

Prepared in cooperation with the City of Chicago, Department of Water Management; City of East Chicago, Utilities Department; Indiana Department of Environmental Management, Drinking Water Branch; National Institutes of Health/National Institute of Environmental Health Sciences (NIH/NIEHS); University of Illinois at Chicago, School of Public Health

Concentrations of Lead and Other Inorganic Constituents in Samples of Raw Intake and Treated Drinking Water From the Municipal Water Filtration Plant and Residential Tapwater in Chicago, Illinois, and East Chicago, Indiana, July–December 2017

Open-File Report 2018–1071

Concentrations of Lead and Other Inorganic Constituents in Samples of Raw Intake and Treated Drinking Water From the Municipal Water Filtration Plant and Residential Tapwater in Chicago, Illinois, and East Chicago, Indiana, July–December 2017

By Kristin M. Romanok, Dana W. Kolpin, Shannon M. Meppelink, Michael J. Focazio, Maria Argos, Mary E. Hollingsworth, R. Blaine McCleskey, Andrea R. Putz, Alan Stark, Christopher P. Weis, Abderrahman Zehraoui, and Paul M. Bradley

Prepared in cooperation with the City of Chicago, Department of Water Management; City of East Chicago, Utilities Department; Indiana Department of Environmental Management, Drinking Water Branch; National Institutes of Health/ National Institute of Environmental Health Sciences (NIH/NIEHS); University of Illinois at Chicago, School of Public Health

Open-File Report 2018–1071

**U.S. Department of the Interior
U.S. Geological Survey**

U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2018

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment—visit <https://www.usgs.gov> or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit <https://store.usgs.gov>.

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this information product, for the most part, is in the public domain, it also may contain copyrighted materials as noted in the text. Permission to reproduce copyrighted items must be secured from the copyright owner.

Suggested citation:

Romanok, K.M., Kolpin, D.W., Meppelink, S.M., Focazio, M.J., Argos, M., Hollingsworth, M.E., McCleskey, R.B., Putz, A.R., Stark, A., Weis, C.P., Zehraoui, A., and Bradley, P.M., 2018, Concentrations of lead and other inorganic constituents in samples of raw intake and treated drinking water from the municipal water filtration plant and residential tapwater in Chicago, Illinois, and East Chicago, Indiana, July–December 2017: U.S. Geological Survey Open-File Report 2018–1071, 10 p., <https://doi.org/10.3133/ofr20181071>.

ISSN 2331-1258 (online)

Contents

Acknowledgments	iv
Abstract	1
Introduction.....	2
Background.....	3
Purpose and Scope	3
Methods.....	3
Sampling Site Selection.....	3
Sampling Methods.....	4
Analytical Methods.....	7
National Water Quality Laboratory	7
Redox Chemistry Laboratory	7
Quality Assurance/Quality Control.....	7
Results	7
Chicago and East Chicago Water Filtration Plant Sampling.....	8
Chicago Area Tapwater Sampling	8
Discussion.....	8
EPA Guidance on Reducing Pb Exposure in Home Drinking Water	9
References Cited.....	9

Figure

1. Diagram showing a typical water distribution system from untreated source water, through water filtration plant to treated residential tap water, with and without point-of-use filtration device

Tables

1. Concentration results of lead analyzed by the U.S. Geological Survey, National Water Quality Laboratory, Denver, Colorado, and Redox Chemistry Laboratory, Boulder, Colorado, for the U.S. Geological Survey Environmental Health Mission Area, Water and Wastewater Infrastructure Project, Tapwater Study, Chicago, Illinois, and East Chicago, Indiana, July–December, 2017
2. Maximum concentrations of trace elements detected in tapwater in the U.S. Geological Survey Environmental Health Mission Area, Water and Wastewater Infrastructure Project, Tapwater Study, Chicago, Illinois, and East Chicago, Indiana, July–December, 2017

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi ²)	2.590	square kilometer (km ²)
Volume		
ounce, fluid (fl. oz)	0.02957	liter (L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8.$$

Data

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius ($\mu\text{S}/\text{cm}$ at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter ($\mu\text{g}/\text{L}$).

Acknowledgments

The authors extend appreciation to Miguel Del Toral, Peggy Donnelly, and Kimberly Harris with the U.S. Environmental Protection Agency, Region 5.

We also acknowledge the assistance of Paul Buszka, David Lampe, and Cheryl Silcox (retired) with the U.S. Geological Survey Ohio-Kentucky-Indiana Water Science Center, and Celeste Journey and Kelly Smalling for providing colleague reviews.

Concentrations of Lead and Other Inorganic Constituents in Samples of Raw Intake and Treated Drinking Water From the Municipal Water Filtration Plant and Residential Tapwater in Chicago, Illinois, and East Chicago, Indiana, July–December 2017

By Kristin M. Romanok,¹ Dana W. Kolpin,¹ Shannon M. Meppelink,¹ Michael J. Focazio,¹ Maria Argos,² Mary E. Hollingsworth,³ R. Blaine McCleskey,¹ Andrea R. Putz,⁴ Alan Stark,⁴ Christopher P. Weis,⁵ Abderrahman Zehraoui,⁶ and Paul M. Bradley¹

Abstract

The U.S. Geological Survey (USGS) Environmental Health Mission Area (EHMA) is providing comprehensive science on sources, movement, and transformation of contaminants and pathogens in watershed and aquifer drinking-water supplies and in built water and wastewater infrastructure (referred to as the USGS Water and Wastewater Infrastructure project) in the Greater Chicago Area and elsewhere in the United States, to fill data gaps identified by stakeholders and collaborators in drinking water and public health. EHMA Water and Wastewater Infrastructure research specifically provides insight into natural factors in the environment as well as those water-infrastructure components and processes (such as source-water corrosivity, treatment, plumbing, and so forth) that might influence human exposure to chemical and microbial contaminants at the residential tap. This infrastructure-exposure research role is fulfilled uniquely by the USGS and not by the U.S. Environmental Protection Agency (EPA), other agencies, or municipalities that focus on regulatory and policy activities and related compliance. The USGS approach to assessing the possible links between human health and chemical contaminant and pathogen exposure in drinking water is conducted in collaboration with public health experts and includes comprehensive characterization of the presence/absence and concentrations of more than 500 organic and 27 inorganic chemical constituents at the point of use (tap).

