four teens who had experienced natural disasters (e.g., tornadoes, hur-

ricanes, wildfires) and focused on what they went through in the months immediately following the disaster. Natural disasters often disproportionately affect low-income communities and communities of color (Centers for Disease Control and Prevention, 2022). To ensure that our materials reflected this priority audience, we included Black and Hispanic teens in our interviews. Due to the COVID-19 pandemic, we conducted and recorded all interviews over Zoom.

Step 3: Create Resources
We designed a suite of engaging and innovative products based on our interviews. These resources included vlog-style videos, posters, and social media graphics.

Step 4: Test Resources
We tested our materials with teens and revised them based on participant feedback. We used click testing to get feedback on the materials within a limited budget and to focus on the areas that most resonated with participants or needed improvement.

Creating Resources That Resonate With Teens
From our formative research, we learned that teens gravitate to real-life, first-person stories on peer-to-peer messaging platforms like TikTok and YouTube. We crafted vlog-style videos, posters, and social media that focus on the personal experiences of teens. We developed a look and feel that combines the bright, welcoming look of these popular apps with encouraging and relatable messages.

Following Clear Writing Best Practices
In keeping with the focus on authentic personal stories, our materials showcase quotes from teens who have been through natural disasters. On social media graphics and posters, we added a brief call to action directing viewers to CDC resources. On the posters, we also incorporated a short introduction to set the stage and provide context for the experience of our participants with natural disasters (Figure 1).

In writing the supplemental content, we followed clear writing best practices that included:
- Adopting a casual, empathetic tone.
- Putting the most important information first.

- Incorporating a strong call to action.
- Keeping sentences simple.

With this approach, we kept the focus on the personal stories of teens, making the materials more relatable to our priority audience.

Adapting to the COVID-19 Pandemic
The pandemic presented some additional challenges to the production of these materials. We had already decided to prioritize vlog-style videos when it became clear that we would not be able to film in person due to social distancing guidelines. We quickly pivoted to conducting interviews over Zoom, enabling our teen participants to share their stories from home.

We also needed compelling images of our teen participants to feature on our posters and social media graphics. Zoom screenshots and photos taken at home proved difficult to incorporate into our materials due to image quality. To get professional-quality images that aligned with our look and feel, we set up socially distanced photoshoots for several of our participants. Teen participants and their parents were thrilled with the outcome and the final photos (Figure 2).

As many families and communities confront the effects of climate change and escalating natural disasters, these relatable and empathetic materials will be resources to help teens cope with stress during a difficult time in their lives. ❧

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References
Centers for Disease Control and Prevention. (2022). *Environmental Justice Dashboard.* https://ephtracking.cdc.gov/Applications/ejdashboard/

Lai, B.S., & La Greca, A. (2020). *Understanding the impacts of natural disasters on children* (Child Evidence Brief, no. 8). Society for Research in Child Development. https://www.srcd.org/sites/default/files/resources/FINAL_SRCDCEB-NaturalDisasters_0.pdf

National Child Traumatic Stress Network. (n.d.). *Disasters.* https://www.nctsn.org/what-is-child-trauma/trauma-types/disasters

U.S. Government Accountability Office. (2020, October 14). *Disaster recovery: COVID-19 pandemic intensifies disaster recovery challenges for K-12 schools.* https://www.gao.gov/products/gao-21-62r

Example of a Poster That Features Jaylon's Experience

FIGURE 2

Example of a Social Media Graphic That Features Abby's Experience

Science and Science-Based Tools to Address Persistent Hazardous Exposures to Lead

Andrew M. Geller, PhD

Actions by the U.S. Environmental Protection Agency (U.S. EPA) and other federal agencies have significantly reduced the use of lead in automotive gasoline, paint, lead-soldered food containers, and new water system components over the past 40 years. Through the collective effort of federal agencies in partnership with local, state, and tribal governments, blood lead levels (BLLs) measured in children have fallen steadily from the 1970s to the 2020s (Egan et al., 2021; President's Task Force, 2016). One indicator of the success of lead mitigation efforts is the Centers for Disease Control and Prevention's (CDC) reduction of the blood lead reference value (BLRV) from 5.0 to 3.5 μg/dL in October 2021 (Ruckart et al., 2021). The BLRV is a population-based measurement of the 97.5th percentile of BLLs of U.S. children ages 1–5 years. Reduction in the BLRV reflects the decline in BLLs among the children most exposed to lead in the U.S.

Despite this progress, lead exposure in children remains a significant public health concern. More than one half million children ages 1–5 years in the U.S. have detectable BLLs and an estimated 6–10 million lead service lines still connect homes to public drinking water systems (Cornwell et al., 2016). Racial disparities in childhood BLLs persist, with higher BLLs observed in non-Hispanic Black children as compared to non-Hispanic White children from 1999 to 2016 (Breysse et al., in press).

To address the remaining lead exposure issues in our country, U.S. EPA (2021) developed the draft *Strategy to Reduce Lead Exposures and Disparities in U.S. Communities* to set goals for an all-of-U.S. EPA and whole-of-U.S.-government plan to strengthen public health protections, promote environmental justice, and address legacy lead contamination for communities with the greatest exposures. Key components of this strategy hinge on the use of science-based approaches to identify lead exposure hotspots, determine site-specific cleanup levels, sequester lead in contaminated soil, identify drinking water lead service lines for replacement, optimize corrosion control for pipes and plumbing fixtures, and support the revisiting of lead rules and guidance in dust, soil, water, and air.

Identifying High Lead Exposure Locations

Public health professionals tasked with primary prevention must know where lead exposure problems remain and what the key sources of lead exposure are in those locations to proactively prevent and mitigate lead exposures and track where progress has been made in reducing lead exposure (Figure 1). U.S. EPA recently published methods for identifying lead exposure hotspots at the census tract level for targeting actions (Xue et al., 2022; Figure 1). For locations where there are BLL data, U.S. EPA developed two methods of identifying hotspots: 1) a top 20th percentile method identifying census tracts with the highest prevalence of elevated BLLs and 2) a geospatial cluster analysis method.

U.S. EPA also explored methods for using exposure-related lead indicators for locations lacking statistically robust and representative

Example of Mapping Locations With a High Prevalence of Elevated Blood Lead Levels (EBLLs)
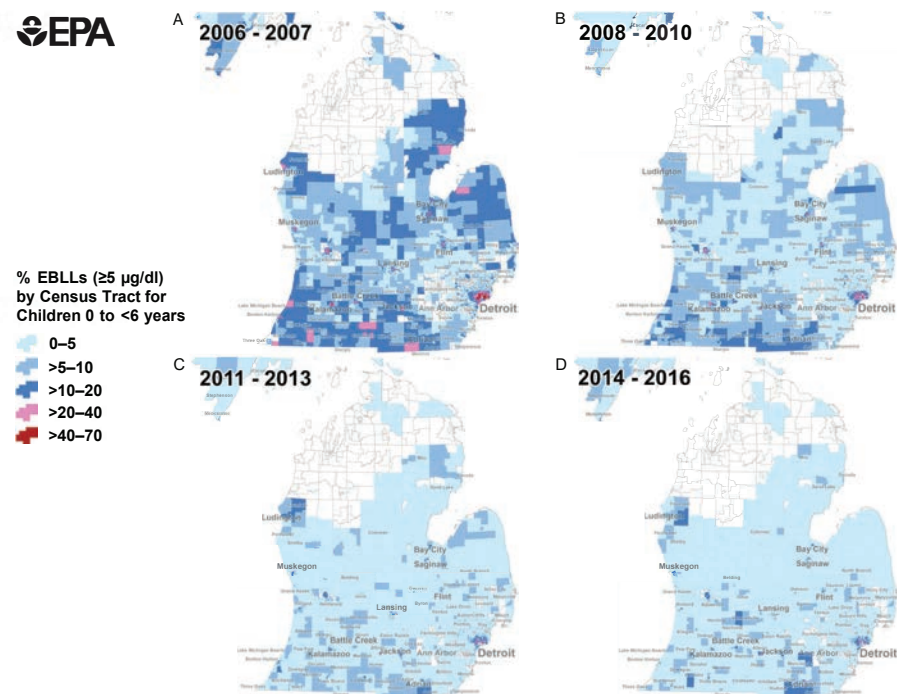
Mapping locations with a high prevalence of EBLLs helps public health practitioners target remediation, outreach, and educational resources and provides a compelling way to visualize success in lead exposure reduction actions. Reproduced with author permission from Xue et al., 2022.

