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Comparison between Washington D.C. and Flint Crises

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Ignorance of the factors of the Washington D.C. crisis contributed to the Flint water crisis.

Corrosion is an inevitable challenge in everyday life. It is crucial to investigate the corrosion of contact materials with drinking water to maintain both the well-being of the population and environmental sustainability. By delving into past incidents and studying the worst-case scenario associated with corrosion's impact on drinking water, we can raise awareness within the community. This knowledge will enable us to take proactive measures to prevent the recurrence of such incidents in the future, thus contributing to a safer and more sustainable environment. Two main cases of corrosion impacting the drinking water quality in the USA have been documented: Washinton D.C.'s and the Flint water crisis.

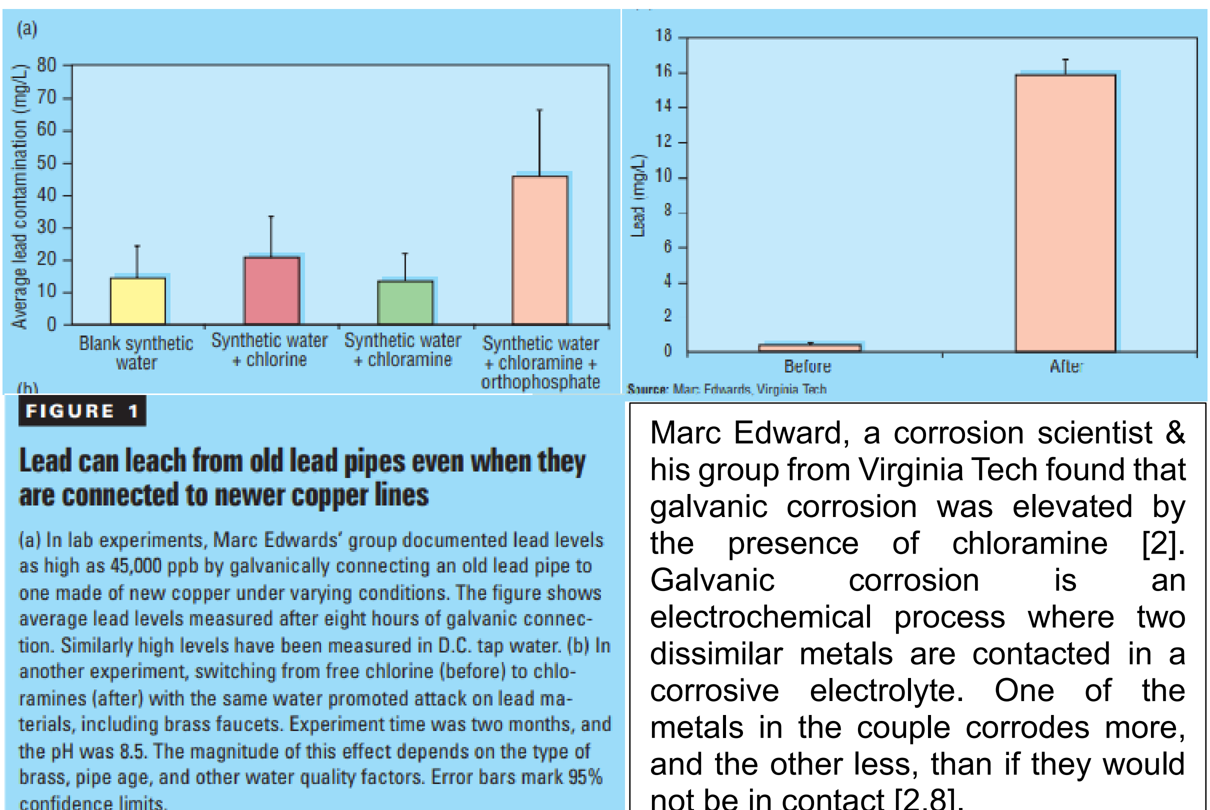
Geographical location and population: The drinking water crisis in Washington D.C. commenced in 2001 [1]. This incident occurred within the USA's capital city [2]. In 2001, Washinton's DC's population was 577,357 [3]. Another case originated in Flint City, Michigan, in 2014 [1]. At that time the population of Flint stood at 99,002 residents [4]. Flint, owing to its distinction as the birthplace of General Motors, was once home to nearly 200,000 people in the mid-20th century. A significant portion of its population was employed in the automobile industry. However, the 1980s brought economic challenges such as escalating oil prices and auto import parts contributed to the closure of auto plants. With these issues, job displacements among the workforce were seen. As a result, Flint's population decreased, leading to poverty among its residents, affecting approximately 45% of the population. Most of the remaining population in Flint was African American during this time period [5].