Laboratory results for lead and other inorganic contaminants in Chicago, Illinois, and East Chicago, Indiana, residential tapwater are being released to ensure the timely release of quality-assured data to participants in the study. Concentrations of lead and other inorganic constituents were assessed in drinking water at the point of use (kitchen tap or filter) in 45 residential locations and in two locations within each of the two Chicago water purification plants and the two East Chicago water filtration plants during July–December 2017. Three methods were used for analyzing lead. The most sensitive method had a reporting limit of 0.020 micrograms per liter ($\mu\text{g/L}$). When using the most sensitive analytical method, lead was detected in 39 of 45 residential tapwater samples, with concentrations ranging from less than 0.020 $\mu\text{g/L}$ to 5.31 $\mu\text{g/L}$ (median of the detected values = 0.481 $\mu\text{g/L}$). Concentrations of lead also were detected in Lake Michigan intake water at all water purification/filtration plant facilities at concentrations ranging from 0.083 to 0.330 $\mu\text{g/L}$, but were not detected above the reporting limit in any samples of treated, pre-distribution drinking water at any of the water purification/filtration plant facilities.

Because the USGS Water and Wastewater Infrastructure project in the Greater Chicago Area is focused on the potential human exposure to a broad suite of organic and inorganic contaminants in drinking water and is not focused specifically on lead, the sampling protocol did not include “first-draw,” stagnant sampling and samples were collected with point-of-use treatment in place, if present. ***Thus, the lead results reported herein are not appropriate for assessment of compliance with the EPA 1991 Lead and Copper Rule.*** Information resources for lead mitigation and water filtration are provided.

¹U.S. Geological Survey.

²University of Illinois.

³Indiana Department of Environmental Management.

⁴Chicago Department of Water Management.

⁵National Institutes of Health/NIEHS.

⁶East Chicago Utilities Department.

Introduction

Population growth, increased urbanization, complex environmental contaminant mixtures, and aging water-supply infrastructure have raised public concerns about the quality and long-term sustainability of drinking water across the United States. For decades, the U.S. Geological Survey (USGS) has assessed the quantity and quality of the Nation's ambient groundwater and surface-water drinking-water supplies (<https://www.usgs.gov/science/mission-areas>). To help address the public's concerns about water quality and to provide regulatory and public health agencies the scientific context for managing human-health risks associated with exposure to contaminants in drinking water, the USGS Environmental Health Mission Area (EHMA, <https://www2.usgs.gov/envirohealth/>) has initiated water and wastewater infrastructure research. The focus of the research is on (1) assessing point-of-use (tapwater) drinking-water exposure pathways for a broad range of potential environmental contaminants and (2) exploring infrastructure-related factors that could alter or transform chemical constituents or microbial communities in drinking water (such as treatment technology, distribution system characteristics, private plumbing technology, distribution system characteristics, private plumbing components, and point-of-use treatment) (fig. 1).

The USGS EHMA is collaborating with the University of Illinois at Chicago (UIC) School of Public Health and the National Institutes of Health/National Institute of Environmental Health Sciences (NIH/NIEHS) to assess the quality and potential human-health concerns of residential tapwater in the Greater Chicago area, including in the city

of East Chicago, Indiana. The USGS EHMA is focusing on developing comprehensive datasets that document the presence and (or) absence and concentrations of more than 500 organic and 27 inorganic chemical constituents as well as conducting analyses to determine the presence of bacterial community composition in tapwater to provide insights into infrastructure-related factors that might influence contaminant exposures at the point of use. These datasets are scoped and collected in collaboration with UIC and NIH/NIEHS to explore associations between contaminant exposures in drinking water and human health. The overall project objective is to characterize the occurrence of a broad range of possible organic and inorganic constituents in tapwater and possible links to human health. Lead (Pb) contamination of tapwater is a concern for residents of Chicago, Illinois, and East Chicago, Indiana, because of the existence of legacy lead service lines in both public and private (curb to tap premise plumbing) segments of the municipal drinking-water distribution systems, the documented occurrence of low orthophosphate levels in the drinking-water system, the documented industrial lead contamination of surface soils and ongoing Superfund assessment and mitigation in East Chicago, and concerns that active remediation of soil contamination may alter the structural integrity and biochemical quality of the drinking-water supply in East Chicago (EPA, 2018d). Thus, the timely release of quality-assured data on concentrations of Pb and other inorganic constituents in tapwater samples collected as part of the EHMA's Water and Wastewater Infrastructure Project's Greater Chicago Area investigation is an important part of the EHMA's Tapwater Exposure Study.

