Title: Improving drinking water consumer confidence reports: Applying user-centered design

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Abstract

The US Environmental Protection Agency is revising its policy on drinking water quality reports for consumers. These reports are intended to enhance the public's "right to know" and to spur action to protect and promote safe water. However, these reports are known to be highly technical and difficult to access compromising their communication value. This study engaged a focus group to gather evidence on how these reports can be improved. We applied user-centered design principles to understand public drinking water consumer information needs and preferences and to develop new communication tools and methods. Through a set of in-depth interviews, we learned that most participants were unaware of the report until introduced to it during the study. The focus group participants voiced preferences for: better ways to convey technical information; more health information; a clearer understanding of costs and billing; and neighborhood or household level water quality information. Following the interviews, we convened two rounds of small group meetings to create new report designs and to review and refine the designs. The focus group developed a one-page summary statement, water contaminant trend charts, an interactive map, and other recommendations on ways to improve dissemination of the report. The project results, focus group recommendations and designs were submitted to the US Environmental Protection Agency for consideration as the policy for these reports is finalized. We believe these findings provide valuable insights into water quality communication challenges that are widely applicable and will be informative for water utilities as they prepare future reports.

Introduction

Racial, ethnic, and income-based inequities in drinking water quality are pervasive in many US cities. (1, 2) Disparities in rates of drinking water violations have been observed in non-white and low-income communities, suggesting the potential for differential exposure and health risk (3). Public knowledge of unsafe drinking water conditions can have a dramatic effect in generating the political will to protect water supplies and public health. For example, a key element of the Flint, Michigan lead contamination event, and the national attention that accompanied it, was an awareness among its drinking water consumers of the contamination. Authorities failed to fully investigate the health issues and citizens took matters into their own hands, exposing the crisis. (4) This public knowledge and pressure ultimately forced regulatory intervention to address the problem. Unfortunately for many low-income communities of color, information about drinking water violations can be elusive.

The 1996 amendments to the Safe Drinking Water Act were designed to provide hundreds of millions of American public water users with information about their drinking water. The amendments required water utilities to issue annual "consumer confidence" reports (CCRs) to their customers; the final legislation regulating CCRs christened them the "centerpiece of public right-to-know" under the Safe Drinking Water Act. (5) While the intent of these reports was to bolster consumer awareness of potential issues related to their water quality, research on CCRs as communication tools has shown that they are unclear about water quality safety and overly complex as defined by the CDC's Clear Communication Index (6, 7) In 2018, an additional amendment to the Safe Drinking Water Act required EPA to improve the "readability, clarity, and understandability of the information presented in consumer confidence reports" by October 2020. (8) When EPA failed to act, the National Resources Defense Council (NRDC) filed a lawsuit to force the EPA to revise the CCR regulations. (9) This successful suit resulted in a consent decree; the proposed rule revisions were released for comment in April 2023, with

a final rule expected in 2024.(10) This work was developed to provide input to EPA's revisions emphasizing consumer needs and preferences to create new approaches to consumer confidence reports. The study aims to improve the communication potential of CCRs to enhance community awareness and empower consumers to reduce the harmful impacts of drinking water contaminants.

Given the limitations of the current CCR approach, this study explored how consumer needs and preferences could be harnessed to shape new ideas for drinking water quality reporting. Baltimore and other cities have experienced drinking water quality challenges over many years. (4, 11) We focused this work on public drinking water users in Baltimore with the following objectives:

1) Describe public drinking water consumer information needs and preferences; and
2) Propose new visual and other communication tools and methods responsive to those needs and preferences to improve CCRs.

