Understanding U.S. Chemical Regulation and Considerations of Environmental Remediation Using Actor-Network Theory

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

It is an unfortunate truth that many industries in the U.S. use toxic chemicals and generate hazardous wastes, which the Environmental Protection Agency (EPA) defines as "waste with properties that make it dangerous or capable of having a harmful effect on human health or the environment" (US EPA, *Learn the Basics of Hazardous Waste*, 2015). The improper handling of chemicals, accidental leakages, and historic ignorance of chemical hazards have caused communities and environments to be contaminated. When this happens, using remediation technology is one of the possible solutions for restoring the environment to a healthy state where people and nature are not at risk. However, the process for implementing permanent solution remediation technology is lengthy. Due to this, more emphasis needs to be focused on reducing the fundamental cause of environmental contamination – the use of hazardous chemicals.

This paper sheds light on the issues with U.S. chemical regulations and offers suggestions, informed by Actor-Network Theory (ANT), on how systems could be improved to protect society and the environment. In this paper, the word "chemicals" specifically refers to industrial chemicals and excludes chemicals—pesticides, tobacco, nuclear material, firearms and ammunition, food, food additives, drugs, and cosmetics—regulated by government acts or agencies beyond the scope of this paper (US EPA, *Toxic Substances […]*, 2013).

To write this paper, I use a literature review, conversations with industry professionals, and a case study to research the topic of hazardous contamination and remediation. The literature review includes scholarly essays, historical records, and governmental regulations sourced from science, technology, and society (STS) databases, government websites, and other online resources. Additionally, I use knowledge I have gained from speaking with the remediation engineers who are mentoring my technical project. To emphasize the actors and behaviors involved in remediation decisions, I apply ANT to a case study of a remediation decision at Crown Cleaners of Watertown, Inc. Superfund Site in Herrings, New York.

This paper is organized into the following sections: relevant context, introduction to ANT, ANT analysis, and discussion of insights. The first section includes context to explain the broad actors relevant to remediation projects and to inform the later ANT analysis. The next section—introduction to ANT—provides a brief overview of the ANT framework and how it is used in the paper. Once the fundamentals of ANT are explained, I use a case study to highlight behaviors individual actors must have for remediation technology to be utilized to clean up a hazardous site. Finally, I conclude with a discussion on the insights ANT brought to light and I propose solutions for how issues could be addressed.

Relevant Context

Chemical Industry

The chemical industry emerged as industrialization increased the demand for chemicals. In the 1800s, Europe dominated the chemical industry; however, the U.S. also produced chemicals—mostly inorganics (Landau & Arora, 1999). In 1872, the Manufacturing Chemists' Association, now named the American Chemistry Council (ACC), was formed and since has had a major influence over chemical policy in the U.S. (Goldman, Carlson, & Zhang, 2015). During World War I, U.S. companies decided to supplant shortages of European imports; and after the war, the companies used their scaled-up war infrastructure to create new products for the chemical market (Chandler Jr., 2004, pg. 44, 55). Post-World War I to 1970 marked a period of substantial growth in the U.S. chemical industry, with companies like the Dow Chemical

Company (Dow) and E.I. Du Pont de Nemours & Company (Du Pont) leading R&D in chemical development and processing (Chandler Jr., 2004, pg. 81-82).

Hazardous Chemical Regulation

Up until the 1970s, national environmental laws were meager. Most environmental decisions were regulated by state and local governments, and environmental conflicts that arose often fell to the judicial system to settle (Percival, 1997). Rachel Carson's 1962 book, *Silent Spring*, shed light on the impacts that chemicals, specifically DDT, were having on health and the environment. The book and many public environmental disasters are credited with drawing widespread public attention to environmental issues and leading to the modern environmental movement (PBS, 2010). The environmental focus of the 70s also led to the creation of the EPA—which is tasked with protecting human health and the environment—and an onslaught of novel and revamped bipartisan regulation (PBS, 2010).[1] Legislation passed was meant to address hazardous chemicals at three stages of life: initial market entry, pollution prevention, and environmental clean-up.