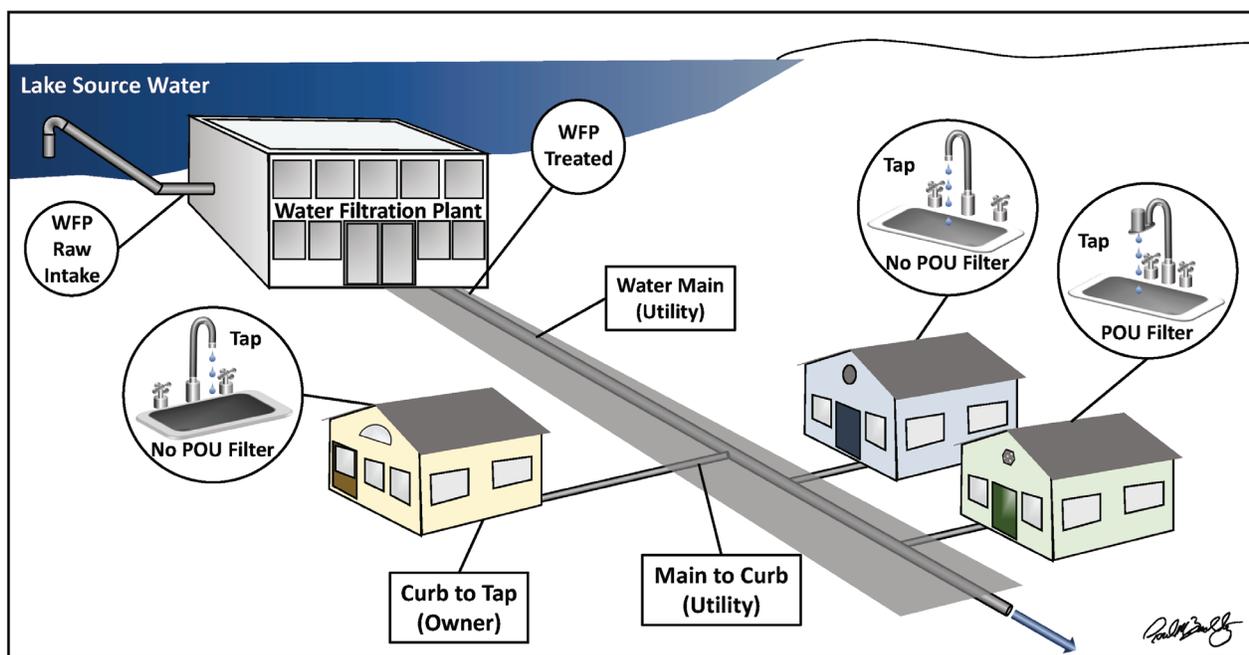


Figure 1. Typical water distribution system from untreated source water, through water filtration plant (WFP) to treated residential tap water, with and without point-of-use (POU) filtration device.

Background

The U.S. Environmental Protection Agency (EPA) has established human-health regulations and guidelines for inorganic drinking-water constituents under the National Primary Drinking Water Regulations (NPDWR) (EPA, 2018c) and the Lead and Copper Rule (LCR) of 1991 (EPA, 2008, 2018a). These standards include Maximum Contaminant Level (MCL), Maximum Contaminant Level Goal (MCLG), and Treatment Technique Action Level (TTAL) concentration standards to limit contaminants in public drinking water. Compliance monitoring in regard to these standards is based on established EPA sample-collection methods (EPA, 2016). In the current report, reference to these standards is for comparison purposes only.

The TTAL for Pb is 15 micrograms per liter ($\mu\text{g/L}$) (additional information available at EPA, 2008, 2018a). Exceedance of the TTAL for samples collected using EPA protocols may require additional tapwater quality monitoring, corrosion control treatment, source water monitoring/treatment, public education, and replacement of lead service lines (EPA, 2008). For example, the City of East Chicago currently (2018) uses orthophosphate at an average concentration of 1.35 milligrams per liter (mg/L) for corrosion inhibition (Indiana General Assembly, 2018) and, under a fund from the Indiana Department of Environmental Management (IDEM), is replacing lead service lines in three Superfund zones to address concerns about Pb in tapwater. The NPDWR MCLG is defined as the level in drinking water below which there is no known or expected risk to health and is a non-enforceable public health goal (EPA, 2018c). The EPA has set the MCLG for Pb at zero (EPA, 2018c), “because lead is a toxic metal that can be harmful to human health even at low exposure levels” (EPA, 2018b).

The LCR is intended to minimize Pb levels in drinking water primarily through corrosion control and monitoring of community-water-system tapwater samples (EPA, 2008, 2018a). The monitoring of Pb contaminants in tapwater under the LCR is focused on the protection of human health, including vulnerable populations (infants, young children, pregnant women), from possible contamination related to Pb-based materials (Pb pipes, Pb solder, and so forth) in the drinking-water distribution system (EPA, 2008, 2017, 2018a, 2018c; Triantafyllidou and Edwards, 2012). Lead contaminants originating from Pb-based plumbing materials can leach into drinking water, leading to increasing dissolved concentrations under static conditions over time (Triantafyllidou and Edwards, 2012). Consequently, the protocol for LCR compliance monitoring is intended to target a presumptive “worst-case” exposure (EPA, 2008, 2016; Triantafyllidou and Edwards, 2012). Guidance for LCR compliance monitoring stipulates collection of “first-draw,” stagnant (minimum of 6 hours since the last draw, typically overnight) samples of cold tapwater from a faucet without point-of-use treatment in homes in the service area that are considered to be at greatest risk of elevated Pb concentrations (EPA, 2016).

In contrast, the USGS EHMA Greater Chicago Area Tapwater Exposure Study is being conducted to assess the potential human exposure to a broad suite of organic and inorganic contaminants in drinking water. This study is not focused specifically on Pb, and the sampling protocol does not include first-draw, stagnant sampling. All samples were collected with faucet screens (aerator screens) and point-of-use treatment equipment left in place. Domestic tapwater sample collections were distributed throughout the day, resulting in a range of pre-sample flushing periods. Information on resident water use prior to the beginning of sampling was not obtained. Trace element samples were the 11th (USGS National Water Quality Laboratory, NWQL) and 12th (Redox Chemistry Laboratory, RCL) containers in the sample collection sequence and were collected approximately 5 minutes after the faucet was turned on. Considering only the water used during the collection process, the USGS protocol involves flushing approximately 12 liters (3 gallons) of water prior to trace element sample collection. *The tapwater Pb results reported herein are not appropriate for assessment of LCR compliance, because the samples were not collected using a first-draw, stagnant sampling protocol and, where present, were collected with the point-of-use treatment in place.*

Purpose and Scope

The purpose of this report is to describe the site selection, sampling protocol, and inorganic chemical analytical methods used for the collection of samples of residential tapwater as well as samples of untreated (raw intake water) and treated (finished water) pre-distribution water from two Chicago water purification plants and two East Chicago water filtration plants during the EHMA’s Water and Wastewater Infrastructure Project’s Greater Chicago Area Tapwater Exposure Study. Samples discussed in this report were collected in Chicago, Illinois, and East Chicago, Indiana, during July–December 2017. This sampling was planned and implemented in cooperation with the UIC School of Public Health, City of Chicago Department of Water Management, City of East Chicago Utilities Department, and other non-governmental organizations. EPA regulations presented in this report are provided for reference only.

