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The Land's Liver

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The Land's Liver

Abstract
Economic progress seems to consistently come with a steep price tag. The Industrial Revolution was birthed in the 1800's, and as a result manufacturing, mining, transport, as well as other industries within our system systematically tainted viable water sources, contaminated soil, and increased greenhouse gases that include, but are not limited to, carbon dioxide and methane. By 1889 the first sewage treatment plant was installed at Washington D.C., but there were still a very small number of laws that were enacted in order to regulate the mounting amount of industrial waste. Not until 1970, almost 20 years after the fiery vision of the Cuyahoga River, did President Richard Nixon issue forth a mandate for change. In July of the same year, with Congress and the White House working collectively, the Environmental Protection Agency was formed in response to the public demand for an increase in quality standards that included the life sustaining elements; water, air, and land. On December 2nd of the same year, the Environmental Protection Agency opened its doors to fulfill its contract with America (EPA).

This paper fulfilled C. Turner's Honor Contract for Honors Botany. Her faculty supervisor was Professor Steven Giambrone.

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The Land’s Liver

> “In dealing with the State we ought to remember that its institutions are not aboriginal, though they existed before we were born; that they are not superior to the citizen; that every one of them was once the act of a single man; every law and usage was a man’s expedient to meet a particular case; that they all are imitable, all alterable; we may make as good, we may make better. Society is an illusion to the young citizen. It lies before him like a rigid repose, with certain names, men and institutions rooted like oak-trees to the centre, round which all arrange themselves as best they can. But the old statesman knows that society is fluid…politics rest on necessary foundations, and cannot be treated with levity. Republics abound young civilians who believe that the laws make the city, the grave modifications of the policy and modes of living and employments of the population, that commerce, education and religion may be voted in or out, and that any measure though it were absurd, may be imposed on a people if only you can get sufficient voices to make it the law. But the wise know that foolish legislation is a rope of sand which perished in the twisting… they only who build on Ideas, build for eternity; and that form of government which prevails is the expression of what cultivation exists in the population which permits…law is only memorandum” (Emerson 378)
>
> -Ralph Waldo Emerson
> *Politics*

1. Introduction

Economic progress seems to consistently come with a steep price tag. The Industrial Revolution was birthed in the 1800’s, and as a result manufacturing, mining, transport, as well as other industries within our system systematically tainted viable water sources, contaminated soil, and increased greenhouse gases that include, but are not limited to, carbon dioxide and methane. Factories, in the beginning, directly disposed untreated waste materials into our nation’s rivers, and our sewage lines flowed into these river systems additionally (Faughn, Chang, and Turk 519). By 1889 the first sewage treatment plant was installed at Washington D.C., but there were still a very small number of laws that were enacted in order to regulate the mounting amount of industrial waste (Faughn, Chang, and Turk 519). By November 1952, the Cuyohoga River, outside of Cleveland, was in flames due to pollutants, and only out of the rising smoke and flames was public awareness raised about pollution (Faughn, Chang, and Turk 519). Not until 1970, almost 20 years after the fiery vision of the Cuyahoga River, did President Richard Nixon issue forth a mandate for change. Nixon stated:

> "The 1970's absolutely must be the years when America pays its debt to the past by reclaiming the purity of its air, its waters, and our living environment. It is literally now or never" (Faughn, Chang, and Turk 519-520).

In July of the same year, with Congress and the White House working collectively, the Environmental Protection Agency was formed in response to the public demand for an increase in quality standards that included the life sustaining elements; water, air, and land. On December 2nd of the same year, the Environmental Protection Agency opened its doors to fulfill its contract with America (EPA).

2. Environmental Protection Agency Legislation

Under President Jimmy Carter's Administration, the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), better known as Superfund, was passed in order to help aid in governmental clean up of abandoned hazardous waste sites. This was partially in response to the disaster involving *dioxin* exposure in Times Beach, Missouri. CERCLA helped to launch

> “prohibitions and requirements concerning closed and abandoned hazardous waste sites, provided for liability of persons responsible for releases of hazardous waste at these sites, and established a trust fund to provide for cleanup when no responsible party could be identified” (EPA)

In order to help fund these hazardous sites, a tax was implemented on big polluters which included the petroleum and chemical industries. The tax was to be set aside in the aforementioned trust fund (Ivins 109). Two types of response action were authorized through this enacted law, and they included:

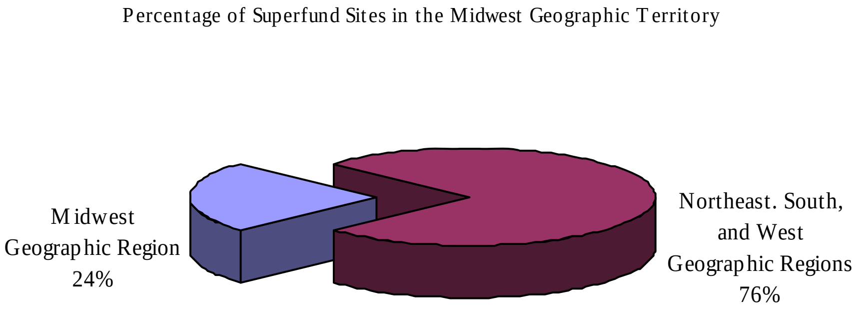
- Short-term removals, where the Environmental Protection Agency could tackle health threats requiring high priority response.
- Remedial responses that would address, and notably reduce, the long-term health hazards that were deemed non-life-threatening, but that were of impending threat. These sites only would be relevant to ones listed on the Environmental Protection Agency’s National Priority List, or *NPL* (EPA)

In 1986, the *Superfund Amendments and Reauthorization Act* (SARA) passed in order to augment funding for cleaning up hazardous waste sites, and for developing new and innovative technologies. But in 1995, when the Superfund trust fund had roughly speaking $3.3 billion built up, notwithstanding avid opposition from President Bill Clinton, the then Republican Congress refused to reinstate the tax as part of Newt Gingrich’s “Contract with America”. By the year 2002, the Superfund trust was depleted to $100 million dollars (Ivins 109). In February of 2009, and with the EPA trust fund being almost exhausted, President Barack Obama signed into legislation the *American Recovery and Reinvestment Act*. A function of this newly enacted legislation agreed to allocating money for the Environmental Protection Agency in order to help them control more than $7 billion dollars worth of projects and programs (EPA).

3. Superfund Sites

As of September of 2009, the Environmental Protection Agency has 1663 *NPL* (National Priority List) sites on their list (e.g. see fig. 1), of which 397 are to be found in the Midwest:

Figure 1

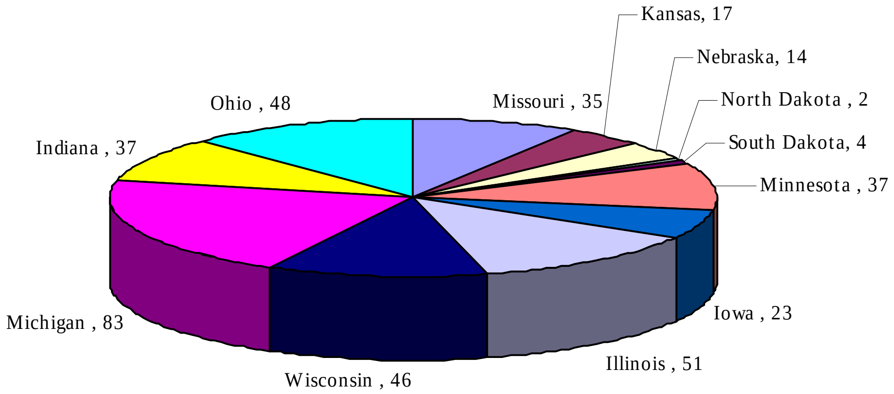


`Source: Environmental Protection Agency, Superfund Sites September 2009, Excel.`

In the Midwest, the state with the peak number of *NPL* sites is Michigan (e.g. see fig. 2), with 83 total sites. Missouri has 35 sites on the *NPL* list, 4 of which are in the Greater Kansas City Area (Clay and Jackson County), and Kansas has 17 sites, 2 of which are in the Johnson County area (Shawnee and Olathe):

Figure 2

Number of Midwest Superfund Sites by State



`Source: Environmental Protection Agency, Superfund Sites September 2009, Excel.`

4. Bioremediation and Phytoremediation

Phytoremediation and *bioremediation* are successful *in situ* technologies that can be used in combination with other technologies in order to uptake and transport contaminants into a plant’s body. Metabolic actions, as well as storing toxins, take place within the plant’s body and these remedies of action help to stimulate, speed up, and aid in breaking down wastes in the environment. While these remediation techniques do not produce instant results, as will be shown at the Cabin Creek and El Dorado sites, and certain health concerns are posed with phytoremediation, such as the food chain, this remediation technique should not be readily dismissed since many of the positives effects of the remediation technique outweigh the negative. In addition, certain actions can be implemented to lower the risks, such as *phytoextraction*. These types of remedial action have been demonstrated to be cost efficient, and cost effectiveness is a notable factor when budgetary restrictions are in place for approved projects.