BLL data. These surrogate indicators are largely based on data from the U.S. Census and American Community Survey. For example, U.S. EPA's EJScreen Lead Paint Index (www.epa.gov/ejscreen) and a recent statistical model (Schultz et al., 2017) are based on housing age, race, and income variables. The U.S. Department of Housing and Urban Development's (HUD) Deteriorated Paint Index predicts risk based on pre-1980 homes with large areas of deteriorating paint based on microdata from the American Community Survey and the American Housing Survey (Garrison & Ashley, 2021).

U.S. EPA, HUD, and CDC recently collaborated on a state-of-science summary of publicly available methods, data, and maps for identifying lead hotspots in the U.S. The summary provides descriptions and references for currently available lead indices, BLL data, and environmental data. It also identifies environmental data gaps and data accessibility needs to improve our ability to identify these hotspots (Zartarian et al., in press).

Removing Lead From Drinking Water

The Lead and Copper Rule Revisions (U.S. EPA, 2022a) require water systems to establish service line (i.e., water supply lines to homes and businesses) inventories and proactively replace lead and galvanized service line pipes. U.S. EPA scientists in the Office of Research and Development (ORD) have developed noninvasive methods based on sampling tap water to help speed up identifying these pipes (Hensley et al., 2021; Lytle et al., 2018). In addition, ORD scientists provide technical support to states, consultants, and water system operators to help them reduce the release of lead from pipes and plumbing fixtures. The ORD Small Drinking Water Systems Webinar Series (www.epa.gov/water-research/small-drinking-water-systems-webinar-series) and Annual U.S. EPA Drinking Water Workshops provide state of the art training on lead service line identification, optimizing

corrosion control, and evaluating the efficacy of point-of-use water filters (Doré et al., 2021; Harmon et al., 2022; Liggett et al., 2022; Schock et al., 2021). ORD also recently reviewed field analyzers used for rapidly quantifying lead in drinking water samples and provided recommendations for their use (Doré et al., 2020).

Remediating Lead in Soil

Contaminated soil remains a critical driver of elevated BLLs, especially for young children who are exposed by hand-to-mouth contact and by ingestion of dust and soil (Özkaynak et al., 2022; Zartarian et al., 2017). Remediating soil lead is associated with declines in BLLs in children (Klemick et al., 2020; Mielke et al., 2019; Ye et al., 2022), therefore understanding soil lead levels and various remediation approaches is critical for environmental health practitioners.

ORD has developed rapid and cheap methods to estimate how much lead at a particular site can be absorbed when ingested by people or taken up by plants (Bradham et al., 2016, 2017; Griggs et al., 2021; Misenheimer et al., 2018). The integrated biokinetic exposure and uptake model can be used by environmental professionals to estimate specific site cleanup levels (U.S. EPA, 2022b). ORD has also shown that the addition of soil amendments like phosphate can be used to form long-lasting insoluble mineral complexes that help to sequester the lead in the soil, and that new ways to lock up the lead in soil might help reduce removal cleanup efforts and costs (Bradham et al., 2018; Karna et al., 2020; Sowers et al., 2021).

Moving Onward

In many ways, lead is the opposite of emerging chemical contaminants—it is a well characterized developmental and adult toxicant that affects multiple human organ systems. Lead sources in the environment are also well known; one indicator of this understanding is the myriad laws and rules that regulate lead (President's Task Force, 2016). Yet repeatedly, it is the legacy chemical that draws our attention to public health emergencies in places (e.g., Flint, Michigan; Syracuse, New York; and East Chicago, Indiana) where exposure resulting from lead in drinking water, old housing, and contaminated soil still affects children and their families.

U.S. EPA is currently revisiting six different lead standards or guidance that affect lead levels in dust, soil, water, aviation fuel, and paint. For this multimedia contaminant, however, collaborations are critical to ensuring success. U.S. EPA and its fellow agencies are working to eliminate this preventable environmental health hazards (Breysse et al., 2022). We will continue to provide tools and data so environmental health practitioners at the local level can identify and remediate remaining environmental lead sources in the places where we live, work, learn, and play (Figure 2). ✺

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References

Bradham, K.D., Diamond, G.L., Nelson, C.M., Noerpel, M., Scheckel, K.G., Elek, B., Chaney, R.L., Ma, Q., & Thomas, D.J. (2018). Long-term in situ reduction in soil lead bioavailability measured in a mouse model. *Environmental Science & Technology*, *52*(23), 13908–13913. https://doi.org/10.1021/acs.est.8b04684

Bradham, K.D., Green, W., Hayes, H., Nelson, C., Alava, P., Misenheimer, J., Diamond, G.L., Thayer, W.C., & Thomas, D.J. (2016). Estimating relative bioavailability of soil lead in the mouse. *Journal of Toxicology and Environmental Health, Part A*, *79*(24), 1179–1182. https://doi.org/10.1080/15287394.2016.1221789

Bradham, K.D., Nelson, C.M., Kelly, J., Pomales, A., Scruton, K., Dignam, T., Misenheimer, J.C., Li, K., Obenour, D.R., & Thomas, D.J. (2017). Relationship between total and bioaccessible lead on children's blood lead levels in urban residential Philadelphia soils. *Environmental Science & Technology*, *51*(17), 10005–10011. https://doi.org/10.1021/acs.est.7b02058

Breysse, P.N., Cascio, W.E., Geller, A.M., Choiniere, C.J., & Ammon, M. (in press). Targeting coordinated federal efforts to address persistent hazardous exposures to lead. *American Journal of Public Health*.

Cornwell, D.A., Brown, R.A., & Via, S.H. (2016). National survey of lead service line occurrence. *Journal–American Water Works Association*, *108*(4), E182–E191. https://doi.org/10.5942/jawwa.2016.108.0086

Doré, E., Formal, C., Muhlen, C., Williams, D., Harmon, S., Pham, M., Triantafyllidou, S., & Lytle, D.A. (2021). Effectiveness of point-of-use and pitcher filters at removing lead phosphate nanoparticles from drinking water. *Water Research*, 201, Article 117285. https://doi.org/10.1016/j.watres.2021.117285

Doré, E., Lytle, D.A., Wasserstrom, L., Swertfeger, J., & Triantafyllidou, S. (2020). Field analyzers for lead quantification in drinking water samples. *Critical Reviews in Environmental Science and Technology*, *51*(20), 2357–2388. https://doi.org/10.1080/10643389.2020.1782654

Egan, K.B., Cornwell, C.R., Courtney, J.G., & Ettinger, A.S. (2021). Blood lead levels in U.S. children ages 1–11 years, 1976–2016. *Environmental Health Perspectives*, *129*(3), Article 037003. https://doi.org/10.1289/EHP7932