The Toxic Substance Control Act (TSCA) of 1976 was passed to regulate novel chemicals entering the market. The original TSCA was created under the influence of the chemical industry. The Assistant Administrator for Toxic Substances at the EPA went so far as to call the act "industry-blessed." The administrator identified the issue of the law making it the

[1] Among the 1970s laws are some that are pertinent to the regulations of chemicals, including the Clean Air Act (CAA) of 1970 which now gives the EPA the authority to set National Ambient Air Quality Standards (NAAQS) that regulate criteria pollutants and National Emissions Standards for Hazardous Air Pollutants (NESHAP) that regulate emissions of hazardous air pollutants from stationary sources; the Clean Water Act (CWA) of 1972 that allows the EPA to implement pollution control programs, such as establishing wastewater standards and requiring permits for pollutant discharges; and the Safe Drinking Water Act (SDWA) of 1974 that regulates public drinking water supplies and establishes maximum contaminant levels for harmful contaminants (US EPA, *Evolution […]*, 2023; US EPA, *Summary of the Clean Water Act*, 2023; US EPA, *Overview of the Safe Drinking […]*, 2024).

government's responsibility to prove a chemical is dangerous, rather than the chemical industry's responsibility to prove a chemical is safe, as a major enforcement problem (Jellinek, 2010, pg. 12). The TSCA requires chemical companies to submit premanufacture notices and previously generated toxicity data to the EPA, which then has 90 days to determine if a chemical poses an "unreasonable risk of injury to health or the environment" (*15 USC Ch. 53*). The 1976 law also requires the EPA to choose the "least burdensome" regulation to the chemical company. Courts have ruled against EPA decisions if they do not abide by this rule (Gerlach, 2016). Furthermore, TSCA wording allowed the 62,000 previously created chemicals to be grandfathered in as approved chemicals, making it the EPA's responsibility to prove the chemicals are an "unreasonable risk" to get them banned. Because of this, only five of these chemicals were banned as of 2015 (Kollipara, 2015).

Due to the overwhelming failure of the 1976 TSCA to substantially regulate chemicals, there were calls for reform by some legislators. When it became apparent reform was on the horizon, the ACC increased spending on lobbying (Goldman, Carlson, & Zhang, 2015). In 2016, an update to the TSCA called the Frank R. Lautenberg Chemical Safety for the 21st Century Act, was passed with bipartisan support and had the approval of the ACC. Among the many revisions, the act removed the "least burdensome" requirement, made evaluating existing chemicals mandatory, and made federal testing standards supersede individual state standards—a win for the ACC as some states had stricter standards (Bedi, Lerner, & McGrory, 2022).

The Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendment (HSWA) were added to the Solid Waste Disposal Act to prevent pollution derived from the mishandling of chemicals.[2] Subtitle C of RCRA allows the EPA to regulate hazardous waste from generation to disposal. This is done through a permit system where different rules apply to companies based on the quantity of hazardous waste they produce. However, permits are sometimes not required when generators recycle or treat their waste on-site (US EPA, *Hazardous Waste Generators*, 2014). The HSWA established EPA authority for corrective action, which enables investigations and clean-ups of hazards released into the environment (US EPA, *Learn about Corrective Action*, 2016).

RCRA was discovered to be ill-suited to address chemical contamination on sites no longer owned by active generators. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and its 1986 amendments—referred to as "Superfund"—, were passed to hold former site owners responsible for paying for remediation efforts (US EPA, *CERCLA*, 2013). There are shortcomings to this law too, as companies have been known to file for bankruptcy to avoid full financial obligations, and a serious lack of funding and federal resources means only select sites on the National Priorities List can be given resources (Bogardus, 2007 & Hembra, 1993).

State governments are allowed to make state-level environmental laws and states participate in cooperative federalism to enforce federal laws (US EPA, *State [...]*, 2016). An example of a state passing legislation is California's Proposition 65, which requires warning labels to be attached to items to notify consumers of toxic chemicals ("New Proposition", n.d.). California is the only state to require such a measure. An example of states enforcing federal legislation is RCRA. Under RCRA, state governments are responsible for setting up clean-up

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[2] In 1965, the Solid Waste Disposal Act (SWDA) was passed to improve solid waste disposal methods (US EPA, *History of the [...]*, 2024).

standards and remediating brownfields (US EPA, *Brownfields*, 2020). This means the states contract the engineers and are responsible, in many cases, for financing projects.