Methods

Site selection, sampling protocols, and analytical methods are described in this section.

Sampling Site Selection

Sampling sites were selected on the basis of the availability and permission of Chicago and East Chicago community volunteers. Sites in Chicago were selected to ensure equal number of samples and broad spatial coverage of

4 Lead and Inorganic Constituents in Water From the Filtration Plant and Tapwater in Chicago, Ill., and East Chicago, Ind.

residences within the service areas of the two water filtration plants. Sites in East Chicago were selected to ensure samples were collected from residences within the area of documented soil Pb contamination and to provide broad spatial coverage of the East Chicago study area. One-time site access of approximately 30 minutes was required to complete the sampling of the domestic water supply at a kitchen tap. Samples were collected during July–December 2017 from a total of 45 residences (table 1). All domestic tapwater station names, station numbers, location information, and collection times and dates are anonymized. Latitude and longitude data are generalized and do not indicate exact sampling site location. Additionally, for comparison purposes, water-quality samples were collected from the raw-water intake in Lake Michigan and from post-treatment (pre-distribution) locations two times each at the Chicago (July, November) water purification plant facilities and at the two East Chicago (August, September) water filtration plant facilities in operation at the time of residential sample collection (table 1). A water-parcel-tracking (Lagrangian) sampling approach was not used in this study. In other words, collections were not timed to sample a theoretical parcel of water as it moved from the raw-water intake through the filtration plant water and distribution system to individual residences.

Sampling Methods

Domestic tapwater sampling site visits were distributed throughout the day, as dictated by residents' in-home availability. Detailed protocols, following guidelines established by the USGS (U.S. Geological Survey, variously dated), were provided to USGS personnel who conducted the sampling (Romanok and others, 2018b). An initial set of disposable gloves was donned to lay out a clean polyethylene (chamber bag) workspace on the floor in front of the kitchen sink and to record date and time on pre-labeled sample bottles. Fresh gloves were then donned to fill and cap narrow-neck sample bottles; sample collection began immediately after the faucet was turned on. Samples were collected with the faucet screen (aerator screen) in place. If the tap was equipped with a point-of-use treatment or other filtration device, the

tapwater sample was collected post-treatment/filtration and the treatment device was visually inspected and noted along with the resident's recollection of the device maintenance history (table 1). Approximately 30 containers for each sample were filled with cold tapwater in the same sequence established for previous USGS tapwater studies in order to improve comparison of results. After all samples were collected at a given site, field properties (dissolved oxygen [mg/L], water temperature [degrees Celsius], specific conductance [microsiemens per centimeter at 25 degrees Celsius, $\mu\text{S}/\text{cm}$], and pH [standard units]) were measured in an open chamber with water flowing (Romanok and others, 2018b). Total sample collection time (including measurements of field properties) was approximately 20 minutes. No information was obtained about the composition or materials in residential (curb-to-tap) drinking-water service lines and plumbing.

Two samples were collected in polyethylene containers for trace element analysis (Fishman and Friedman, 1989; Hoffman and others, 1996; Hergenreder, 2011; USEPA, 2014). For the first sample, an acid-rinsed, 250-milliliter (mL), narrow-neck (28-mL) polyethylene bottle was pre-rinsed three times with sample water, and samples were collected as follows. Approximately 20 mL of tapwater was collected, capped, vigorously shaken, and discarded. The bottle was then filled to the shoulder with tapwater, preserved with 2 mL of 7.5 Normality, ultrapure grade, nitric acid (HNO_3), capped, shaken to completely mix, sealed in two self-closing plastic bags, and placed on ice. The trace element samples and other chemical analysis samples for each location were shipped together overnight, on ice, to the USGS Organic Geochemistry Research Laboratory (OGRL) in Lawrence, Kansas. All trace element samples were then aggregated into a single cooler and shipped overnight on ice to the USGS NWQL in Denver, Colorado. The second trace element sample was collected in a 15-mL polyethylene Falcon tube, acidified with 150 microliters of 7.5 Normality, ultrapure grade, nitric acid, similarly bagged, and shipped overnight to the RCL in Boulder, Colo. Because the trace element samples were the 11th and 12th containers in the sample collection sequence, these samples were collected approximately 5 minutes after the faucet was turned on and after approximately 12 liters (3 gallons) of water flow.

Table 1. Concentration results of lead analyzed by the U.S. Geological Survey, National Water Quality Laboratory, Denver, Colorado, and Redox Chemistry Laboratory, Boulder, Colorado, for the U.S. Geological Survey Environmental Health Mission Area, Water and Wastewater Infrastructure Project, Tapwater Study, Chicago, Illinois, and East Chicago, Indiana, July–December, 2017.