FIGURE 2

Examples of Where Lead Is Present and Regulated Where We Live, Work, Learn, and Play
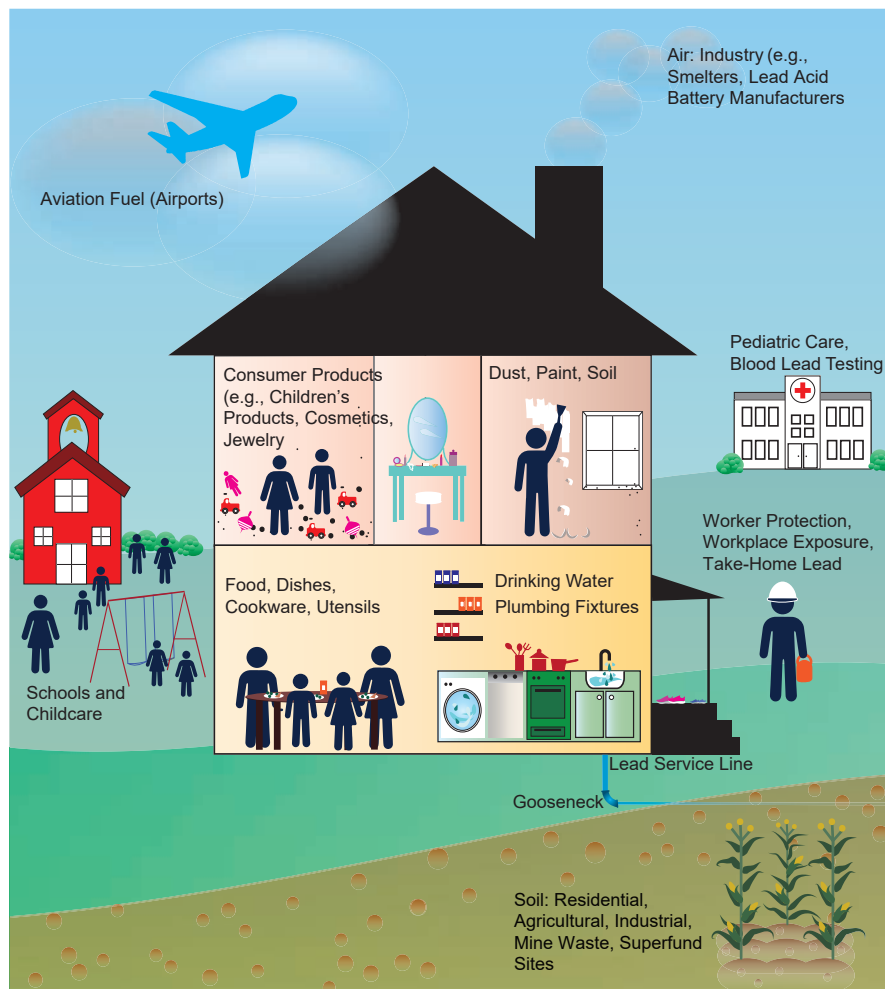
Science from the U.S. Environmental Protection Agency supports further regulation and remediation of lead levels in dust, soil, paint, water, and air. Reducing lead exposure in all these environments requires partnerships among federal, state, tribal, and local governments and community-based organizations.

Garrison, V.E.H., & Ashley, P.J. (2021). Identifying jurisdictions at risk of containing housing units with deteriorated paint: Results and targeting implications for the US Department of Housing and Urban Development. *Journal of Public Health Management & Practice, 27*(6), 546–557. https://doi.org/10.1097/PHH.0000000000001191

Griggs, J.L., Thomas, D.J., Fry, R., & Bradham, K.D. (2021). Improving the predictive value of bioaccessibility assays and their use to provide mechanistic insights into bioavailability for toxic metals/metalloids—A research prospectus. *Journal of Toxicology & Environmental Health, Part B: Critical Reviews, 24*(7), 307–324. https://doi.org/10.1080/10937404.2021.1934764

Harmon, S.M., Tully, J., DeSantis, M.K., Schock, M.R., Triantafyllidou, S., & Lytle, D.A. (2022). A holistic approach to lead pipe scale analysis: Importance, methodology, and limitations. *AWWA Water Science, 4*(2), e1278. https://doi.org/10.1002/aws2.1278

Hensley, K., Bosscher, V., Triantafyllidou, S., & Lytle, D.A. (2021). Lead service line identification: A review of strategies and approaches. *AWWA Water Science, 3*(3), e1226. https://doi.org/10.1002/aws2.1226

Karna, R.R., Noerpel, M.R., Nelson, C., Elek, B., Herbin-Davis, K., Diamond, G., Bradham, K., Thomas, D.J., & Scheckel, K.G. (2020). Bioavailable soil Pb minimized by in situ transformation to plumbojarosite. *Proceedings of the National Academy of Sciences of the United States of America, 118*(3), e2020315117. https://doi.org/10.1073/pnas.2020315117

Klemick, H., Mason, H., & Sullivan, K. (2020). Superfund cleanups and children's lead exposure. *Journal of Environmental Economics and Management, 100*, Article 102289. https://doi.org/10.1016/j.jeem.2019.102289

Liggett, J., Baribeau, H., Deshommes, E., Lytle, D.A., Masters, S.V., Muylwyk, Q., & Triantafyllidou, S. (2022). Service line material identification: Experiences from North American water systems. *Journal–American Water Works Association, 114*(1), 8–19. https://doi.org/10.1002/awwa.1841

Lytle, D.A., Schock, M.R., & Triantafyllidou, S. (2018). Identify lead plumbing sources to protect public health. *Opflow, 44*(3), 16–20. https://doi.org/10.5991/OPF.2018.44.0027

Mielke, H.W., Gonzales, C.R., Powell, E.T., Laidlaw, M.A.S., Berry, K.J., Mielke, P.W., Jr., & Egendorf, S.P. (2019). The concurrent decline of soil lead and children's blood lead in New Orleans. *Proceedings of the National Academy of Sciences of the United States of America, 116*(44), 22058–22064. https://doi.org/10.1073/pnas.1906092116

Misenheimer, J., Nelson, C., Huertas, E., Medina-Vera, M., Prevatte, A., & Bradham, K. (2018). Total and bioaccessible soil arsenic and lead levels and plant uptake in three urban community gardens in Puerto Rico. *Geosciences, 8*(2), 43. https://doi.org/10.3390/geosciences8020043

Özkaynak, H., Glen, G., Cohen, J., Hubbard, H., Thomas, K., Phillips, L., & Tulve, N. (2022). Model based prediction of age-specific soil and dust ingestion rates for children. *Journal of Exposure Science & Environmental Epidemiology, 32*(3), 472–480. https://doi.org/10.1038/s41370-021-00406-5

President's Task Force on Environmental Health Risks and Safety Risks to Children. (2016). *Key federal programs to reduce childhood lead exposures and eliminate associated health impacts*. https://ptfceh.niehs.nih.gov/features/assets/files/key_federal_programs_to_reduce_childhood_lead_exposures_and_eliminate_associated_health_impactspresidents_508.pdf

Ruckart, P.Z., Jones, R.L., Courtney, J.G., LeBlanc, T.T., Jackson, W., Karwowski, M.P., Cheng, P.-Y., Allwood, P., Svendsen, E.R., & Breysse, P.N. (2021). Update of the blood lead reference value—United States, 2021. *Morbidity and Mortality Weekly Report, 70*(43), 1509–1512. https://doi.org/10.15585/mmwr.mm7043a4

Schock, M.R., Lytle, D.A., James, R.R., Lal, V., & Tang, M. (2021). Rapid and simple lead service line detection screening protocol using water sampling. *AWWA Water Science, 3*(5), e1255. https://doi.org/10.1002/aws2.1255

Schultz, B.D., Morara, M., Buxton, B.E., & Weintraub, M. (2017). Predicting blood-lead levels among U.S. children at the census tract level. *Environmental Justice, 10*(5), 129–136. https://doi.org/10.1089/env.2017.0005

Sowers, T.D., Bone, S.E., Noerpel, M.R., Blackmon, M.D., Karna, R.R., Scheckel, K.G., Juhasz, A.L., Diamond, G.L., Thomas, D.J., & Bradham, K.D. (2021). Plumbojarosite

remediation of soil affects lead speciation and elemental interactions in soil and in mice tissues. *Environmental Science & Technology, 55*(23), 15950–15960. https://doi.org/10.1021/acs.est.1c06067

U.S. Environmental Protection Agency. (2021). *Public comment draft: EPA strategy to reduce lead exposures and disparities in U.S. communities*. https://www.epa.gov/system/files/documents/2021-11/updated-public-comment-draft-lead-strategy-11-16-2021.pdf

U.S. Environmental Protection Agency. (2022a). *Revised Lead and Copper Rule*. https://www.epa.gov/ground-water-and-drinking-water/revised-lead-and-copper-rule

U.S. Environmental Protection Agency. (2022b). *Lead at Superfund sites: Software and users' manuals*. https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals

Xue, J., Zartarian, V., Tornero-Velez, R., Stanek, L.W., Poulakos, A., Walts, A., Triantafillou, K., Suero, M., & Grokhowsky, N. (2022). A generalizable evaluated approach, applying advanced geospatial statistical methods, to identify high lead exposure locations at census tract scale: Michigan case study. *Environmental Health Perspectives, 130*(7), Article 077004. https://doi.org/10.1289/EHP9705

Ye, D., Brown, J.S., Umbach, D.M., Adams, J., Thayer, W., Follansbee, M.H., & Kirrane, E.F. (2022). Estimating the effects of soil remediation on children's blood lead near a former lead smelter in Omaha, Nebraska, USA. *Environmental Health Perspectives, 130*(3), Article 037008. https://doi.org/10.1289/EHP8657

Zartarian, V., Poulakos, A., Garrison, V.H., Spalt, N., Tornero-Velez, R., Xue, J., Egan, K., & Courtney, J. (in press). Lead data mapping to prioritize US locations for whole-of-government exposure prevention efforts: State of the science, federal collaborations, and remaining challenges. *American Journal of Public Health*.