Solutions and Responses for Hazardous Sites

Another important aspect of the history of hazardous site remediation is the technology itself. Modern environmental remediation technology for chemical waste is relatively new, as only in recent history have there been laws to outlaw the discharge of hazardous chemicals into the environment and mandate the clean-up of hazardous sites. Major downfalls of remediation technology include the long-time scales of remediation projects and high costs, which include paying for site assessments and engineering expertise required to develop a remediation plan (Villars, 2023). Additionally, it is not uncommon for there to be technical challenges.

Once a hazardous site is suspected, a state response is initiated. Engineers are likely hired at this point to measure contaminant levels at the site. If they are above certain safety thresholds, the site will be deferred to the federal government under CERCLA; if below, the state response will continue. The government response is important to note because though progress has been made in U.S. chemical regulation, the U.S. Government Accountability Office (GAO) has listed the need for controlling toxic chemicals on their High-Risk Series since 2009—indicating it is still an issue that is not adequately addressed. The GAO identifies the need to hire more staff and to update the Integrated Risk Information System used for assessing chemicals (US GAO, 2023). Another barrier to the effectiveness of the government's regulation of chemicals and hazardous sites is that different Executives have differing priorities and can appoint people with varying skill sets to positions in the EPA.[3]

Hazardous Chemicals and the Environment

When a hazardous chemical enters the environment, it can have long-lasting harmful effects on the land, water, and atmosphere. If animals and insects come into contact with these chemicals they can perish, have affected fertility, and develop genetic defects (US EPA, *Health [...]*, 2023). Additionally, bioaccumulation can happen and cause biomagnification— meaning the chemicals are passed on to higher levels of the food chain (*Bioaccumulation*, 2023). Biodiversity is not the only planetary boundary threatened by chemical pollution; so is freshwater use (Rockström, et. al., 2009). Chemicals can directly flow into bodies of water or leach into the soil and contaminate fresh groundwater aquifers, making the hazardous water non-potable and offering a non-visible vector to spread the contamination (Villars, 2023). On land, pollution can kill crops and plants, affecting food supplies and natural habitats. In the atmosphere, chemicals can also cause havoc. Airborne chemicals can cause acid rain, deplete the ozone layer that protects life on Earth from UV radiation from the sun, and affect the greenhouse effect which regulates the temperature of the planet (Rutledge, et. al., 2023).[4]

Hazardous Chemicals and Society

The people living in communities near hazardous sites are impacted by chemical contamination. The public at large can be exposed to the hazard or be impacted on other non-

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[3] Additionally, courts have historically decided the bounds of loosely worded laws leaving departments in the government to have the authority of interpretation, this is called Chevron deference after the original court case. However, the Supreme Court is anticipated to have a 2024 opinion that may overturn this, which if the case, could potentially lessen EPA's authority.

[4] The depletion of stratospheric ozone, another identified planetary boundary, was so at risk that in 1987, alarm over a seasonal hole in the ozone layer contributed to one of the only successful globally supported environmental agreements, called the Montreal Protocol (U.N. Environment Programme, 2018).

physical levels, such as the stress provoked by the knowledge of the contaminant. Businesses and homes adjacent to hazardous sites can be affected by the contaminants and have increased healthcare costs (Lybarger, et. al., 1998). Additionally, the demographics of the communities affected by hazardous sites require further investigation. The people living around Superfund sites are disproportionately minority groups, low-income groups, linguistically isolated groups, and non-high school educated groups (US EPA, *Population […]*, 2020). These relevant social groups could be used to stratify the public further into more specific populations, but have not been in this paper, since these categories are not always mutually exclusive. Because of this, it is important to note that the actions of the broader community substitute for nuances of the perspectives and implications towards these sub-social groups in the later ANT analysis. This broader view considers the perspective of the public at sites with contaminated groundwater. Janet Fitchen argues that in the U.S., the value of individualism has led to groundwater being seen as an individual resource, in that private wells give people a sense of independence. This feeling has led people to have warped perceptions about their water (Fitchen, 1987).[5] Under CERCLA, communities have the right to know when a hazardous substance has leaked into the environment (US EPA, *What is EPCRA?*, 2013). However, Fitchen found that people with private wells are more willing to deal with contaminants if it means they can keep their sense of independence (Fitchen, 1987).

Workers at facilities that use hazardous chemicals are another notable group affected by the use of toxic chemicals. Chemical exposure has been a prevalent part of American life. Still, it was not until 1983 that chemical manufacturers and importers were required by the Occupational

[5] For example, individuals who have city water buy filters—think of the now ubiquitous Brita (Fitchen, 1987).