Methods

Overview

The study was funded by the Bloomberg American Health Initiative as a one-year pilot project beginning in July 2021. This study was conducted during the emergency phase of the COVID-19 pandemic and all interactions were virtual necessitating an oral consent process. The study protocol was reviewed and approved by the Johns Hopkins Bloomberg School of Public Health IRB in September 2021 (#17052). This qualitative study applied user-centered design principles by engaging public water supply users in design thinking about the Baltimore CCR. (12) Participant interactions in the form of interviews and small group meetings each lasting about 1 hour were conducted over Zoom from December 2021 to June 2022. Participants were paid twenty-five dollars for each interaction.

Participant recruitment

Participants were recruited through outreach to community groups affiliated with SOURCE, a community engagement and service-learning center at the Bloomberg School of Public Health. Through SOURCE, the principal investigator was connected to leaders of several community groups with environmental health interests. Those leaders then suggested potential study participants. A recruitment email was sent to potential participants. People responding to the recruitment email were screened to ensure eligibility (Baltimore City residents over 18 years of age). This process began on December 13, 2021 and continued until ten participants were enrolled (end date March 11, 2022).

User-centered design process

User- or human-centered design is an iterative process starting with the people you are designing for and ending with new solutions tailor-made to suit their needs. (12) User-centered design is used to design interventions that better serve the community. This approach has yielded much success in areas as diverse as emergency department clinician systems and community smoking cessation counseling. (13, 14) The study protocol adapted the process defined and applied by colleagues at the Maryland Institute College of Art's (MICA) Center for Social Design. (15, 16) This design process allowed public water supply users in Baltimore City to create new ways to convey water quality information. The adapted process was carried out through three sequential interactions including in-depth individual interviews and two sets of small group meetings, as described below.

In-depth interviews

The first interaction was an individual interview with each participant to review the Baltimore CCR and gather first impressions. The oral consent process was completed at the beginning of the interview and documented in a secure electronic file by the Principal Investigator. The interview had three

components: questions about the participant's awareness and previous use of the CCR; a general evaluation of the report's contents and selection of important report elements; and participant's preferences for report delivery. The interview discussion guide is shown in S1 Appendix. At the end of all 10 interviews, a summary of the interview findings was prepared. (Data from the interviews is provided in S2 Interview Data.)

Small group meetings to identify and prototype CCR solutions

The second participant interaction was a set of small group meetings with multiple participants together to develop new design ideas for CCRs. Three small group meetings were scheduled based on participant availability. At each meeting, the interview results were reviewed, and discussion centered on identifying new visual ways to present information for the important report elements participants identified in the interviews (see S1 Appendix, Interaction 2). The meeting discussions generated visual design ideas and other recommendations. After these meetings, the study team reviewed the visual design ideas and selected several to prototype based on level of interest among participants as well as the time constraints of the study funding. All recommendations were included in the final technical report (S3 Project Report). Following the first set of group meetings, the study team developed prototype designs.

For the third participant interaction, another set of small group meetings was organized to review and refine the prototype designs. Two small group meetings were scheduled based on participant availability. At each meeting, the prototype designs were reviewed and participant input on edits and revisions to the prototypes was gathered (see S1 Appendix, Interaction 3). One participant could not attend either meeting and provided written input. Participant comments were used to refine and revise the prototypes for inclusion in the final technical report (S3 Project Report).

Results

In-depth interviews

Most (8 of 10) of participants were not aware of the CCR until they were introduced to the Baltimore City CCR during the study. They also reported that they found the Baltimore CCR to be technical and difficult to read, seemingly written for scientists instead of water consumers. Quotes from two participants illustrate these points (interview quotes lightly edited for clarity):

> *‘‘… there's a lot of background information but also a lot of technical information which I guess was kind of explained by the background but was a little bit hard to figure out.”*
>
> *“… the scientists, you know, the people who went to school for chemistry maybe they all know. It is not easy for a person like me to understand.”*

On the other hand, 6 of 10 participants thought the Baltimore CCR covered most of what they wanted to know. Participants were very interested in the health information, as expressed below:

> *“…[I’m] concerned that this contaminated water can affect people with compromised immune systems, which is very important… the facts about the health concerns [are] really crucial to everybody”*
>
> *“Knowing what kind of water we have, and how it can be to people that have sickness in a body and shouldn't drink it was like wow!”*

More information on infrastructure improvements and costs was requested. One source of cost concern was differences in billing for Baltimore City and County residents. (The City water system supplies the County). Study participants expressed interest in more specific information on the water in their homes and neighborhoods and the health effects of contaminants particularly for vulnerable populations.