Zartarian, V., Xue, J., Tornero-Velez, R., & Brown, J. (2017). Children's lead exposure: A multimedia modeling analysis to guide public health decision-making. *Environmental Health Perspectives, 125*(9), Article 097009. https://doi.org/10.1289/EHP1605

ENVIRONMENTAL HEALTH CALENDAR

UPCOMING NATIONAL ENVIRONMENTAL HEALTH ASSOCIATION (NEHA) CONFERENCE

July 31–August 3, 2023: NEHA 2023 Annual Educational Conference & Exhibition, Hilton New Orleans Riverside, New Orleans, LA, https://www.neha.org/aec

NEHA AFFILIATE AND REGIONAL LISTINGS

California
June 19–22, 2023: 2023 Annual Educational Symposium (AES), hosted by the Superior Chapter of the California Environmental Health Association, Sacramento, CA, https://www.ceha.org

Michigan
March 22–24, 2023: 2023 Annual Education Conference, Michigan Environmental Health Association, Port Huron, MI, https://www.meha.net/AEC

Minnesota
January 12, 2023: MEHA Winter Conference, Minnesota Environmental Health Association (MEHA), Brooklyn Center, MN, https://mehaonline.org

Ohio
April 13–14, 2023: 2023 Annual Educational Conference, Ohio Environmental Health Association, Dublin, OH, http://www.ohioeha.org

Washington
May 8–10, 2023: Annual Educational Conference, Washington State Environmental Health Association, Tacoma, WA, https://www.wseha.org/2023-aec

TOPICAL LISTINGS

Food Safety
2023 Integrated Foodborne Outbreak Response and Management (InFORM) Regional Meetings, hosted by NEHA in partnership with the Centers for Disease Control and Prevention, https://www.neha.org/inform
- January 24–25, 2023: East Regional Meeting, Greenville, SC
- January 31–February 1, 2023: West Regional Meeting, San Diego, CA
- February 14–15, 2023: Central Regional Meeting, St. Louis, MO

Preparedness
February 26–March 4, 2023: Environmental Health Training in Emergency Response (EHTER) Operations, Center for Domestic Preparedness, Federal Emergency Management Agency, Anniston, AL, https://cdp.dhs.gov/training/course/PER-309 ✿

DAVIS CALVIN WAGNER SANITARIAN AWARD
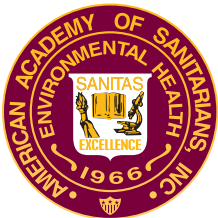
The American Academy of Sanitarians (AAS) announces the annual Davis Calvin Wagner Sanitarian Award. The award will be presented by AAS during the National Environmental Health Association (NEHA) 2023 Annual Educational Conference & Exhibition. The award consists of an individual plaque and a perpetual plaque that is displayed in the NEHA office.

Nominations for this award are open to all AAS diplomates who:

1. Exhibit resourcefulness and dedication in promoting the improvement of the public's health through the application of environmental and public health practices.

2. Demonstrate professionalism, administrative and technical skills, and competence in applying such skills to raise the level of environmental health.

3. Continue to improve through involvement in continuing education type programs to keep abreast of new developments in environmental and public health.

4. Are of such excellence to merit AAS recognition.

NOMINATIONS MUST BE RECEIVED BY APRIL 15, 2023.

Nomination packages should be emailed to Eric Bradley, AAS Executive Secretary/Treasurer, at ericbradley30252@gmail.com. Files should be in Word or PDF format.

For more information about the nomination, eligibility, and evaluation process, as well as previous recipients of the award, please visit www.sanitarians.org/awards.

Resource Corner highlights different resources the National Environmental Health Association (NEHA) has available to meet your education and training needs. These resources provide you with information and knowledge to advance your professional development. Visit the NEHA online Bookstore at www.neha.org/store for additional information about these and many other pertinent resources!

REHS/RS Study Guide (5th Edition)
National Environmental Health Association (2021)

The Registered Environmental Health Specialist/Registered Sanitarian (REHS/RS) credential is the premier credential of the National Environmental Health Association (NEHA). This edition reflects the most recent changes and advancements in environmental health technologies and theories. Incorporating the insights of 29 subject matter experts from across academia, industry, and the regulatory community, paired with references from over 30 scholarly resources, this essential reference is intended to help those seeking to obtain the NEHA REHS/RS credential. Chapte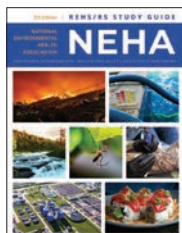rs include general environmental health; statutes and regulations; food protection; potable water; wastewater; solid and hazardous waste; hazardous materials; zoonoses, vectors, pests, and poisonous plants; radiation protection; occupational safety and health; air quality and environmental noise; housing sanitation and safety; institutions and licensed establishments; swimming pools and recreational facilities; and emergency preparedness.

261 pages / Spiral-bound paperback
Member: $169 / Nonmember: $199

NEW! CP-FS Study Guide (4th Edition)
National Environmental Health Association (2022)
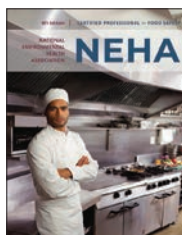
NEHA has released a new edition of the *Certified Professional–Food Safety (CP-FS) Study Guide.* The fourth edition of the study guide has been updated to the current FDA *Food Code* and includes information and requirements from the Food Safety Modernization Act. It was developed by retail professionals to help prepare candidates for the NEHA CP-FS credential exam with in-depth content, an examination blueprint, practice test, and many helpful appendices. The study guide is the go-to resource for students of food safety and food safety professionals in both regulatory agencies and industry. Chapters in the new edition include causes and prevention of foodborne illness, HACCP plans, cleaning and sanitizing, facility and plan review, pest control, inspections, foodborne illness outbreaks, sampling food for laboratory analysis, food defense, responding to food emergencies, and legal aspects of food safety.

358 pages / Spiral-bound paperback
Member: $199 / Nonmember: $229

Handbook of Environmental Health, Volume 1: Biological, Chemical, and Physical Agents of Environmentally Related Disease (4th Edition)
Herman Koren and Michael Bisesi (2003)
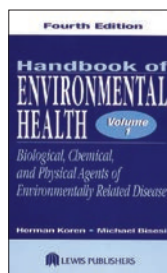
A must for the reference library of anyone in the environmental health profession, this book focuses on factors that are generally associated with the internal environment. It was written by experts in the field and copublished with NEHA. A variety of environmental issues are covered such as food safety, food technology, insect and rodent control, indoor air quality, hospital environment, home environment, injury control, pesticides, industrial hygiene, instrumentation, and much more. Environmental issues, energy, practical microbiology and chemistry, risk assessment, emerging infectious diseases, laws, toxicology, epidemiology, human physiology, and the effects of the environment on humans are also covered. Study reference for the NEHA Registered Environmental Health Specialist/Registered Sanitarian credential exam.

790 pages / Hardback
Member: $215 / Nonmember: $245

Handbook of Environmental Health, Volume 2: Pollutant Interactions With Air, Water, and Soil (4th Edition)
Herman Koren and Michael Bisesi (2003)
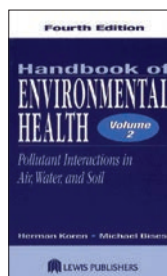
A must for the reference library of anyone in the environmental health profession, this book focuses on factors that are generally associated with the outdoor environment. It was written by experts in the field and copublished with NEHA. A variety of environmental issues are covered such as toxic air pollutants and air quality control; risk assessment; solid and hazardous waste problems and controls; safe drinking water problems and standards; onsite and public sewage problems and control; plumbing hazards; air, water, and solid waste programs; technology transfer; GIS and mapping; bioterrorism and security; disaster emergency health programs; ocean dumping; and much more. Study reference for the NEHA Registered Environmental Health Specialist/Registered Sanitarian credential exam.