Safety and Health Administration (OSHA) to label chemicals with the hazards they pose, provide buyers with material safety sheets, and inform their employees of these hazards (Federal Register, 1983). Even though this policy is in place, it is estimated that more than 190,000 worker illnesses and 50,000 worker deaths are caused by workplace chemical exposure annually (OSHA, n.d.).

Actor-Network Theory

What is Actor-Network Theory?

ANT is a social theory that seeks to understand science and technology. ANT allows a unique way of thinking where the parties involved in technological or scientific processes can be human or non-human (Sismondo, 2010, p. 81). In the ANT framework, each actor's interests are equally important, natural and social events are treated as similar, and no prior knowledge about the actors is considered (Callon, 1984 pg. 3-4,). These actors have "interests that cause them to act" and "form associations" with other actors to create a network (Sismondo, 2010, p. 81). A fundamental element of ANT is that the different actors must behave in a specific way for the problem to be solved or for the technology to turn out the way it was intended to. The areas in the network in which actors interact are called "translation" and the specific action that an actor must take for the translation to work to create a desired network behavior is called the "obligatory passage point" (OPP) (Callon, 1984, pgs. 6-8).

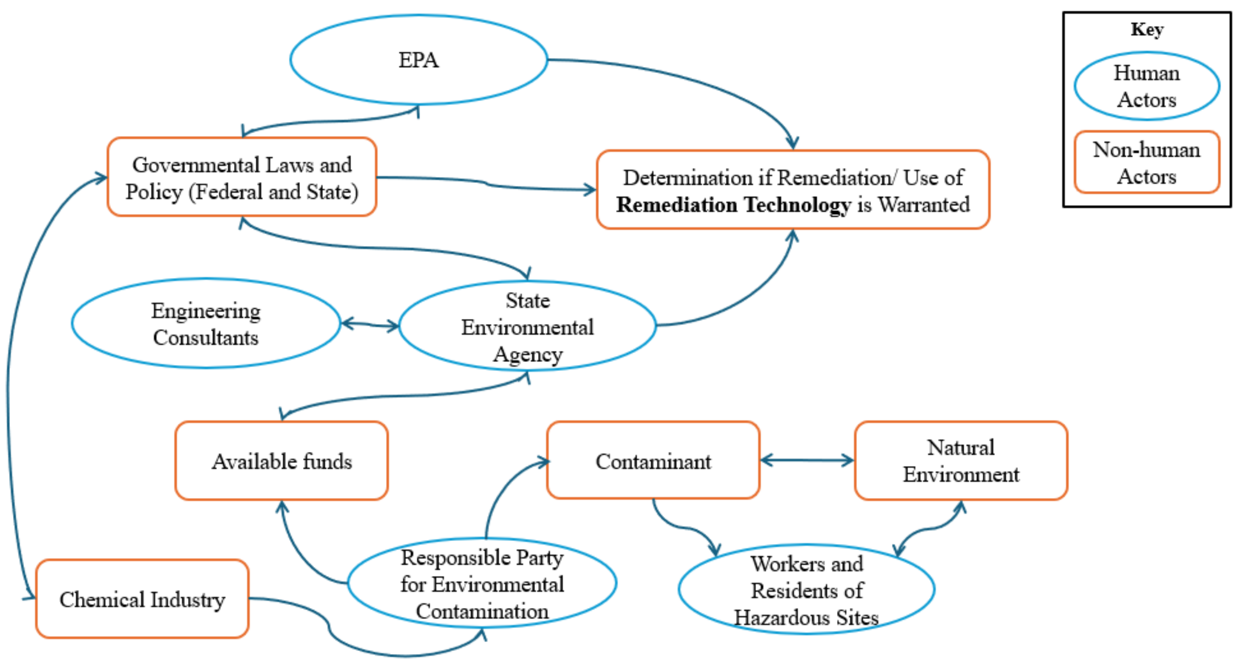
As an analysis must have bounds, it should be noted that a major limitation of ANT is that it necessitates that there is some information on all actors. Because of this, those who are left out can have their points of view excluded and an important node that may have a significant contribution to the network can be left undiscovered.