[Samples were collected, during five trips, as part of the U.S. Geological Survey Environmental Health Mission Area, Water and Wastewater Infrastructure Project, Tapwater Study, East Chicago, Indiana, July–December 2017. Reporting levels: ICP-MS, 0.020 µg/L; GFAAS, 0.600 µg/L; ICP-OES, 0.008 mg/L. Abbreviations: ICP-MS, inductively coupled plasma-mass spectrometry; ICP-OES, inductively coupled plasma-optical emission spectrometry; GFAAS, graphite furnace atomic absorption spectrometry; mg/L, milligrams per liter; µg/L, micrograms per liter; WFP, water filtration plant; WT, treated water; WS, surface water; NA, not analyzed; <, less than; —, not relevant]

Station number	State	Station name	Medium code	Sampling trip	Lead (µg/L, ICP-MS ¹)	Lead (µg/L, GFAAS ²)	Lead (mg/L, ICP-OES ³)	Point-of-use treatment ²
414500087320009	Illinois	38N-15E-29 001 (raw water)	WS	Trip 1	0.098	NA	NA	—
414500087320010	Illinois	38N-15E-29 002 (pre-distribution water)	WT	Trip 1	<0.020	NA	NA	—
415300087360009	Illinois	39N-14E-10 001 (raw water)	WS	Trip 1	0.083	<0.6	<0.008	—
415300087360010	Illinois	39N-14E-10 002 (pre-distribution water)	WT	Trip 1	<0.020	NA	NA	—
91808900008	Indiana	IN5245012 LAKE EAST CHICAGO WATER WORKS (WFP 1 pre-distribution)	WT	Trip 2	<0.020	<0.600	<0.008	—
413700087270001	Indiana	37N 9W 28 003	WT	Trip 2	2.49	2.61	<0.008	Yes
413700087270002	Indiana	37N 9W 33 004	WT	Trip 2	0.020	<0.600	<0.008	Yes
413700087280001	Indiana	37N 9W 29 002	WT	Trip 2	0.090	<0.600	<0.008	No
413700087280002	Indiana	37N 9W 28 007	WT	Trip 2	1.15	<0.600	<0.008	Yes
413800087260001	Indiana	37N 9W 22 006	WT	Trip 2	1.92	1.16	<0.008	No
413800087260002	Indiana	37N 9W 27 012	WT	Trip 2	0.740	<0.600	<0.008	No
413800087270001	Indiana	37N 9W 21 013	WT	Trip 2	0.280	<0.600	<0.008	No
413800087270002	Indiana	37N 9W 22 005	WT	Trip 2	0.060	<0.600	<0.008	No
413800087280001	Indiana	37N 9W 29 001	WT	Trip 2	0.530	<0.600	<0.008	No
413900087260001	Indiana	IN5245012 LAKE 00087 INTAKE 1 LAKE MICHIGAN (WFP 1 raw water)	WS	Trip 2	0.130	<0.600	<0.008	—
413900087260003	Indiana	IN5245012 LAKE 05021 INTAKE 2 LAKE MICHIGAN (WFP 2 raw water)	WS	Trip 2	0.210	<0.600	<0.008	—
413900087260004	Indiana	37N 9W 22 008 (WFP 2 pre-distribution)	WT	Trip 2	<0.020	<0.600	<0.008	—
91808900008	Indiana	IN5245012 LAKE EAST CHICAGO WATER WORKS (WFP 1 pre-distribution)	WT	Trip 3	<0.020	<0.600	<0.008	—
413900087260001	Indiana	IN5245012 LAKE 00087 INTAKE 1 LAKE MICHIGAN (WFP 1 raw water)	WS	Trip 3	0.250	<0.600	<0.008	—
413900087260003	Indiana	IN5245012 LAKE 05021 INTAKE 2 LAKE MICHIGAN (WFP 2 raw water)	WS	Trip 3	0.330	<0.600	<0.008	—
413900087260004	Indiana	37N 9W 22 008 (WFP 2 pre-distribution)	WT	Trip 3	<0.020	<0.600	<0.008	—
413700087260001	Indiana	37N 9W 27 018	WT	Trip 3	1.12	0.921	<0.008	No
413700087270003	Indiana	37N 9W 33 015	WT	Trip 3	0.480	<0.600	<0.008	Yes
413700087270004	Indiana	37N 9W 27 017	WT	Trip 3	0.020	<0.600	<0.008	Yes
413800087260003	Indiana	37N 9W 22 016	WT	Trip 3	<0.020	<0.600	<0.008	Yes
413800087260004	Indiana	37N 9W 27 019	WT	Trip 3	1.58	1.38	<0.008	No
413800087280002	Indiana	37N 9W 29 014	WT	Trip 3	1.36	1.00	<0.008	No

6 Lead and Inorganic Constituents in Water From the Filtration Plant and Tapwater in Chicago, Ill., and East Chicago, Ind.

Table 1. Concentration results of lead analyzed by the U.S. Geological Survey, National Water Quality Laboratory, Denver, Colorado, and Redox Chemistry Laboratory, Boulder, Colorado, for the U.S. Geological Survey Environmental Health Mission Area, Water and Wastewater Infrastructure Project, Tapwater Study, Chicago, Illinois, and East Chicago, Indiana, July–December, 2017.—Continued

[Samples were collected, during five trips, as part of the U.S. Geological Survey Environmental Health Mission Area, Water and Wastewater Infrastructure Project, Tapwater Study, East Chicago, Indiana, July–December 2017. Reporting levels: ICP-MS, 0.020 µg/L; GFAAS, 0.600 µg/L; ICP-OES, 0.008 mg/L. Abbreviations: ICP-MS, inductively coupled plasma-mass spectrometry; ICP-OES, inductively coupled plasma-optical emission spectrometry; GFAAS, graphite furnace atomic absorption spectrometry; mg/L, milligrams per liter; µg/L, micrograms per liter; WFP, water filtration plant; WT, treated water; WS, surface water; NA, not analyzed; <, less than; —, not relevant]