After collecting information on first impressions the interview probed other questions about the CCR contents. US EPA has identified a number of required and optional elements for CCRs and participants were asked to identify three items from each list that were most important to them (listing of the required and optional elements are included in the S1 Appendix). (17) The most important required elements identified by the focus group were: identifying the source(s) of water (item 2), the detected contaminant table (item 4) and other required information such as explanation of contaminants, statements about lead, nitrate and arsenic (item 8). The most important optional elements identified were: a brief summary statement (optional item 3), the cost of making water safe and maintaining infrastructure (optional item 5), and customer education about water quality concerns in their service area (optional item 8).

Of the current approved delivery methods (see section 1C of S1 Appendix), 7 of 10 participants reported a preference for receiving a paper copy by mail to ensure report dissemination; others preferred an email-based delivery. Several participants voiced concern that many consumers could not access an electronic report, lacking a computer or internet service. Participants also suggested that the CCR information should be publicized widely on both traditional and social media outlets. Another participant suggested developing a school-based curriculum to prepare future report readers, calling it a "trickle-up approach." (See S2 Interview Data.)

Small group meetings: solutions to improve CCRs

After reviewing the Baltimore CCR, participants then envisioned solutions and offered recommendations building on their first impressions. Several information preferences were identified that informed the solutions and recommendations:

1. Create a report for lay audiences to counter information overload and the technical nature of the water sampling results;
2. Clarify water costs and billing to understand perceived disparities;
3. Provide neighborhood- and home-specific information; and
4. Provide more health information and information on contaminant trends over time.

To better reach the lay audience, or more specifically multiple audiences with differing education and information gathering habits, the participants developed several solutions that can be implemented in CCRs and through other means. Taken in combination, the participants outlined a multi-component information dissemination approach, including: a) a summary to be sent by mail; b) a website to find the full CCR with details and short videos to explain the water treatment process and water sampling procedures; c) distribution of the CCR in various forms of media (noted in previous section); and d) more community outreach including distribution of home water test kits and regular contact with residents at community events such as neighborhood association meetings.

Five prototypes were drafted from participant input: a one-page summary; a factsheet with tips about common water concerns; water contaminant trend charts; a water treatment process diagram; and an interactive map illustration. A first draft of each prototype was reviewed at the first set of small group meetings to gather further input or revisions. The participants generally liked the prototypes with some refinements requested. For example, participants asked that water discoloration be added as a topic on the factsheet and different shaped icons were suggested for the interactive map. Additional discussion about water costs clarified that the concern was not simply about how much the water system spends on treatment or new infrastructure (included on the one-page summary) but a question about how billing is done in different service areas. The investigators did not have access to service-area details and

no changes were made to the prototype, but the specific billing concern was included in the written project report (S2 Project Report). Selected prototypes are presented below and could be adapted by water utilities including the Baltimore Department of Public Works for their current website and future CCRs.

Summary statement prototype with violation

The participants created a prototype summary statement addressing preferences 1 and 2 above, see Figure 1. The prototype includes text at the top of the page with the key message of the report – in this case, indicating that a violation occurred and that immediate action was taken to correct the problem. The remaining page space is devoted to five sub-sections with high-level summary information explaining: contaminants detected; common tap water issues; some detail on the violation(s) that occurred; the major categories of spending; and highlights of infrastructure improvement.