Actor-Network Theory Applied to Remediation Technology

ANT is an appropriate framework to consider whether remediation technology should be used because hazardous sites involve human stakeholders—regulation agencies, polluters, and the public— as well as non-human actors—the contaminant, the polluted natural resource, the law, the chemical industry, and the money available to support clean-up initiatives. Knowledge of how the uses of remediation technology are affected by society is distilled from the translations and the OPP identified with ANT. See Figure 1 for a depiction of the actors and the relationships between them, most of which will be touched on in this paper.

Figure 1

Actor-Network Theory Applied to Remediation Technology Illustration



Note. The illustration depicts the relationships between basic actors involved in the determination of whether remediation is necessary for a hazardous pollutant. Human actors are shown in blue ovals and non-human actors are shown in orange rectangles.

Actor Analysis

Introduction to the Crown Cleaners Case Study

The New York State Department of Health discovered that the Village of Herrings' water supply well was contaminated with PCE in 1991. This contamination was from the use of the chemical at the Crown Cleaners of Watertown, Inc. drycleaning facility that operated from the late 1970s to 1991. In the two decades of operations, the drycleaners had used PCE and discharged their wastewater into a storage pit in the basement where the chemicals were able to leach into the ground and they also dumped used dry cleaning filters on the property (US EPA, *Record [...]*, 2012, pg. 1). The case study will be used to highlight the major actors involved in remediation technology decisions.

Contaminant

The dry-cleaning industry was in full swing by 1919 and until 1962, petroleum distillates were mainly used as cleaning agents. These chemicals made dry cleaning expensive and left an odor on the clothes. Chlorinated solvents were found to be a better alternative to these distillates because they were cheaper, faster, odorless, non-flammable, and more effective, which led to the widespread use of PCE at dry cleaning facilities (Doherty, 2000).

Responsible Party for Contamination

Many dry cleaners are small businesses that create no more than 100 kilograms of hazardous waste per month. These businesses can acquire a very small quantity generator (VSQG) status, which means they have more lenient RCRA compliance requirements than larger generators (US EPA, *Hazardous Waste Generators*, 2014). However, they are still required to notify the government if there are chemical releases and they could be held liable (US EPA, *RCRA in Focus […]*, 1999).

Chemical Industry

At the Crown Cleaners site, the major contaminants of concern were chlorinated solvents. The previously mentioned company, Dow, was a major developer and producer of chlorinated solvents starting with the founder's ambition in exploring chlorine compounds in 1913. Du Pont was another major U.S. producer of chlorinated solvents meant for dry cleaning beginning in the 1930s (Doherty, 2000, pg. 70). ACC lobbying contributed to the TSCA grandfathering in chemicals made before 1976.

EPA and Government Policy

Dry cleaning is an industry that is so well known for polluting that the sector is specifically called out in the National Emissions Standards for Hazardous Air Pollutants (NESHAP) and regulated. Additionally, the EPA announced PCE as one of the first ten chemicals to be evaluated under the 2016 TSCA amendments; and in 2022, the EPA determined it posed an "unreasonable risk of injury to human health." In 2023, the EPA proposed a ban on most uses of PCE (EPA, *Risk Evaluations […]*, 2016). However, the Crown Cleaners contamination happened before these reforms, so at the time, PCE was still an acceptable solvent.

Natural Environment

As the Crown Cleaners contaminant is a VOC, special environmental challenges are posed. Groundwater, which acts as a drinking water supply, is contaminated and chemicals trapped in the soil are sources of pollution for the groundwater. Additionally, VOC can accumulate under sub-slabs of buildings and cause vapor intrusion, a buildup of chemical vapor in the building (Villars, 2023). Luckily, this was not an issue at the site (US EPA, *Record […]*, 2012). Chlorinated solvents are common environmental pollutants and unfortunately, are some of the most commonly found chemicals at Superfund sites (Doherty, 2000).

Workers and Residents of Hazardous Sites

The Record of Decision for Crown Cleaners did not mention if previous employees of the cleaners were contacted and notified of the site's status. In 2023, a while after the time of this case study, the EPA proposed a PCE ban. However, this proposal will not make an immediate impact as it allows for a 10-year phaseout of the use of PCE at dry cleaning facilities to make the transition feasible for small business owners (US EPA, *EPA Proposes […]*, 2023). This means people could still be exposed to new PCE contaminants until 10 years after the ban is approved.