Station number	State	Station name	Medium code	Sampling trip	Lead (µg/L, ICP-MS ¹)	Lead (µg/L, GFAAS ²)	Lead (mg/L, ICP-OES ³)	Point-of-use treatment ²
414100087320001	Illinois	37N 15E 18 021	WT	Trip 4	0.489	<0.600	<0.008	No
414200087400001	Illinois	37N 14E 7 023	WT	Trip 4	0.03	<0.600	<0.008	Yes
414200087400002	Illinois	37N 14E 7 024	WT	Trip 4	5.31	5.46	<0.008	No
414300087320001	Illinois	37N 15E 6 020	WT	Trip 4	3.74	3.28	<0.008	No
414300087330001	Illinois	37N 15E 7 022	WT	Trip 4	0.404	<0.600	<0.008	No
414500087320010	Illinois	38N-15E-29 002 (pre-distribution water)	WT	Trip 4	<0.020	<0.600	<0.008	—
415300087360009	Illinois	39N-14E-10 001 (raw water)	WS	Trip 4	0.104	0.52	<0.008	—
415300087360010	Illinois	39N-14E-10 002 (pre-distribution water)	WT	Trip 4	<0.020	<0.600	<0.008	—
415400087420001	Illinois	40N 13E 36 028	WT	Trip 4	1.78	1.51	<0.008	No
415400087420002	Illinois	40N 13E 36 029	WT	Trip 4	1.34	1.77	<0.008	No
415500087410001	Illinois	40N 13E 36 026	WT	Trip 4	0.031	<0.600	<0.008	No
415500087410002	Illinois	40N 13E 25 027	WT	Trip 4	1.53	1.30	<0.008	No
415500087420001	Illinois	40N 13E 25 030	WT	Trip 4	0.344	<0.600	<0.008	No
415600087380001	Illinois	40N 14E 28 025	WT	Trip 4	0.133	<0.600	<0.008	No
415700087410001	Illinois	40N 13E 13 033	WT	Trip 4	0.8	0.94	<0.008	No
415700087440001	Illinois	40N 13E 15 031	WT	Trip 4	1.75	1.43	<0.008	No
415800087390001	Illinois	40N 14E 17 034	WT	Trip 4	<0.020	<0.600	<0.008	No
415800087420001	Illinois	40N 13E 11 032	WT	Trip 4	3.43	3.10	<0.008	No
414400087440001	Illinois	38N 13E 34 045	WT	Trip 5	0.481	<0.600	<0.008	No
414600087390001	Illinois	38N 14E 20 044	WT	Trip 5	<0.020	<0.600	<0.008	No
414700087340001	Illinois	38N 14E 12 047	WT	Trip 5	0.4	<0.600	<0.008	No
414700087350001	Illinois	38N 14E 11 048	WT	Trip 5	2.06	1.41	<0.008	No
414700087350002	Illinois	38N 14E 11 049	WT	Trip 5	0.616	<0.600	<0.008	No
414700087350003	Illinois	38N 14E 14 050	WT	Trip 5	0.486	<0.600	<0.008	No
414700087350004	Illinois	38N 14E 12 051	WT	Trip 5	<0.020	<0.600	<0.008	No
414800087350001	Illinois	38N 14E 11 052	WT	Trip 5	0.0200	<0.600	<0.008	No
414800087360001	Illinois	38N 14E 3 043	WT	Trip 5	0.03	<0.600	<0.008	No
414800087360002	Illinois	38N 14E 11 046	WT	Trip 5	1.63	1.00	<0.008	No
414900087360001	Illinois	38N 14E 2 042	WT	Trip 5	0.047	<0.600	<0.008	No
415400087410001	Illinois	39N 13E 01 039	WT	Trip 5	<0.020	<0.600	<0.008	No
415500087460001	Illinois	40N 13E 32 038	WT	Trip 5	3.37	7.60	<0.008	No
415800087390002	Illinois	40N 14E 08 040	WT	Trip 5	<0.020	<0.600	<0.008	No
420000087380001	Illinois	41N 14E 32 041	WT	Trip 5	0.032	<0.600	<0.008	No

¹Fishman and Friedman (1989); Hoffman and others (1996).

²Hergenreder (2011).

³EPA (2014).

Analytical Methods

Samples from 45 residential kitchen taps and the four Chicago and four East Chicago water filtration plant locations (two locations in each of the four facilities) were analyzed at the NWQL and RCL for concentrations of trace elements by using three analytical methods. Results for all trace element analytes, in milligrams per liter and micrograms per liter, are available for download at (Romanok and others, 2018a). Lead concentrations are summarized in table 1.

National Water Quality Laboratory

Whole-water samples were analyzed for 27 trace elements, including Pb, as described in (Fishman and Friedman, 1989; Hoffman and others, 1996). Briefly, samples were digested with hydrochloric acid, heated, and analyzed by inductively coupled plasma-mass spectrometry (ICP-MS) or by atomic absorption (cadmium and calcium) (as described in Fishman and Friedman, 1989; Hoffman and others, 1996). Trace element concentrations, including Pb, are reported in microgram per liter concentrations. The reporting level (RL) type used by the NWQL varies by analyte. The RL type used to report Pb concentrations is DLBLK, meaning the detection level is determined using blank data. A description of how this RL is determined can be found in U.S. Geological Survey (2015). The detection level for Pb, for this analytical method, was 0.020 µg/L.

Redox Chemistry Laboratory

Whole-water samples were analyzed for 32 inorganic constituents and alkalinity at the RCL. Cations and trace elements were analyzed using inductively coupled plasma-optical emissions spectrometry (ICP-OES); anions were analyzed using ion chromatography; and alkalinity was determined using an automated titration, with first derivative

near pH 4.5 (Pfaff, 1993; EPA, 2014). Trace element cations (including Pb) and anions are reported in milligrams per liter, and alkalinity is reported in milligrams per liter of bicarbonate. Concentrations of lead were also analyzed by graphite-furnace, atomic-absorption spectrometry (GFAAS), and results are reported in micrograms per liter. The method detection limit (MDL) (Childress and others, 1999; EPA, 2005) for Pb by GFAAS was 0.600 µg/L. The MDL for Pb, using the ICP-OES method, was 0.008 mg/L.