876 pages / Hardback
Member: $215 / Nonmember: $245

JEH QUIZ

FEATURED ARTICLE QUIZ #3

Biological Factors That Impact Variability of Lead Absorption and Blood Lead Level Estimation in Children: Implications for Child Blood Lead Level Testing Practices

Available to those with an active National Environmental Health Association (NEHA) membership, the *JEH* Quiz is offered six times per calendar year and is an easily accessible way to earn continuing education (CE) contact hours toward maintaining a NEHA credential. Each quiz is worth 1.0 CE.

Completing quizzes is now based on the honor system and should be self-reported by the credential holder. Quizzes published only during your current credential cycle are eligible for CE credit. Please keep a copy of each completed quiz for your records. CE credit will post to your account within three business days.

Paper or electronic quiz submissions will no longer be collected by NEHA staff.

INSTRUCTIONS TO SELF-REPORT A *JEH* QUIZ FOR CE CREDIT

1. Read the featured article and select the correct answer to each *JEH* Quiz question.
2. Log in to your MyNEHA account at https://neha.users.membersuite.com/home.
3. Click on Credentials located at the top of the page.
4. Select Report CEs from the drop-down menu.
5. Enter the date you finished the quiz in the Date Attended field.
6. Enter 1.0 in the Length of Course in Hours field.
7. In the Description field, enter the activity as "*JEH* Quiz #, Month Year" (e.g., *JEH* Quiz 3, December 2022).
8. Click the Create button.

JEH Quiz #1 Answers
July/August 2022

1. d	4. a	7. c	10. d
2. a	5. c	8. b	11. a
3. d	6. b	9. a	12. b

→ **Quiz effective date: December 1, 2022 | Quiz deadline: March 1, 2023**

1. In most states in the U.S., one or two blood lead level (BLL) tests administered in early childhood are used to rule out lead exposure.
   a. True.
   b. False.

2. Lead exposure occurs via
   a. inhalation.
   b. ingestion.
   c. all of the above.
   d. none of the above.

3. Among children, when exposure is chronic, __ of absorbed lead is taken up by red blood cells.
   a. 69%
   b. 79%
   c. 89%
   d. 99%

4. BLLs reflect circulating lead and, in many cases, exposure occurring in the preceding
   a. 8 to 20 days.
   b. 28 to 40 days.
   c. 48 to 60 days.
   d. none of the above.

5. Approximately __ of inhaled lead is retained in the lungs.
   a. 20–30%
   b. 20–40%
   c. 20–50%
   d. 20–60%

6. The chemical forms of lead that exist in non-nutritive substances—such as in leaded paint chips, paint dust, and in some contaminated soils—are far less bioaccessible than the forms of lead commonly found in foods.
   a. True.
   b. False.

7. Lead absorption in the small intestine occurs primarily in the __ via passive diffusion and active transport.

   a. duodenum
   b. jejunum
   c. ileum
   d. none of the above.

8. Similar to calcium, __ deficiencies in children are associated with higher BLLs.
   a. potassium
   b. zinc
   c. iron
   d. vitamin C

9. Lead elimination occurs primarily via the
   a. kidneys.
   b. liver.
   c. gall bladder.
   d. spleen.

10. Lead stored in fat can be re-released into the bloodstream when fat reserves are mobilized, such as during
    a. fasting.
    b. hunger.
    c. exercise.
    d. all of the above.
    e. none of the above.

11. Approximately __ of the lead that the body absorbs is stored in bone/mineralized tissues.
    a. one quarter
    b. one third
    c. one half
    d. two thirds

12. Ingested lead is influenced by complex interactions of chemical, biological, biophysicochemical, and behavioral factors related to dietary intake, dietary deficiencies, and maturity of the gastrointestinal tract.
    a. True.
    b. False.

SPECIAL **LISTING**

The National Environmental Health Association (NEHA) Board of Directors includes nationally elected officers and regional vice-presidents. Affiliate presidents (or appointed representatives) comprise the Affiliate Presidents Council. Technical advisors, the executive director, and all past presidents of the association are ex-officio council members. This list is current as of press time.

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A Tribute
to *JEH* 2022 Peer Reviewers

We thank and honor the individuals listed below whose contributions as peer reviewers are vital to our effort to advance, educate, and promote the science and profession of environmental health. We sincerely appreciate their hard work, devotion to the environmental health profession, and willingness to share their wealth of knowledge and expertise.

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IN MEMORIAM

The National Environmental Health Association (NEHA) was saddened to learn of the deaths of the following individuals. We extend our sympathies to the families, friends, and colleagues of these individuals. Each had a profound impact on our profession and the people around them. All will be greatly missed.

Ronald Cohen

Ronald "Doc" Cohen passed away in June 2022. He was born in August 1926 in New York City. He was a licensed pharmacist, public health officer, electrician, exterminator, high school teacher, university instructor, veteran of World War II, navy reservist, postal worker, and inventor. He was a fellow of the World Health Organization and the Royal Society for Public Health. He edited such diverse professional and scholarly publications as the *New England Journal of Medicine*, *Journal of Environmental Health*, and *New York State Sanitarian*. He was also the occupational health editor for *JAMA* and was consulted frequently for his expertise in public health. In 1996, Cohen was the recipient of the prestigious Richard J. Sullivan Award that honors a New Jersey resident who "demonstrates exceptional leadership and outstanding accomplishment in safeguarding public health, protecting and enhancing New Jersey's diverse natural resources, and creating vibrant, sustainable communities that provide economic opportunity for all."

Cohen held a doctorate in philosophy from New York University in public health administration, two master's degrees in public health and pharmacy, and a bachelor's degree in pharmacy. He worked in public health departments in New York City, New York; North Bergen County, New Jersey; and the Middlebrook Regional Health Commission in Bound Brook, New Jersey.

Cohen's contributions to public health were numerous. He succeeded in eliminating carbon monoxide poisoning in New York City tenements in the 1950s by inventing an automatic shut-off device for heaters and boilers. He detected and helped address Karposi's sarcoma in the early stages of the AIDS epidemic. He worked tirelessly to reduce cancer incidence in central New Jersey. Cohen also developed computerized environmental hazard response strategies for local public health authorities and determined that the fouling of beaches in New Jersey resulted from medical waste disposal. He testified before Congress on environmental health issues at the invitation of Senator Millicent Fenwick (R-NJ) and also served as part of a World Health Organization asbestos task force in Israel, South Africa, the Soviet Union, and the UK.

According to his family, he was friendly to all and sought to address racism and prejudice throughout his long life. The town of Middlesex, New Jersey, established a "Doc Cohen" day to recognize his many contributions to the community and its people.

Source: Obituary provided by Mark Cohen.

Larry J. Gordon

Larry J. Gordon passed away in April 2022. Gordon, a giant of the environmental health field, was born in Oklahoma and grew up in New Mexico. After graduating high school and attending several semesters of college, he joined the U.S. Navy in 1944. He was stationed at the National Naval Medical Center in Bethesda, Maryland, and worked as a pharmacist assistant. After being honorably discharged from the U.S. Navy, he went to the University of New Mexico and earned bachelor and master degrees in biology and chemistry. In 1950, Gordon saw an advertisement for a "sanitarian" position that required a degree plus a car. He had both and took the job with the county health department in Silver City, New Mexico.

Gordon earned his master of public health from the University of Michigan School of Public Health in 1954. After earning his degree, he went to work for the city of Albuquerque as chief sanitarian and later as director of the Division of Environmental Health. He held this position for several years and was then asked to become director of environmental health for the State Department of Health and Social Services. He held numerous positions within New Mexico, including health commissioner of New Mexico in 1975 and state secretary of Health and Environment in 1987. On June 30, 1988, Gordon retired from public service.