The story of the origins of the crisis: It was crucial to reduce the generation of harmful byproducts (trihalomethane/THMs) in the water during the disinfection process according to the Environmental Protection Agency's (EPA) disinfectant byproducts rule. As a result, the Washington aqueduct took the first step by introducing chloramine as a substitute for the chemical chlorine which was used for the treatment of city water in 2000 [1]. In contrast, from June 2012 to April 2013, Flint officials investigated alternative methods of sourcing more cost-effective water. Also, the city council minutes revealed that constructing a pipeline to the Karegnondi Water Authority (KWA) could result in savings of $200 million over 25 years. The water crisis in Flint started when the administration of Flint decided to switch its drinking water supply from the Detroit system (Lake Huron) to the Flint River on 25th April 2014 as a cheap option [5, 6].

Discovering lead/Pb contamination: High levels of lead contamination in the city water were discovered by the Water and Sewer Authority (WASA) of Washington's city in 2001. Surprisingly, despite federal laws requiring the reporting of such high lead levels to federal regulators, WASA did not report it. Finally, WASA informed the residents about the issue. However, the authority failed to inform the public effectively and did not convey how urgent the situation was [2]. This situation damaged the public trust in the local drinking water supply. The Washington D.C. water crisis remained largely unnoticed until 2004 when WASA eventually released the findings of comprehensive tap water analysis conducted across the city. These findings revealed that lead (Pb) levels exceeded 300 ppb (μg/L) in the tap water from more than 157 houses. Thus, many residents were shocked to discover that the lead levels in their home's water exceeded the Environmental Protection Agency's (EPA's) permissible limit of 15 ppb action level [2]. Besides, over 1,000 homes exhibited Pb levels surpassing the EPA's action level [2].

Flint inhabitants began complaining and protesting about the water contamination with a foul odor and dark color. Besides, they noticed skin rashes and hair loss. Moreover, several tests discovered higher Pb levels than the action level set by the U.S. EPA. Virginia Tech University confirmed elevated Pb levels, with 17% of samples exceeding the federal action level of 15 ppb and more than 40% measured samples above 5 ppb of Pb [5-7].

Understanding the rise in Pb levels and discoloration in drinking water: Both cases, Washinton D.C. and Flint, Michigan, began due to corrosion of contact materials with drinking water. The main reason for the D.C. water crisis was the corrosion of the passivation layer, or protective mineral coatings, of Pb pipes, which allowed Pb to leach from the city's older pipes into the water supply due to the replacement of the chemical chlorine treatment with chloramine [1,2].



Marc Edward, a corrosion scientist & his group from Virginia Tech found that galvanic corrosion was elevated by the presence of chloramine [2]. Galvanic corrosion is an electrochemical process where two dissimilar metals are contacted in a corrosive electrolyte. One of the metals in the couple corrodes more, and the other less, than if they would not be in contact [2,8].

Figure 1. Pb leakage from old pipes [2] © 2004 American Chemical Society

Results in Figure 1 show that brass is highly anodic when coupled with more cathodic copper during treatment of chloramine [1]. These phenomena accelerate the release of Pb from the older Pb-containing brass pipes. Pb leaching can be elevated 4 to 100 times when copper plumbing network in houses speeds up the corrosion of the brass located at the faucet where water is collected (Lead corrosion equation: $2Pb(s) + O_2(aq) + 4H^+ \leftrightarrow 2Pb^{2+}(aq) + 2H_2O$).