Quality Assurance/Quality Control

Field blanks were collected as part of the quality assurance/quality control (QAQC) protocols at three sites (station numbers: 414500087320010, 91808900008, 413900087260001) and analyzed at the NWQL and RCL to determine if any contamination bias was introduced during sampling. Field blank samples analyzed at the NWQL had detections for two trace elements, copper (0.400 µg/L) and silver (0.200 µg/L) (Romanok and others, 2018a). Reporting limits for copper and silver are 0.200 and 0.030 µg/L, respectively. Additionally, field blanks analyzed at RCL had detections for alkalinity (6.0 mg/L, as bicarbonate) and calcium (0.013 and 0.021 mg/L) (Romanok and others, 2018a). Method detection limits for alkalinity and calcium are 2.00 mg/L, as bicarbonate, and 0.006 mg/L, respectively. Lead was not detected in any field blank, using any method.

Results

Lead concentration results are summarized in table 1. Concentration data for all analyzed trace elements and alkalinity are provided in Romanok and others (2018a). Inorganic constituents regulated under the NPDWR or LCR are summarized in table 2. Respective standards are listed for reference only.

8 Lead and Inorganic Constituents in Water From the Filtration Plant and Tapwater in Chicago, Ill., and East Chicago, Ind.

Table 2. Maximum concentrations of trace elements detected in tapwater for the U.S. Geological Survey Environmental Health Mission Area, Water and Wastewater Infrastructure Project, Tapwater Study, Chicago, Illinois, and East Chicago, Indiana, July–December, 2017.

[U.S. Environmental Protection Agency (EPA) standards and public health goals are listed for reference only. Abbreviations: MCL, EPA Maximum Contaminant Level; TTAL, EPA Treatment Technique Action Level; —, not analyzed; mg/L, milligrams per liter; RLC, Redox Chemistry Laboratory; NWQL, National Water Quality Laboratory; <, less than]

Trace element	MCL ¹ (mg/L)	Public health goal ¹ (mg/L)	Maximum value, RCL (mg/L)	Maximum value, NWQL ² (mg/L)
Antimony	0.006	0.006	<0.030	0.00019
Arsenic	0.010	zero	< 0.040	0.001
Barium	2.00	2.00	0.108	0.022
Beryllium	0.004	0.004	<0.0005	0.00004
Cadmium	0.005	0.005	<0.003	0.00009
Chromium	0.100 (total)	0.100	0.002	0.0007
Copper	1.30 TTAL	1.30	0.019	0.036
Fluoride	4.00	4.00	0.723	—
Lead	0.015 TTAL	zero	0.008 ³ / $<0.008^4$	0.005
Selenium	0.050	0.050	<0.040	0.0003
Thallium	0.002	0.0005	—	0.00002
Uranium	0.030	zero	<0.010	0.0004

¹EPA (2009).

²Fishman and Friedman (1989); Hoffman and others (1996).

³Hergenreder (2011).

⁴EPA (2014).

Chicago and East Chicago Water Filtration Plant Sampling

Four water purification/filtration plant facilities (two in Chicago; two in East Chicago) supplied drinking water to residences included in 2017 Chicago Area Tapwater Exposure Study. Samples of raw water from Lake Michigan (7 total samples) and treated, pre-distribution drinking water (8 total samples) were collected at all four facilities during the residential tapwater sampling period. Lead, which has an RL of 0.020 $\mu\text{g/L}$, was detected only in raw-water intake samples (at all four facilities, in all collected samples) and only by using the most sensitive NWQL method (ICP-MS) (Fishman and Friedman, 1989; Hoffman and others, 1996) (table 1). Lake Michigan raw-water intake Pb concentrations ranged from 0.083 to 0.330 $\mu\text{g/L}$, with a median of 0.130 $\mu\text{g/L}$ (table 1). Lead was not detected in any samples of treated, pre-distribution drinking water at either facility. No other inorganic constituents were detected in raw intake water or in treated, pre-distribution drinking water in excess of the respective EPA MCLG (public health goal) (table 2).

Chicago Area Tapwater Sampling

Lead was detected at or above the RL (0.020 $\mu\text{g/L}$) in 39 (87 percent) of the 45 residential tapwater samples collected for this study (table 1). Lead concentrations in tapwater ranged from below the reporting limit to 5.31 $\mu\text{g/L}$, with a median of 0.481 $\mu\text{g/L}$. The MCLG for Pb is zero, and 39 of 45 tapwater samples had detectable Pb concentrations when using the most sensitive method of analysis. No other inorganic constituents were detected in tapwater in excess of the corresponding EPA MCLG (public health goal) (table 2).

Discussion

The steps suggested by the EPA (2018a) to reduce Pb exposure in home drinking water include installation and proper maintenance of a point-of-use (at the tap) water filter that is certified to remove Pb. Six of the 15 East Chicago homes and one of the 30 Chicago homes sampled for this study had point-of-use (at the tap) water filters installed at

the time of sampling, and some of the lowest tapwater Pb concentrations in the study were observed in four of these locations. The fifth highest concentration of Pb detected in the study (2.49 µg/L) corresponded to an unmaintained point-of-use filter unit.

The results of sampling reported for Pb and inorganic constituents in Chicago Area tapwater are only a subset of a broad suite of chemical constituents and microbial communities being assessed by the USGS as part of ongoing studies of tapwater in the Greater Chicago Area and elsewhere in the United States. The completed sample collections and datasets are intended to provide insight into those water infrastructure components and processes (such as source-water corrosivity, treatment, plumbing, and so forth) that might influence human exposure to chemical and microbial contaminants at the residential tap. Conducted in collaboration with colleagues and stakeholders from academia, public health agencies, and water utilities, this work can contribute to the foundational understanding of potential associations between human-health effects and drinking-water exposures at the tap.

EPA Guidance on Reducing Pb Exposure in Home Drinking Water

The EPA lists five approaches to reduce exposure to Pb in home drinking water (EPA, 2018a).

- “Use only cold water for drinking, cooking and making baby formula. Boiling water does not remove lead from water.
- Regularly clean your faucet’s screen (also known as an aerator).
- Consider using a water filter certified to remove lead and know when it’s time to replace the filter.
- Before drinking, flush your pipes by running your tap, taking a shower, doing laundry or a load of dishes.
- Contact your water system to learn more about sources of lead and removing lead service lines.”