Communities affected by the Crown Cleaners site included the workers of the old cleaners and the village of Herring. The EPA held a town hall meeting to gauge the Herring community's response to the proposed remediation plan. According to the sign-in sheet, 22 people attended, and 2 letters were sent afterward. At the meeting, attendees expressed a desire to enhance the design so that the land would be fit for recreational use, talked about their concerns about asbestos being in buildings on the site, and showed their happiness over the project removing eye-sore buildings. The citizens did not ask questions about the contaminants or if their water would be safe to drink. Citizens' low level of concern about polluted groundwater near wells could be attributed to Fitchen's assessments that individuals do not view groundwater as a collective resource and that individuals are more willing to take a risk if it affirms their autonomy. The Record of Decision also concluded that the public's comments to make the standards up to residential levels, instead of the planned commercial, would only be implemented if the town acquired the land before the final decision deadline.

Remediation Technology, State Environmental Agencies, and Engineers

Crown Cleaners exemplifies the lengthy time scales of remediation projects. The contaminant was discovered in 1991 by the state of New York, promoted to the EPA's radar in 2000, investigated from 2004 to 2011, remediation strategies decided in 2012, and is expected to be remediated by 2025 (US EPA, *Record […]*, 2012; US EPA, *Crown Cleaners […]*, n.d.). Additionally, the case study demonstrates some of the complicated considerations for selecting remediation technology, as one concern about using bioremediation in groundwater contaminated with PCE is that VC could be produced if the de-chlorination process does not fully occur.

ANT Synthesis and Discussion of Insights

For remediation technology to be implemented in the Crown Cleaners case study, the actors must translate in the following ways: a chemical company must produce PCE, the toxic chemical; the dry cleaner applies for a hazardous waste generator permit to use PCE and the EPA approves it; the cleaners improperly disposes PCE; the state discovers the hazardous contaminant in the environment; the EPA acquires funding and hires engineers to design a remediation; and finally, the design is approved and implemented. The discovery of the contaminant in the environment is the obligatory passage point, as it ultimately instigates the necessity of remediation. The driver of protecting human health must be clear for remediation to start, except when there is imminent danger that requires emergency measures. However, actions of the other actors—like money being available, engineers designing, community approval, and government approval mechanisms—must also equally occur to make remediation endeavors successful.

So why are there so many dry cleaners with similarly contaminated sites? Because even under the US government's numerous regulations, there are insufficient protections against toxic chemicals. ANT reveals these incongruencies in chemical regulation. The chemical industry is given too much autonomy to bring new chemicals to market without proving they are safe first, the EPA is understaffed and unable to handle oversight of the thousands of chemicals on the market, and chemical-using industries are not given proper oversight to prevent waste from being improperly disposed of. Better oversight of harmful chemicals is necessary to prevent them from causing health and environmental problems. Possible improvements include the government's adoption of safety-first chemical regulations modeled after the EU's REACH program, closing loopholes in existing regulations that allow polluters to escape financial responsibility, and building out systems that allow for better management of hazardous sites.

I first recommend the US should replace the TSCA with a more fortified piece of legislation to shift the burden of proving chemical safety from the government to the chemical manufacturers. The EU has human safety as the priority of its chemical approval process. Instead of an approval process that has a deadline and is informed with fairly limited data, the EU requires chemical companies to prove to the agency that their products are safe. This helps prevent toxic substances from being introduced into society in the first place which has many benefits. The primary benefits are that chemicals are less likely to have to be investigated later for harmful effects; workers and other people are not exposed recklessly to unproven chemicals; and the fewer available chemicals, the fewer chances for environmental disasters. A program like REACH replacing the TSCA would go far to address some of its major downfalls. Also, it could potentially help us in the US to reconsider what is a toxic substance. I argue that putting the burden on chemical companies to prove their products do not harm humans or the environment could go far in helping to reduce many forms of pollution, not just toxic. Who knows, carbon dioxide emissions could end up being deemed harmful to the environment and human health, because it is well known that the compound contributes to the warming of the climate which creates physical phenomena that negatively impact humans.

To address the financial and limited human resources barriers to implementing remediation technology, legislation gaps need to be closed, funding needs to be readily available for remediation projects, and more efficient project management needs to be encouraged. Legislation could be passed to close loopholes in CERCLA that are sometimes taken advantage of by companies to escape financial responsibility. Additionally, an obligatory fund could be made to compel the manufacturers of known carcinogens to contribute, and the resources could be dispersed to help pay for remediation projects. The US should also attempt to reduce the timescales of remediation projects. If REACH was implemented in the US, the workers currently bogged down with chemical oversight could potentially shift focus to help manage hazardous sites and speed up bureaucratic processes.