Moreover, PbO_2 is expected to remain stable in highly oxidizing water over the pH range of treated drinking water. This stability implies that when Washington D.C. used a significant amount of chlorine in the past, the highly oxidizing water facilitated the development of PbO_2 scales. As long as the drinking water maintained its high oxidation state, these scales remained stable and insoluble [2]. However, within the transition to chloramines, the water oxidizing potential in D.C. was reduced. Researcher Schock suggested that after this change, D.C. water might be capable of dissolving the PbO_2 scales. This dissolution could potentially increase Pb in drinking water [2].

Similar to Washington D.C., Pb contamination was the most concerning issue among several water problems that Flint City has faced since the summer of 2014 due to corrosion in Pb and iron pipes. After switching to the Flint River water, the ability of the water to corrode those pipes was not controlled properly. Flint River water lacked the phosphate that Lake Huron had. Detroit treats orthophosphate as a corrosion inhibitor to their water to control the corrosion because insoluble lead phosphates are formed when orthophosphate interacts with Pb in pipes water ($3Pb^{2+}(aq)+2PO_4^{3-}(aq)\leftrightarrow Pb_3(PO_4)_2(s)$) and act as passivation layer which prevent further Pb corrosion by avoiding the contact of pipes with oxidant species such as dissolved O_2 and Cl^- [9]. Furthermore, high concentration of broken-down Cl_2 disinfectants (high chloride level) in the absence of corrosion inhibitor in drinking water led to an increase in corrosion in Flint's pipelines ($Pb_{(s)} + 2Cl^-_{(aq)} \leftrightarrow PbCl_2(s)$) due to the weakened passive layer by dissolving [9]. When Pb pipes were partially replaced with copper, galvanic corrosion accelerated in the pipe system as described earlier. Otherwise, iron corrosion caused the discoloration of water (rust-colored) [9].

Stakeholder considerations: Decisions made by the Washington Aqueduct and WASA directly influenced the community and its social life in Washington D.C. [1. 2]. Similarly, the judgment of the state-appointed emergency manager to change Flint's water source from the Detroit system without adequate corrosion control severely impacted the Flint community and local companies. For example, the General Motors plant stopped the usage of tap water due to corrosion in steel components [9]. The Flint community organized a national mile-long march to protest for clean water, exerting significant pressure on the government in the Flint case. Mark Edwards played a most important role in both water crises by conducting tests and revealing the test results regarding the Pb concentration in drinking water as well as the reasons of Washington D.C.'s Pb contamination. In my point of view, he was the key figure who had a substantial influence on government officials with experimental evidence and data (children's blood samples test data for Pb) of "Children's National Medical Center" by representing both Washington D. C. and Flint communities [10,14]. For instance, during his speech at the Student Union Theater at the University at Buffalo (UB), he revealed that even though Congress discovered the high levels of Pb in D.C. water, no action was taken to address the issue [14]. In both cases, official decisions had a significant impact on children and pregnant women, putting them at a higher level of risk [15].

In the case of Washington D.C., the crisis was significantly impacted by various responsible agencies including DC Water (water distributor), the health department and the federal health agency. In a parallel manner, MDEQ (the primary agency with direct oversight), federal oversight, the city of Flint and the MI council (Michigan council) were the most influential other agencies for the Flint crisis [15].

Impact of drinking water crisis on humans and environment: Elevated blood lead level (EBL) (Pb >- 10 μg/dL) in children under 1.3 years in Washington, DC from 2001 to 2003 elevated by more than four times from 2001 to 2003 compared to the level in 2000 when Pb in the water was low [11]. Furthermore, one of the studies discovered that fetal death (200 fetal deaths) and miscarriage rates (2,000 miscarriages) reached their peak during the Washington D.C. drinking water crisis since Pb levels elevated to a maximum in 2001 [15]. This rate decreased after healthcare measures were implemented for pregnant women. Approximately 42,000 children were exposed to Pb during the Washington D.C. water crisis. Those who were under the age of two during this crisis, currently show serious effects of Pb exposure such as cardiovascular and reproductive problems as well as issues with mental and physical development [1]. Overall, increased Pb exposure was associated with a higher number of miscarriages and fetal deaths, even at low blood lead elevations (5 μg/dL) [12].