Figure 1. Summary statement with violation reported

Interactive map illustration

The resource constraints of the project precluded the development of a fully functional interactive map; instead, Figure 2 represents an illustration or mock-up of what such a map might look like addressing preference 3. The map plots important water system features, such as water filtration and treatment plants, and icons for each neighborhood and other landmarks. If the icon for a neighborhood is selected, the residents envisioned a pop-up box or link to the current water sampling results. The participants were aware that changes in water sampling procedures might be needed to develop neighborhood-level information. The Baltimore Department of Public Works has an interactive map currently on its website that tracks water main breaks and repairs (18); the drinking water quality prototype could build on that existing map.

Figure 2. Mock-up of interactive map with neighborhood-level water information

Contaminant trend chart with health information

To address preference 4 for trend and health information, trend charts were prototyped (Figure 3). Two potential displays, either in bar- or line-chart form were developed. The charts track trends over several years and each includes space for text describing related information about the trend observed for a contaminant and potential health risks related to exposure to that contaminant. (Data shown in the prototype charts was taken from past Baltimore CCRs.) (19)

Figure 3. Trend chart examples

Discussion

This study gathered Baltimore water consumer input on the annual CCR, the primary communication tool used by water utilities. The consumers in the focus group recognized the potential of the CCR and corroborated prior findings regarding challenges with its interpretation. Our focus groups yielded specific ideas for improving the CCR content that reflected local preferences.

It is important to consider feedback from consumers for designing the content requirements of CCRs. Previous focus groups yielded small changes in mandatory educational language, but not in CCR content (Johnson 2003). In working on the proposed CCR Rule, EPA has solicited feedback from tribal governments, the National Drinking Water Advisory Council, as well as states, community water systems, and a public interest group. (10). While these groups represent a diverse array of stakeholders, we are still missing perspectives from the vast majority of American public water consumers.

We leveraged user-centered design to help understand the needs and views of water consumers. Through our work we found that these tools are useful in communicating science to the general public and allow for a deeper understanding of community perspectives. Involving the lived experience of community members allows for the inclusion of perspectives otherwise difficult to acquire. We believe that many of our findings provide insights into water quality and science communication challenges that are applicable nationwide. Using user-centered design shows promise in ensuring interventions and policies meet the needs of the community, and we believe our resulting output documents (e.g., the one-page summary statement) can be used more broadly. We also recognize that our efforts may have yielded some lessons that are unique to Baltimore, introducing some uncertainty in the generalizability of the findings. We believe that additional research in other communities would be warranted to uncover values and needs that are specific to those localities.

This work was designed with a basis in current practices and structures of water quality management, but some focus group preferences went beyond that, such as their interest in household level information. At present, there is limited tap water sampling for lead at the household level, e.g., according to the Lead and Copper Rule a public water system serving more than 100,000 people must sample water for lead testing at 100 home or building taps under the standard protocol. (20) To fully realize household-level water quality reporting new protocols and systems would be required.

In seeking other examples of water quality reports to identify communication approaches, we found several international reports that included features responsive to our focus group's preferences: namely by providing information on trends in contaminant levels over time and providing granular water results at a local level. In the United Kingdom, many residents can access their water company website, and enter their postcode, to receive their local results. (21) In Ireland and Victoria, Australia, water quality

results are shared based on sampling location. (22, 23) Reports from Victoria, Australia also shared information on contaminant trends. (22) Such reports provide tangible examples of how the focus group's suggestions can be incorporated into water quality reports.

Conclusions

The proposed revisions to the CCR rule were posted on April 5, 2023. (10) The proposal addresses the report's contents, required additional health information and established requirements for reporting of SDWA compliance monitoring data. The proposed revisions include providing a summary statement, as our focus group recommended.

While the focus group participants expressed concern and sometimes alarm about the information in the Baltimore CCR, most also found the information valuable. All participants thought the information should be shared more widely and particularly with water users lacking access to the electronic report. As US EPA continues work on the revised rule for CCRs, we have a unique opportunity to influence this critical policy to enhance awareness and understanding of drinking water quality. We shared the project findings with the local water utility and submitted formal comments to US EPA on the proposed rule revisions. We hope this work provides the agency and water utilities with practical ideas that enhance report content to truly foster "consumer confidence" in the next iteration of drinking water quality reports.