An advantageous and novel approach to remediate soil containing, among other things, organic contaminants is *bioremediation*, or more specifically, *phytoremediation* as mentioned above. *Phytoremediation*, a form of *in situ* (in the site) remediation, also acknowledged as the *green liver model* (McCutcheon, Schnoor 61) is the usage of vegetative species, such as *vascular plants*, *mycorrihizal fungi*, and species of *algae* to uptake and transport contaminants, stimulate, speed up, and aid in the breakdown of wastes via *microorganisms* present at the sites. It also metabolizes wastes so that the plants detoxify the organic compounds or even store them in their tissues (McCutcheon, Schnoor 60-61). The *translocation* of contaminants, by methods such as, metals from the soil to harvestable plant or root tissue is *phytoextraction* (McCutcheon, Schnoor 25). *Translocation* of organic compounds is classically the most predominant method in which a contaminant penetrates the plants tissues through the *xylem* and *phloem* (McCutcheon, Schnoor 62). *Xylem* is a type of plant tissue that is involved in conducting the vast majority dissolved minerals and water; as where *phloem* is involved in food conduction (Stern 603-607). Three primary applications for *phytoremediation* are as follows:

- The execution of phytoremediation at hazardous waste sites when other methods of action are too cost prohibitive or unrealistic (El Gendy et al. para 3)
- When maintenance treatment is considered necessary over an extensive time period at low-level contaminated hazardous sites (El Gendy et al. para 3)

- And when phytoremediation can be used along with other remedies of action. (El-Gendy et al. para 3)

As mentioned earlier, *phytoremediation* tends to be less costly and also more aesthetically appealing than other technological advances such as *ex situ* (from the site) excavation techniques. But with this being said, *phytoremediation* is not at all times the best solution for ridding a site of contaminants. Fitting technologies should be evaluated on a site by site basis because success via *phytoremediation* is reliant upon geological and climatic conditions. It is also necessary to evaluating what contaminants are accessible for uptake through the plants root systems (Marques et al. para 5). For example, some contaminants have *hydrophobic* (phobia of water) high-molecular weights while others have *hydrophobic* moderate to low-molecular weights (El-Gendy et al. para 1). *Hydrophilic (*water friendly) molecules are inherently able to bond more readily (McCutcheon, Schnoor 65). Also problematical scenarios can potentially arise, such as when the contaminated wood is used as fuel or when the abscission of fall leaves release toxins back into the natural world (Marques et al. para 5). Wastes that have the ability to be managed through phytoremediation include, but are not limited to, air pollutants, *xenobiotic* chemicals, and radioactive nuclides (McCutcheon, Schnoor 5).

5. Metabolism

In various ways, the plant’s process of metabolizing *xenobiotic* chemicals is very akin to mammalian liver functions. One case in point includes the metabolic steps of the plant. In plant and mammalian species, *xenobiotic* toxins are “essentially eliminated and removed from active *organelles*” (McCutcheon, Schnoor 61). *Organelles* can be defined as bodies that are positioned within the cell (Stern 31) and the most remarkable similarity of the green-liver model to mammalian liver functions is "the broad range of substrates and enzymes that act on these substrates. The transformation and elimination mechanisms, of green-liver metabolism, have shown to be active for a diverse and wide range of xenobiotic organic compounds" (McCutcheon, Schnoor 61). There are three steps in plant and mammalian metabolic systems, and they include *chemical transformation*, *conjugation*, and as a final point the elimination or storage of the contaminant (McCutcheon, Schnoor 66-67).

Chemical Transformation, the first step in metabolizing organic compounds, converts a substrate through the catalyzing of *enzymes* (McCutcheon, Schnoor 68). *Enzymes* are proteins and catalyze chemical reactions in cells, but are not used in the reactions they cause (Stern 166). The first transformation involves several different reactions, which include many *oxidation-reduction reactions*. *Oxidation* is the process in which electrons are lost, and typically involve oxygen although oxidation can transpire without oxygen being involved (Stern 167*). Lipophillic compound oxidation* is an exceedingly important factor in increasing solubility which leads to giving an occasion for the life form to conjugate (McCutcheon, Schnoor 68). Molecules that include, but are not limited to, fats and waxes are *lipids* (Stern 23); *lipophilicity* is the ability of roots to allow uptake of organics, as well as "the distribution of a chemical between the soil solution and the *lipids* in the plant cell (McCutcheon, Schnoor 361). *Oxidations* opposite, *reduction*, involves the gain of electrons (Stern 167).