After retirement, Gordon served as a visiting professor of public administration with the University of New Mexico and received an honorary doctorate in 2007 for his long-term commitment and leadership in the area of environmental and public health from the University of New Mexico. He also served as a consultant to the Centers for Disease Control and Prevention and was a frequent guest lecturer.

Gordon engaged in various national professional associations. He felt that knowing about what they were doing and why they were doing it was of immense value to him as he tried to make decisions about environmental health issues. He was one of the 12 founders of the American Academy of Sanitarians and become one of the first diplomates to achieve laureate status that is bestowed for continued outstanding commitment, leadership, and accomplishments in the environmental health profession. He was a member of the American Public Health Association (served as president from 1980–1981), Conference of Governmental Environmental Health Engineers, and NEHA. He was one of the founders of the Council on Education for Public Health and was a longtime member of the National Environmental Health Science and Protection Accreditation Council. He also served as chair of the National Committee on the Future of Environmental Health and was a senior fellow at the University of New Mexico Institute for Public Policy.

Gordon was the recipient of several prestigious public health and environmental health awards. In 1961 he was recipient of the Walter S. Mangold Award, the highest honor given by NEHA.

He was the recipient of the Sedgwick Medal in 1987, the highest award given by the American Public Health Association. He was also awarded the Walter F. Snyder Award in 1978 from NEHA and NSF, the Samuel J. Crumbine Consumer Protection Award, and many other state and national awards.

Gordon was a dedicated public health and environmental health professional who made an incredible impact on the professional. He developed, testified, and gained enactment of numerous state and local environmental health measures. He testified before congressional committees regarding several major environmental health issues, including the Clean Water Act, national energy policy, matters of national health policy, and the creation of the U.S. Environmental Protection Agency. He published over 240 articles in all areas of environmental health, environmental protection, and public health. In 2020, Gordon published his memoir, *Environmental Health and Protection Adventures: A Memoir*, that chronicles his career as a nationally recognized figure in matters of public health and environmental health and protection.

Source: Excerpts from the profile of Larry J. Gordon written by Dr. Herman Koren for the NEHA History Project Task Force and reviewed by Bruce Etchison and Gary Gordon; Larry J. Gordon obituary, *Santa Fe New Mexican*, https://www.legacy.com/us/obituaries/santafenewmexican/name/larry-gordon-obituary?id=34650335

Mila Mangold

Mila Mangold passed away in July 2022 at the age of 114. She held the title of California's oldest person, was the second oldest person in the U.S., and was the seventh oldest person in the world. She was the wife of Walter S. Mangold (1896–1978), who played a key role in the development of the environmental health profession. Walter Mangold dedicated his life to the practice of environmental health in an exemplary manner and was a beacon of excellence and inspiration for environmental health professionals. In 1955, NEHA created the Walter S. Mangold Award, the highest honor that can be bestowed on a member for outstanding contributions to the profession.

Mila Mangold was born in Nebraska on November 14, 1907. She was the second youngest of four siblings in a family whose parents had recently immigrated from Prague. Her family moved to Los Angeles, California, in the 1920s and soon after settled in Berkeley. It was there she met her future husband, Walter Mangold. The two met while she worked as a secretary in a health department. Mila Mangold worked as his secretary for many years until transitioning into a homemaker with the birth of her only child, Donald, in 1945.

Over her 114 years, Mila Mangold lived through two world wars, two pandemics that were over one century apart (the 1918 Spanish flu pandemic and the COVID-19 pandemic), and numerous technological advancements. According to Donald Mangold, the greatest elixir of youth appeared to be her effervescent mind and unyielding sense of curiosity. "She was always inquisitive," Donald Mangold said. "It's a lesson that others can take as they strive to match her impressive longevity."

Source: *The Mercury News*, https://www.mercurynews.com/2022/07/13/she-saw-so-much-californias-oldest-person-longtime-berkeley-resident-dies-at-114/; *Los Angeles Times*, https://www.latimes.com/obituaries/story/2022-07-15/mila-mangold-oldest-person-in-california-dies-at-114.

Brian Nummer

Dr. Brian Nummer passed away in September 2022. He was a highly respected subject matter expert in food microbiology relevant to almost all food commodities, with a focus on retail and food service food safety and small business food safety. His specialties included food microbiology, retail food safety, manufacturing food safety, reduced oxygen packaging at retail, hazard analysis critical control point (HACCP), sanitation, food preservation, and food entrepreneurship. Dr. Nummer was an extension food safety specialist and professor in the Department of Nutrition, Dietetics, and Food Sciences at Utah State University. He received his doctorate of philosophy from Clemson University and worked at the U.S. Environmental Protection Agency, University of Georgia, and Tennessee Tech University, along with the creation of a private food safety consulting business.

Dr. Nummer was active in several organizations including the Conference for Food Protection, International Association for Food Protection, Institute for Food Technologists, Association of Food and Drug Officials, and NEHA. He authored over 100 publications, including peer-reviewed articles, book chapters, abstracts, fact sheets, and newsletter articles. His last article published in the *Journal of Environmental Health* was in the September 2022 issue, "Survival of *Listeria monocytogenes* in Commercially Available Refrigerated Cold-Brewed Coffee."

News of his passing was shared on LinkedIn and as one comment stated, "With the passing of Dr. Brian Nummer, the global food safety community has lost a leader, teacher, mentor, and friend. He made a tremendous impact on so many people and organizations."

Source: The Food Safety Guru, http://food-safety.guru; LinkedIn, https://www.linkedin.com/in/nummer/.

Editor's Note: If you would like to share information about the passing of an environmental health professional to be mentioned in a future In Memoriam, please contact Kristen Ruby-Cisneros at kruby@neha.org. The *Journal* will publish the In Memoriam section twice a year in the June and December issues, or in other issues as determined appropriate.

NEHA **NEWS**

NEHA Advocates for Environmental Health in Washington, DC

The National Environmental Health Association (NEHA) President Dr. D. Gary Brown, Region 7 Vice-President Tim Hatch, and Director of Government Affairs Doug Farquhar visited the U.S. Senate during the NEHA Board of Directors meeting in Washington, DC, on October 13, 2022, to advocate for the environmental health workforce.

Our representatives first met with the office of Senator Mitch McConnell (R-KY), Senate minority leader, to discuss environmental health and the importance of federal support of state and local food safety, vector control, and epidemiology programs, among other environmental health needs. Dr. Brown emphasized that the environmental health workforce relies on federal support from the Food and Drug Administration and the National Center for Environmental Health within the Centers for Disease Control and Prevention (CDC).

Photo 1. *National Environmental Health Association (NEHA) representatives Doug Farquhar (left) and Dr. D. Gary Brown (right) visit the office of Senator Richard Shelby (R-AL). Photo courtesy of NEHA.*

We next met with staff from the office of Senator Richard Shelby (R-AL), vice chair of the Senate Appropriations Committee (Photo 1). Hatch spoke about Alabama's environmental health activities and the value of federal funds to support environmental health. The staff from Shelby's office knew of environmental health, referencing the $5 million in federal support being provided for septic systems in Lowndes County. Hatch also spoke on emergency management and other concerns facing the state. He noted the value of the training provided through the Public Health Infrastructure Act, but added that environmental health is often overlooked. Our representatives also met with office staff of Senator Tommy Tuberville (R-AL; Photo 2).

Photo 2. *National Environmental Health Association (NEHA) Board of Directors representatives Dr. D. Gary Brown (left) and Tim Hatch (right) visit the office of Senator Tommy Tuberville (R-AL). Photo courtesy of NEHA.*

Finally, we were fortunate to hold a meeting in the Senate hallways with Dr. Pat Breysse, director, and Pam Berman, associate director of policy, from the National Center for Environmental Health/Agency for Toxic Substances and Disease Registry within CDC. They were in Washington, DC, to testify before the Senate on climate change.

If you have questions about this visit or would like to support future government affairs activities, please email communications@neha.org.

NEHA Recommends Improvements to Food and Drug Administration Human Foods Program

In October, NEHA provided comment on the operations of the Food and Drug Administration (FDA) Human Foods Program to the Reagan-Udall Foundation as part of their FDA Operational Evaluation. Their evaluation will focus on structure, leadership, authority, resources, and the culture of the human foods program.