References Cited

- Childress, C.J.O., Foreman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 99–193, 19 p.
- Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.
- Hergenreder, R.L., 2011, Trace metals in waters by GFAAS, in accordance with U.S. EPA and Health Canada requirements: Waltham, Mass., PerkinElmer, Inc., 5 p.
- Hoffman, G.L., Fishman, M.J., and Garbarino, J.R., 1996, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory; in-bottle acid digestion of whole-water samples: U.S. Geological Survey Open-File Report 96–225, 28 p.
- Indiana General Assembly, 2018, Title 327. Water Pollution Control Division; Article 8. Public Water Supply; Rule 1. Public Water Supply Direct Additive and Indirect Additive Standards, Indiana Administrative Code 327–IAC–8: Indiana General Assembly website, accessed March 4, 2018, at <http://www.in.gov/legislative/iac/>.
- Pfaff, J.D., 1993, Method 300.0, Determination of inorganic anions by ion chromatography, Revision 2.1: U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, 30 p.
- Romanok, K.M., Bradley, P.M., McCleskey, R.B., Meppelink, S.M., Argos, M., and Kolpin, D.W., 2018a, Occurrence and concentrations of trace elements in discrete tapwater samples collected in Chicago, Illinois, and East Chicago, Indiana, 2017: U.S. Geological Survey data release, <https://doi.org/10.5066/F70R9NN0>.
- Romanok, K.M., Kolpin, D.W., Meppelink, S.M., Argos, M., Brown, J.B., DeVito, M.J., Dietze, J.E., Givens, C.E., Gray, J.L., Higgins, C.P., Hladik, M.L., Iwanowicz, L.R., Loftin, K.A., McCleskey, R.B., McDonough, C.A., Meyer, M.T., Strynar, M.J., Weis, C.P., Wilson, V.S., and Bradley, P.M., 2018b, Methods used for the collection and analyses of chemical and biological data for the Tapwater Exposure Study, United States, 2016–17: U.S. Geological Survey Open-File Report 2018–1098, 81 p., accessed November 1, 2018, at <https://doi.org/10.3133/ofr20181098>.
- Triantafyllidou, S., and Edwards, M., 2012, Lead (Pb) in tap water and in blood—Implications for lead exposure in the United States: Critical Reviews in Environmental Science and Technology, v. 42, no. 13, p. 1297–1352, accessed March 4, 2018, at <https://doi.org/10.1080/10643389.2011.556556>.
- U.S. Environmental Protection Agency [EPA], 2008, Lead and Copper Rule—A quick reference guide: EPA 816–F–08–018, accessed March 4, 2018, at <https://nepis.epa.gov/Exec/ZyPDF.cgi?Dockey=60001N8P.txt>.

10 Lead and Inorganic Constituents in Water From the Filtration Plant and Tapwater in Chicago, Ill., and East Chicago, Ind.

- U.S. Environmental Protection Agency [EPA], 2011, Guidelines establishing test procedures for the analysis of pollutants: Code of Federal Regulations, Title 40, chap. 1, app. B to part 136—Definition and procedure for the determination of the method detection limit—Revision 1.11, p. 343–346, accessed March 4, 2018, at <https://www.gpo.gov/fdsys/search/pagedetails.action?collectionCode=CFR&browsePath=Title+40%2FChapter+I%2FSubchapter+D%2FPart+136%2FAppendix+B+to+Part+136&granuleId=CFR-2011-title40-vol23-part136-appB&packageId=CFR-2011-title40-vol23&collapse=true&fromBrowse=true>.
- U.S. Environmental Protection Agency [EPA], 2014, Inductively coupled plasma-optical emission spectrometry, Method 6010D: EPA SW-846 Update V, Revision 4, 35 p., accessed November 2, 2017, at <https://www.epa.gov/sites/production/files/2015-12/documents/6010d.pdf>.
- U.S. Environmental Protection Agency [EPA], 2016, Quick guide to drinking water sample collection, 2d ed.: U.S. Environmental Protection, accessed February 26, 2018, at https://www.epa.gov/sites/production/files/2015-11/documents/drinking_water_sample_collection.pdf.
- U.S. Environmental Protection Agency [EPA], 2017, Water quality standards: U.S. Code of Federal Regulations, title 40, part 131, accessed March 4, 2018, at <https://www.ecfr.gov/cgi-bin/text-idx?SID=454a7b51118b27f20cef29ff071c1440&node=40:22.0.1.1.18&rgn=div5>.
- U.S. Environmental Protection Agency [EPA], 2018a, USEPA Drinking Water Requirements for States and Public Water Systems: Lead and Copper Rule website, accessed January 24, 2018, at <https://www.epa.gov/dwreginfo/lead-and-copper-rule#additional-resources>.
- U.S. Environmental Protection Agency [EPA], 2018b, Ground Water and Drinking Water: Basic Information about Lead in Drinking Water: U.S. Environmental Protection Agency website, accessed January 24, 2018, at <https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water#reducehome>.
- U.S. Environmental Protection Agency [EPA], 2018c, National Primary Drinking Water Regulations: U.S. Environmental Protection Agency website, accessed January 11, 2018, at <https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations>.
- U.S. Environmental Protection Agency [EPA], 2018d, USS lead drinking water pilot study: U.S. Environmental Protection Agency website, accessed February 24, 2018, at <https://www.epa.gov/uss-lead-superfund-site/uss-lead-drinking-water-pilot-study-data>.
- U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1–A9, accessed March 4, 2108, at <https://pubs.water.usgs.gov/twri9A>.
- U.S. Geological Survey, 2015, Changes to National Water Quality Laboratory (NWQL) procedures used to establish and verify laboratory detection and reporting limits: U.S. Geological Survey National Water Quality Laboratory Technical Memorandum 15.02, accessed January 25, 2018, at https://nwql.usgs.gov/Public/tech_memos/nwql.2015-02.pdf.