We now have a basis for attempting to prevent the need for remediation but still need to clear up how to solve the monumental task of remediating the already contaminated sites. To look into this, further research on how governing bodies raise funding would have to be done. Additionally, it would be helpful to find out how many small polluters are held financially responsible for their actions. If I were to continue this project, I would like to focus on community engagement aspects of environmental remediation. Especially as environmental racism has been perpetuated in the US by historical discriminatory housing policies that lead to Black people, or other minority or low-income groups, living closer to industrial sites that pollute (Henderson and Wells, 2021, pg 139). I would like to investigate how often community concerns are implemented as goals of the project and what is done to help the people who were previously employed at sites where toxic chemicals were found to exceed acceptable levels. Additionally, I think it would be useful to investigate the differences between emergency versus non-emergency remediation projects.

References

Bedi, N., Lerner, S., & McGrory, K. (2022, December 14). *Why the U.S. Is Losing the Fight to Ban Toxic Chemicals*. ProPublica. https://www.propublica.org

Bioaccumulation and Biomagnification: Increasingly Concentrated Problems! (2023, March 20). Catalina Island Marine Institute. https://cimi.org

Bogardus, K. (2007, May 3). *Bankrupt companies avoid more than $700 million in cleanup costs*. Center for Public Integrity. http://publicintegrity.org

Callon, M. (1984). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *The Sociological Review*, *32*(1_suppl), 196–233. https://doi.org/10.1111/j.1467-954X.1984.tb00113.x

Chandler Jr., A. D. (2004). *Shaping the Industrial Century: The Remarkable Story of the Evolution of the Modern Chemical and Pharmaceutical Industries*. Harvard University Press. http://ebookcentral.proquest.com

Doherty, R. (2000). A History of the Production and Use of Carbon Tetrachloride, Tetrachloroeth...: EBSCOhost. *Journal of Environmental Forensics*, *1*, 69–81. https://doi.org/10.1006/enfo.2000.0010

Fitchen, J. M. (1987). Cultural Aspects of Environmental Problems: Individualism and Chemical Contamination of Groundwater. *Science, Technology, & Human Values*, *12*(2), 1–12. https://doi.org/10.1177/016224398701200201

Gerlach, C. (2016, October 25). New Toxic Substances Control Act: An End to the Wild West for Chemical Safety? [Academic]. *Science in the News*. https://sitn.hms.harvard.edu

Goldman, G., Carlson, C., & Zhang, Y. (2015). *A Major Lobbying Force* (Bad Chemistry, pp. 2–4). Union of Concerned Scientists. https://www.jstor.org

Hembra, R. (1993, April 21). *Superfund: Progress, Problems, and Reauthorization Issues*. [Testimony]. United States General Accounting Office. https://www.gao.gov

Henderson, S., Wells, R. *Environmental Racism and the Contamination of Black Lives: A Literature Review*. J Afr Am St 25, 134–151 (2021). https://doi.org/10.1007/s12111-020-09511-5

Jellinek, S. (2010, January 29). *Oral history interview of the toxic substances control act from the perspective of Steven D. Jellinek* (J. Roberts & K. Hardy, Interviewers) [Interview]. Chemical Heritage Foundation. https://digital.sciencehistory.org

Kollipara, P. (2015, March 19). The bizarre way the U.S. regulates chemicals—Letting them on the market first, then maybe studying them. *Washington Post*. https://www.washingtonpost.com

Landau, R., & Arora, A. (1999). The chemical industry: From the 1850s until today. *Business Economics, 34*(4), 7–16.