NEHA represents more than 6,700 individuals who are responsible for keeping food safe and communities free from foodborne illness daily and for implementing federal food safety regulations and programs. "Environmental health and foodborne illness risk factors are profoundly local. Individual restaurants are the most reported locations of food preparation associated with foodborne illness outbreaks, many in sit-down establishments," said Doug Farquhar, NEHA Government Affairs director. "History has shown that the single most important investment FDA can make is to build the capacity of local environmental health inspectors by supporting systems that provide training, skills, tools, and resources."

Our recommendations included engaging food safety programs at state, tribal, local, and territorial governments; increasing and appropriately funding food safety agencies; educating, credentialing, and training food safety regulators and industry workers; and adoption of the most recent FDA *Food Code*, among other recommendations.

We also commented on the challenges facing food safety programs. This feedback included difficulties created by the legal patchwork of federal, state, tribal, local, and territorial rules and regulations; limited capacity within organizations to track and surveil foodborne illness outbreaks across organizations; limited funding allocated to the Human Foods Program within the FDA budget; and current program oversight within the FDA structure. We expressed support for the Voluntary National Retail Food Regulatory Program Standards to encourage the use of a standardized set of guidelines for food safety, as well as delegation of FDA authority and funding to state, tribal, local, and territorial food safety programs.

You can learn more about the FDA Operational Evaluation being conducted by the Reagan-Udall Foundation at https://reaganudall.org/programs/operational-evaluation-fdas-human-foods-tobacco-programs.

NEHA Staff Profiles

As part of tradition, we features new staff members in the *Journal* around the time of their 1-year anniversary. These profiles give you an opportunity to get to know our staff better and to learn more about the great programs and activities going on in your association. This month we are pleased to introduce you to two NEHA staff member. Contact information for all NEHA staff can be found on pages 54 and 55.

Heather Folker

I am the director of membership services and credentialing at NEHA. My team consists of Eileen Neison, credentialing manager; Bobby Medina, credentialing specialist; and Alfonso Valadez, membership services representative. Outside of membership and credentialing, I also manage our various awards and scholarships, as well as fundraising and affiliate relationship building along with Michéle Samarya-Timm.

I came to NEHA in December 2021 from the Colorado and Denver Bar Associations. At these associations I held the position of communications and membership director. My expertise in the area of membership comes from over 20 years of working in association membership positions. I have also held national officer positions for bar association membership and communications professionals.

After 20 years working with the Colorado and Denver Bar Associations, I am excited about my new career with environmental health. I love meeting new people and understanding their challenges. My hope is to provide NEHA members with the support and resources they need to help them do their jobs successfully. In the next year my goal is the increase membership numbers by 5% and credential holders by 5%. The project I am most excited about right now is the launch of our online community. The platform will provide NEHA members with an inclusive online environment where they can seek advice, exchange information, develop relationships, collaborate, and enjoy camaraderie through an open exchange.

I grew up on a farm in southeast Iowa and moved to Colorado after graduating from the University of Northern Iowa in Cedar Falls. Since moving to Colorado, I have worked as a wrangler, a sales representative, a marketing professional, and my 20-year career at the Colorado and Denver Bar Associations. During my free time I enjoy yoga, hiking, horseback riding, and hanging out with my cool 15-year-old son. Many years ago, I received the title of Miss Buckskin World and Miss Congeniality. I also volunteer as a kitten foster for the Maxfund Animal Adoption Center on a regular basis.

Katherine Sheppard

I joined NEHA in November 2021 and am excited to celebrate my 1-year anniversary as executive assistant to Dr. David Dyjack, NEHA executive director, and Gail Vail, associate executive director. I perform, coordinate, and oversee general administrative duties while providing an extensive level of support. I aid them in making the best use of their time and ensure work is handled efficiently and effectively. I provide the invisible support and anticipate needs while managing the day-to-day workflow and assisting in prioritizing various projects.

I most recently also took on the role as liaison for the NEHA Board of Directors that consists of five national officers and nine regional vice-presidents. I work closely with board members to coordinate activities related to board correspondence, scheduling, expense reports, and meetings throughout the year. I am also responsible for maintaining the board handbook and the NEHA Policy and Procedure Manual and Articles of Incorporation.

Working so closely alongside Dr. Dyjack has been an amazing education into the world of environmental health. Aside from that experience, my position allows me to work with literally everyone within the NEHA organization, as well as so many influential figures throughout the environmental health and public health sectors. I am truly honored to serve in this capacity and look forward to continuing my learning process.

I am proud to have served as a 37F soldier—a psychological operations specialist in the U.S. Army. This training and education taught me how to be strong in the face of uncertainty and the importance of teamwork. I see this teamwork modeled within our organization. I received my bachelor's degree in natural science and mathematics. My coursework included two senior-level environmental science studies that opened my eyes into developing a

NEHA **NEWS**

clear understanding of the fundamentals of global environmental science and the factors required to maintain ecological stability, sustainability, and the preservation of worldwide resources. I have 16 years of assistant experience having supported executives and physicians in corporate, private, and healthcare sectors.

I was born and raised in Michigan, spent many years in California, had a brief stay in Texas, and finally moved to Colorado where I will most likely remain. In my free time I enjoy a variety of physical pursuits to include beach volleyball, mountain biking, road cycling, and rollerblading. My current passions are my BMW Adventure Motorcycle and my Harley Davidson Dyna/Super Glide Motorcycle. I thoroughly enjoy riding them all over the dirt trails and beautiful canyon roads in this beautiful state! ✻

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National Environmental Health Association

Our Endowment Foundation was created to allow us to do more for the environmental health profession than our annual budget might allow. Donations are used for the sole purpose of advancing the profession and its practitioners.

Thank you to our donors!

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Walter S. Mangold Award

Walter S. Mangold dedicated his life to the practice of environmental health in an extraordinary and exemplary way. In doing so, he became a beacon of excellence and inspiration for all environmental health professionals who followed after him.

Do you have a colleague who fits the definition of doing extraordinary environmental health work? Consider taking the time to nominate them for the Walter S. Mangold Award, our most prestigious award.

Nomination Deadline: May 15, 2023

neha.org/mangold-award

neha National Environmental Health Association

extraordinary *adjective*

ex·traor·di·nary | ikˈstrôrd(ə)nˌerē

1. Going beyond what is usual, regular, or customary

2. Exceptional to a marked extent

Walter F. Snyder Award

Honoring a history of advancing environmental health.

Walter F. Snyder was a pioneer in our field and was the cofounder and first executive director of NSF. He embodied outstanding accomplishments, notable contributions, demonstrated capacity, and leadership within environmental health. Do you know someone like that?