Similar to the D.C. water crisis, elevated Pb levels were verified in children (doubling of percentage of Flint children with EBL (around 200 cases were confirmed)) [10]. Moreover, sensitive groups like pregnant women were at high risk during the Flint crisis. Since Pb easily reacts with chlorine due to a lack of passivation layer (lead phosphates), decreasing disinfectant levels [9] increased the level of pathogens in the Flint water. The presence of fecal coliform bacteria in the drinking water of Flint suggested failure to maintain precise chlorine/Cl_2 concentration in the water. Due to treating more chlorine, total trihalomethane (TTHM) which is a byproduct of chlorination of water, levels increased. A higher risk of developing cancer is associated with the presence of TTHM, a known carcinogenic chemical [5].

Additionally, increased water corrosiveness led to elevated Pb concentration in both water crises. Higher levels of Pb in drinking water cause severe damage to the brain, nervous system, kidneys, and red blood cells, and decrement in intelligence in children and neurological function [17, 18]. Mobile Pb has the potential to run off into the water and can also leach into groundwater. The absorption of Pb by plants can lead to a reduction in growth, metabolic functions, and photosynthesis [16]. The bioaccumulation of Pb in plants and animals occurs through the food chain, with older organisms containing the highest concentration of Pb [16].

Corrosion mitigation methods and health concern: In August 2004, the Washington Aqueduct introduced the corrosion inhibitor (orthophosphate) into the drinking water system to minimize Pb leakage from pipes. Additionally, comprehensive approaches were launched including public education initiatives, replacements of over 15,000 lead pipes on public properties, offering free blood tests, and 30,000 water filters for residents [13, 15]. In contrast, Flint decided to switch back to Lake Huron water in October 2015 and tripled the dose of the orthophosphate corrosion inhibitor. As the subsequent action, over $600 million in relief (Pb filters, bottled water, health care, water testing, public education, water bill credits and nutrients) were distributed to assist Flint residents. As a corrosion control measure, all Pb and galvanized iron pipes were replaced by 2020 [15].

Direct and indirect costs: According to the EPA guidelines, it is important to replace 7% of Pb pipes annually in D.C. The initiative was estimated to cost $10 million to 20 million per year [17]. It has been reported that D.C. officials had to seek $26 million to address Pb contamination in the city's water and cover related expenses [21].
After a victorious lawsuit, the presiding judge approved and granted an estimated $626 million as the final budget to address and resolve the Flint crisis. This sum was distributed as follows; 80% was allocated as compensation for individuals who were exposed to Pb contamination during their formative years, especially those aged 17 and below. A significant portion of this 80% was used for support and care of children 6 and below, given the health risks associated with Pb exposure in this age group [20]. Ultimately, the Flint water crisis incident came to be known as ***"the largest settlement in the state's history"*** [20].

Summary

The primary technical cause for the Washington D.C. water crisis was the switch of disinfectants from free chlorine to chloramine in November 2000, as mandated by the disinfectant byproduct rule. This change was not driven by a cost-saving effort like what we observed in Flint. The change in disinfectant aimed to minimize the levels of disinfection byproducts (THMs). The decision to switch the water source from Lake Huron (treated with orthophosphate for corrosion control) to Flint River (without orthophosphate treatment) in April 2014 was entirely based on cost-cutting measures. In both cases, poor decision-making by officials, poor corrosion control measures, not revealing and failure to convey the truth to the residents coupled with a lack of scientific understanding regarding chemical and metal interactions, not only put the community at risk but also resulted in wasteful expenditure of funds. Continuous monitoring of water chemistry, particularly during the transition between water sources or the use of different chemicals, is crucial. Early research indicated that the extent of the crisis in Washington D.C. in terms of Pb poisoning and people's exposure, was around 20 to 30 times greater than that of Flint [14]. In conclusion, the failure to learn from the lessons of the Washington D.C. water crisis ultimately contributed to the Flint crisis.

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