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S1 Appendix Interview and Discussion Guide

S2 Interview Data

S3 Project Report

WATER REPORT

Summary

We are required to provide safe drinking water. When a violation occurred we acted immediately to make sure the water supply continued to meet safe drinking water standards.

CONTAMINANTS

In the Baltimore water supply, we do detect a number of contaminants but none exceed the established standards.

90
Contaminants

The occasional presence of contaminants is expected and the monitoring and sampling we do allow us to keep contaminant levels low. When sampling found X in violation we immediately did Y and Z to make sure the water supply continued to meet safe drinking water standards.

COMMON TAP WATER ISSUES

In our area, the common issues are:

Change in taste or color

Smells like swimming pool

Debris in faucet

To find out what to do when these arise, please call xxx-xxx-xxxx

VIOLATIONS

There were sampling or reporting violations and we are doing/did Y and Z to bring the water system back into compliance.

What does it mean for me?
Add answer here.....

Your water bill payment is used for:

28%	37%	35%
INFRASTRUCTURE IMPROVEMENTS	WATER AND WASTEWATER TREATMENT	SYSTEM MAINTENANCE

COST

UPGRADES AND INFRASTRUCTURE IMPROVEMENT

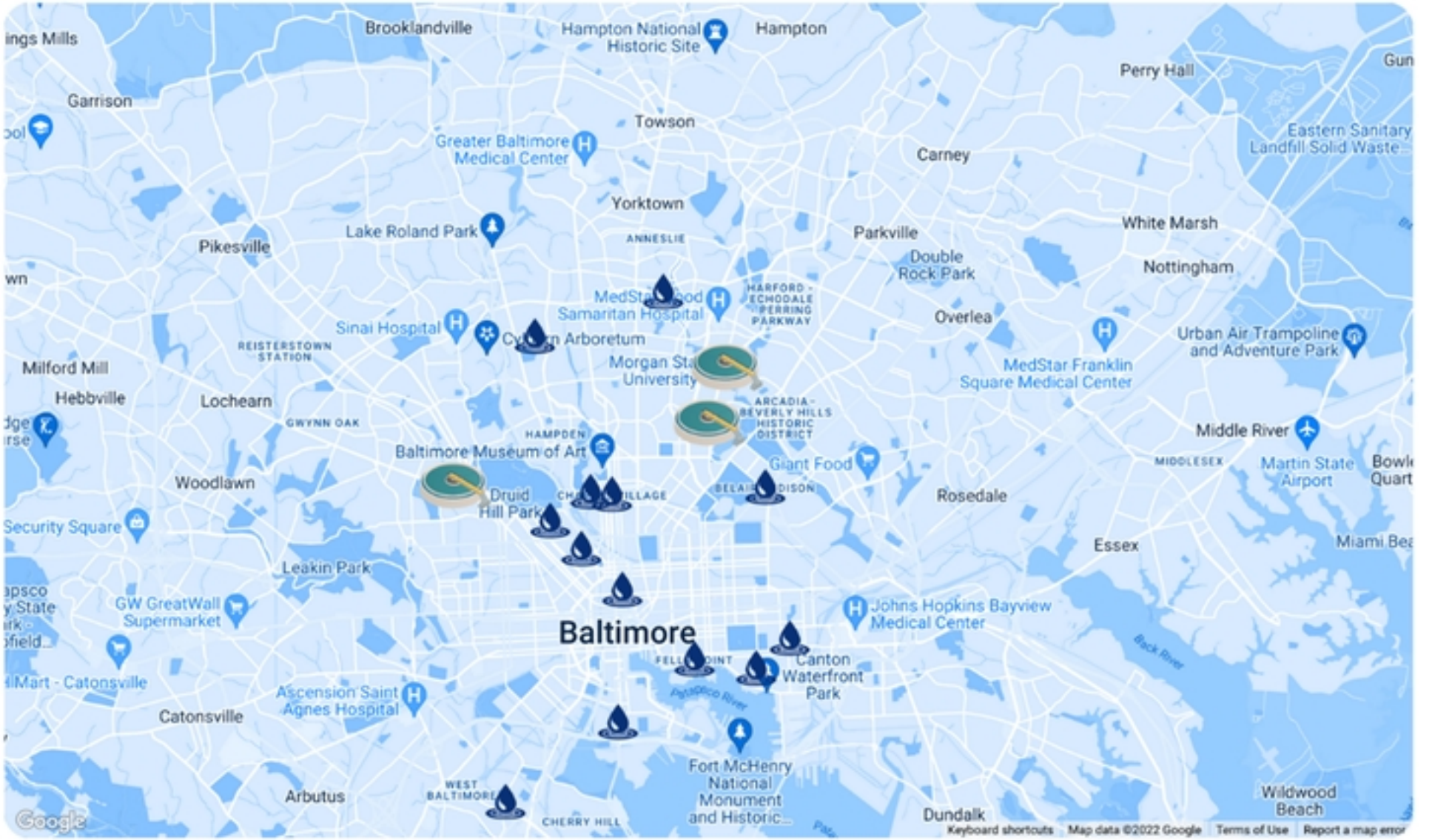
Add any ongoing work....