Nominate them for the Walter F. Snyder Award for outstanding contributions to the advancement of environmental health. This award is cosponsored by NSF and NEHA.
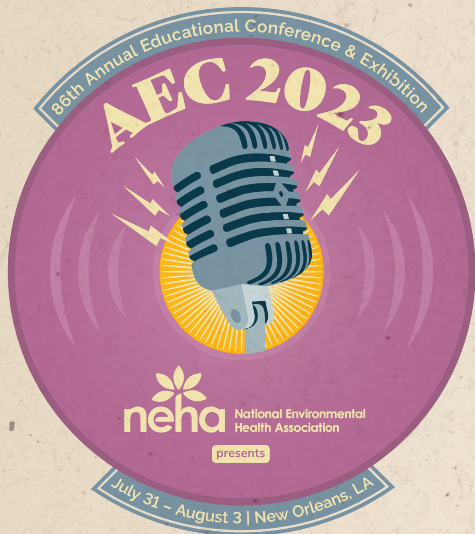
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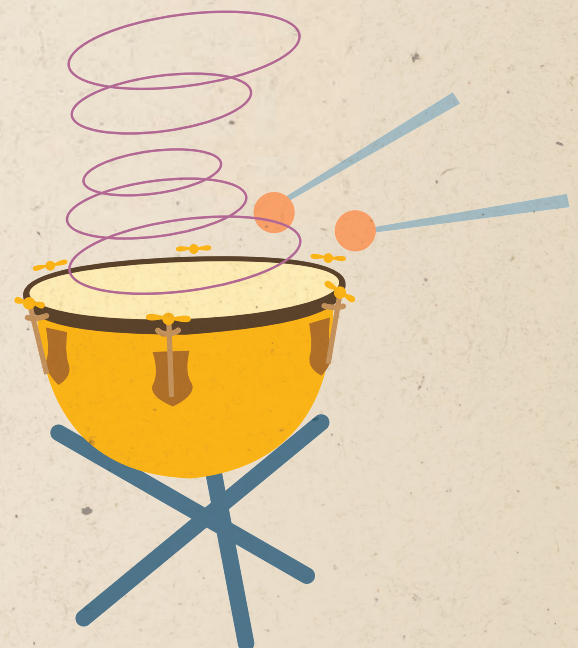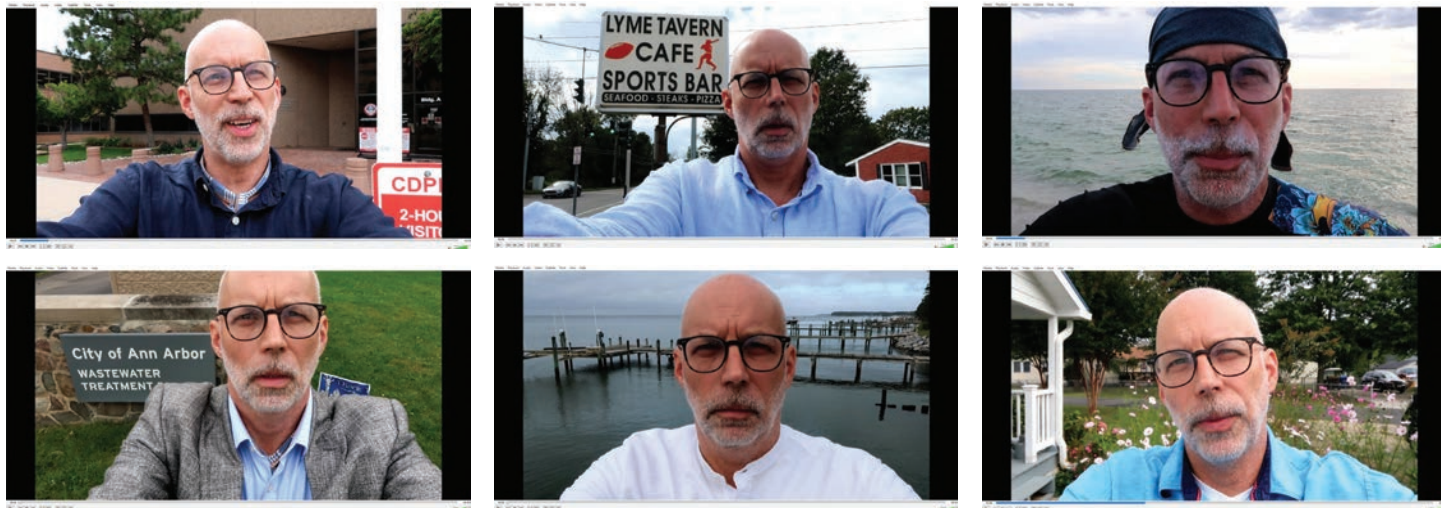
On location with my climate change videos. Images courtesy of David Dyjack.

Each of my attempts at vlogging about climate and health produced hilariously poor videos. I underestimated the skill it takes to act natural and speak extemporaneously while holding a camera and trying to be impressive. Better leave these endeavors to people with talent. Having said that, I was struck by the stories I discovered. I was struck by the implications of climate change at the local level. I was struck by the challenges we face as a society.

I am energized by the notion that it is time for a holistic, integrated approach to climate and health. The breadth and depth of the challenge can seem daunting. I am pleased that the federal government has at last provided leadership in the alternative energy conversation with investments in nonfossil fuel energy sources. But like the profoundly local stories I discovered in my journey across the U.S., there is more to this saga.

Much of the new energy production and storage capacity will require the mining of rare earths and other metals. That means searching out and securing new sources of nickel, cobalt, and lithium. That also means doing business in nefarious places like the Congo, where environmental injustices are abundant. We need to enter this new era with our eyes wide in our zeal to secure clean, renewable energy. I feel the environmental health professional has a unique and valuable perspective on these emerging ethical and technical dilemmas. It is time for us to collaborate with the federal government to develop a partnership for a new generation of environmental health practitioners. A generation with new aptitudes, new skills, and new approaches to the challenges of their generation.

President Thomas Jefferson once quipped, "The care of human life and happiness, and not their destruction, is the first and only object of good government." Well said, President Jefferson, well said. Let us renew our journey with vigor in 2023.

Many blessings for the holiday season. ❧

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Manasota Beach

David Dyjack, DrPH, CIH

A cool, crisp September sunrise enveloped me as I ambled from the hotel lobby into the outdoor seating area, patiently waiting for the van to arrive. I was enroute to the Reno, Nevada, airport as I pondered the quote, "History doesn't repeat itself, but it often rhymes," attributed, perhaps erroneously, to Mark Twain. Places and people I know and love—Puerto Rico, Nova Scotia, the Florida Gulf region, and coastal Georgia—have been hammered by our archnemeses, Hurricanes Fiona and Ian. While I have not visited Alaska, I feel for those affected by Typhoon Merbok, which devastated significant portions of the Bering Sea coast.

Various National Environmental Health Association (NEHA) staff and board members—including myself, Heather Folker, our member services and credentialing director, and Tim Hatch, Region 7 vice-president—have reached out to our colleagues throughout North America as a token of support and reassurance, though in reality there is little we can do to assist. Seems each year it is the same. The names change but the conditions do not, including droughts, fires, and hurricanes. Furthermore, each year is perceptibly more severe than the last.

As the plane departed Reno for Denver, I reminisced about an effort I undertook 1 year ago. NEHA employees Maddie Gustafson and Rosie DeVito requested I record a video on my perceptions of climate change as part of a collaborative effort with ecoAmerica. I proceeded to record several vignettes in various parts of the country: Ann Arbor, Michigan; Lyme, Connecticut; Cobb Island,

Our country's infrastructure was built for a different era and a different climate.

Maryland; Denver, Colorado; and Manasota Beach, Florida. The individual 90-s videos captured how climate change was affecting each locale and the health, safety, and financial security of the local population. The Manasota Beach location is in Sarasota County and was one of those impacted by Hurricane Ian. In that video I describe how the area is affected by red tides, rising sea levels, and the risk of extreme weather events. Prescient.

I also made a roadside visit to Lyme, a quaint town that was a short drive from the location of the 2021 Yankee Conference. Lyme disease in the U.S. historically was limited to New England and a portion of the upper Midwest. The U.S. government is confident the range of the vector, the deer tick, is rapidly expanding because of climate change. There are reports that the tick is migrating northward into Canada at a clip of 46 km per year. The active season for disease transmission could be extended by 1 to 3 weeks per year because of the warming climate.

Ann Arbor, hometown of my alma mater the University of Michigan and our friends at NSF, made for an interesting pit stop. I recorded a video at the sewage treatment plant on the Huron River, where a couple months earlier, a historic amount of rain fell on June 25, 2021. The result was 10 billion gallons of untreated sewage being diverted into surface waters throughout the state. Our country's infrastructure was built for a different era and a different climate.

I planted myself outside the Colorado Department of Public Health and the Environment in Denver for a Rocky Mountain video. Wildfires in the western U.S. have contributed to some of Denver's air pollution woes leading to some of the unhealthiest air in the country and world on some days. Yes, the world—worse than Deli and Beijing. The worst wildfires typically occur in the months of June to September with particulate sources travelling from as far away as Oregon and California.

The first and last stop on my journey was Cobb Island, the place I call home. The 11,600-mi coastline of the Chesapeake Bay makes my home region a natural and cultural treasure. The Bay is also our nation's largest estuary and provides over $100 billion in annual economic value. Sadly, the Chesapeake is uniquely vulnerable to the effects of sea level rise, with the sea level rising at twice the average global rate. People like me, who cherish witnessing the migration of ospreys, bald eagles, geese, purple martins, dolphins, and rockfish, will be displaced as our homes are a mere 3 ft above sea level.

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There is no better time than the holidays to reminisce on the past year. Thank you for coming with us on this journey, and we wish you a wonderful holiday season.

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