Lybarger, J. A., Lee, R., Vogt, D. P., Perhac, R. M., Spengler, R. F., & Brown, D. R. (1998). Medical Costs and Lost Productivity from Health Conditions at Volatile Organic Compound-Contaminated Superfund Sites. *Environmental Research*, *79*(1), 9–19. https://doi.org/10.1006/enrs.1998.3845

The Modern Environmental Movement | American Experience. (2010). PBS. https://www.pbs.org

New Proposition 65 Warnings. (n.d.). Proposition 65 Warnings Website. Retrieved February 2, 2024, from https://www.p65warnings.ca.gov

OSHA. (n.d.). *Transitioning to Safer Chemicals: A Toolkit for Employers and Workers | Occupational Safety and Health Administration*. [Government]. Retrieved February 12, 2024, from https://www.osha.gov

Percival, R. V. (n.d.). Regulatory Evolution and the Future of Environmental Policy. *THE UNIVERSITY OF CHICAGO LEGAL FORUM*.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S. I., Lambin, E., Lenton, T., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P., Costanza, R., Svedin, U., … Foley, J. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society*, *14*(2). https://doi.org/10.5751/ES-03180-140232

Rutledge, K., McDaniel, M., Teng, S., Hall, H., Ramroop, T., Sprout, E., Hunt, J., Brodreau, D., & Costa, H. (2023, October 19). *Air Pollution*. National Geographic Society. https://education.nationalgeographic.org

Sismondo, S. (2010). An Introduction to Science and Technology Studies. 2nd Edition. *Wiley-Blackwell*.

U.N. Environment Programme. (2018, October 29). *About Montreal Protocol*. Ozonaction. http://www.unep.org

US EPA. (2020, October 27). *Brownfields* [Overviews and Factsheets]. https://www.epa.gov

US EPA. (2013, August 20). *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Federal Facilities* [Other Policies and Guidance]. https://www.epa.gov

US EPA. (n.d.). *CROWN CLEANERS OF WATERTOWN INC. Site Profile*. Retrieved February 18, 2024, from https://cumulis.epa.gov

US EPA. (2023, June 7). *EPA History: Resource Conservation and Recovery Act* [Collections and Lists]. https://www.epa.gov

US EPA. (2023, June 8). *EPA Proposes Ban on All Consumer and Many Commercial Uses of Perchloroethylene to Protect Public Health* [News Release]. https://www.epa.gov

US EPA. (2023, November 21). *Evolution of the Clean Air Act* [Overviews and Factsheets]. https://www.epa.gov

US EPA. (2014, August 27). *Hazardous Waste Generators* [Collections and Lists]. https://www.epa.gov

US EPA. (2023, December 13). *Health and Ecological Hazards Caused by Hazardous Substances* [Overviews and Factsheets]. https://www.epa.gov

US EPA. (2024, January 3). *History of the Resource Conservation and Recovery Act* [Other Policies and Guidance]. https://www.epa.gov

US EPA. (2016, January 22). *Learn about Corrective Action* [Other Policies and Guidance]. https://www.epa.gov

US EPA. (2015, November 25). *Learn the Basics of Hazardous Waste* [Overviews and Factsheets]. https://www.epa.gov

US EPA. (2024, February 14). *Overview of the Safe Drinking Water Act* [Other Policies and Guidance]. https://www.epa.gov

US EPA. (2020, September). *Population Surrounding 1,857 Superfund Remedial Sites*. https://www.epa.gov

US EPA. (1999). *RCRA in Focus Dry Cleaning*. www.epa.gov/osw

US EPA. (2012, March). *Record of Decision for the Crown Cleaners of Watertown, Inc. Superfund Site*. SDMS Document 115780. https://semspub.epa.gov

US EPA. (2016, November 23). *Risk Evaluations for Existing Chemicals under TSCA* [Overviews and Factsheets]. https://www.epa.gov

US EPA. (2016, April 28). *State Authorization under the Resource Conservation and Recovery Act (RCRA)* [Collections and Lists]. https://www.epa.gov

US EPA. (2023, June 22). *Summary of the Clean Water Act* [Overviews and Factsheets]. https://www.epa.gov

US EPA. (2013, September 19). *Toxic Substances Control Act (TSCA) and Federal Facilities* [Other Policies and Guidance]. https://www.epa.gov

US EPA. (2013, July 24). *What is EPCRA?* [Overviews and Factsheets]. https://www.epa.gov

US GAO. (2023, April). *High-Risk Series*. United States Government Accountability Office. https://files.gao.gov

Villars, K. (2023, September 13). [Jackson Cleaners site information rundown]. Zoom.

15 USC Ch. 53: TOXIC SUBSTANCES CONTROL, Pub. L. No. 94–469, 15 U.S.C. 2601–2692. Retrieved February 13, 2024, from uscode.house.gov