Contact us at xxx-xxx-xxxx

Figure

Baltimore water report

- ASHBURTON FILTRATIO...
- MONTEBELLO FILTRATI...
- MONTEBELLO FILTRATI...
- Chinquapin Park - Belve...
- Lakeland
- Curtis Bay
- South Baltimore
- Belair - Edison
- Reservoir Hill
- Highlandtown
- Mount Vernon
- Canton
- Bolton Hill
- Roland Park
- Charles Village
- Remington

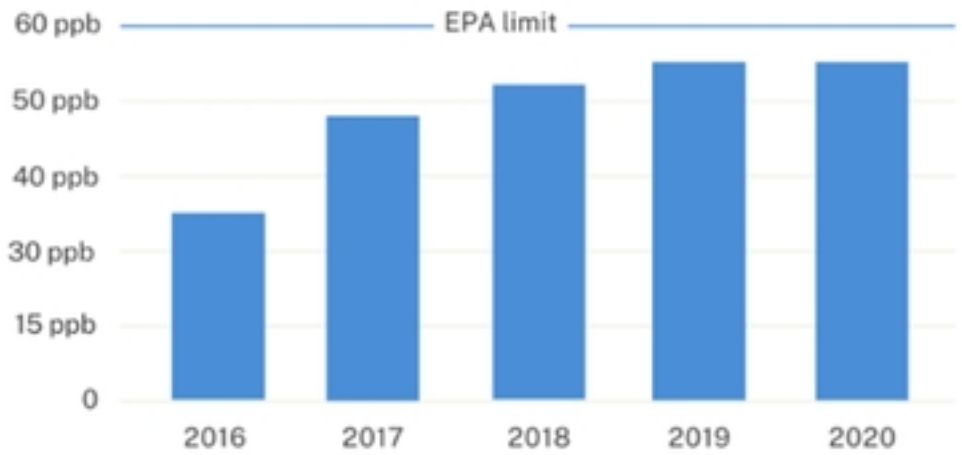


Figure

HALOACETIC ACID

Chlorination byproduct

Baltimore city: Trend of contaminant concentration



60 ppb (parts per billion): EPA limit

What is the city doing:
Health risks:

HALOACETIC ACID

Chlorination byproduct

Baltimore city: Trend of contaminant concentration

60 ppb (parts per billion): EPA limit

What is the city doing:
Health risks:

Figure