Following *chemical transformation*, *conjugation* (when atoms are covalently bonded in organic compounds) is more often than not the next step in the detoxification and metabolizing process of the plant although some compounds have been found to conjugate prior to transformation (McCutcheon, Schnoor 69). After *conjugation,* the resulting *conjugates* are typically less toxic and have increased solubility. *Conjugates,* as has been found, “can be deposited into vacuoles or incorporated into bound residues through sequestration” (McCutcheon, Schnoor 69). Almost 90% of a living plant cell is composed of one to two *vacuoles*. At one time it was understood that the *vacuole* was composed of categorically nothing but vacant space, but in recent years it has been found that the *vacuole* is made up of a watery like fluid called *cell sap*. Pressure within the cell is maintained through cell sap, and the watery fluid is acidic in nature (Stern 43).

6. Mychorrhizal Fungi

Plants have an array of different shields within vulnerable sites within cells that prevent damaging effects; however, when toxins, such as metals, accumulate in tissue the contaminants can habitually cause toxicity problems that lead to direct damage of the cell structure. Studies have shown that plants with *mycorrhizal fungi* attached to the root system are sheltered against toxic levels of contaminants in the soil such as heavy metals and radionuclides (Nellessen, Entry para 12). *Mycorrhizal fungi* forms a symbiotic relationship between the plant’s roots in one of two ways; it can be a mutualistic relationship in that it benefits both species, as with preventing heavy metal build-up, or it can be injurious to one species and benefit the other, as in the case with parasitism (Stern 606). One study in particular focused on preventing build-up, such as with heavy metals, and hampered interchange primarily due to the plants *fungal sheath* (Marques et al. para 6). The *fungal sheath* that is associated with the fungi prevents direct contact between the plant's root system and the surrounding soil (Nellessen, Entry para 2). Under these conditions, this relationship allows the plant to endure soil conditions that would normally not be able to sustain healthy growth patterns (Nellessen, Entry para 2). In addition, *mychorrhizal fungi* play a significant role within our ecosystem because they improve the structure of the soil via *fungal hyphae* that extend throughout the soil. This helps to increase infilteration, and can increase moisture, but also aids in aerating the soil which is a crucial element in breaking down contaminants (Nellessen, Entry para 11).

7. Root Systems

Land plants root systems are generally considered to be the "hidden half" of the species and the development of root systems range from *xerophytic* (deep-penetrating roots that grow in dry conditions), to the shallow root systems that are predominant in short-season annuals (McCutcheon, Schnoor 235). The functions of plant roots are extensive. The roots first and foremost anchor the plant in the soil, provide for support, and also allow the plant to uptake and transport solution in the soil and disseminate throughout the plant's tissues (McCutcheon, Schnoor 235). Additional functions include "metabolism and storage of carbohydrates and other metabolites, the synthesis of plant hormones, the secretion of exudates that provide a growth medium for free-living rhizosphere organisms, and the formation of intercellular air spaces that permit diffusion of air to the respiring root tissues"(McCutcheon, Schnoor 235-236). *Exudates* are organic and inorganic compounds that are of low molecular weight. These compounds routinely inertly leak from the cells of plant roots, and include, but are not limited to, simple carbohydrates as well as small organic acids (McCutcheon, Schnoor 337).

8. Poplars

The genus named *Populus*, more universally known as a Poplar, is a deciduous flowering plant with *phreatophyte* root system that can grow up to 10 mm per day, attaining lengths as much as 12 m. They can penetrate the *phreatic zone*, or *zone of saturation* (El-Gendy et al. para 28) which is the “subsurface zone of soil and rock that is completely saturated with water” (Faughn, Change, Turk G-12). Although there is limited information known about the ability for rooting in genus *Populus* in *phytoremediation*, there have been a few noteworthy examples. One case in point documented growth grate at 3.9 mm per day. Conditions differed due to changes in induced air in the root zone (El-Gendy et al. para 28) and found “that poplars can transport oxygen to the root zone in the *aerenchyma* of the vascular plant system; however, as the roots grew, they released plant *exudates* which are used by *microorganisms* in the *root zone*” (El-Gendy et al. para 35). *Plant exudates* have proved to be a more functional source of carbon (El-Gendy et al. para 35) and the previous value was used to approximate the growth of installed Poplar trees at Cabin Creek, West Virginia, past location of Pure Oil Refinery that discontinued operations in 1954 (El-Gendy et al. para 28).

9. Cabin Creek

Cabin Creek was the first phytoremediation project approved by the West Virginia Department of Environmental Protection (WVDEP) designated to clean up the contaminated site's groundwater and soil. The WVDEP evaluated Cabin Creek in 1996, and 1997, and concluded that the site's soil and groundwater were dirtied with *petroleum hydrocarbons*. Planting of approximately 5000 poplar trees began in 1999, and utilized other remediation techniques. As well, it was projected that the poplar tree roots would reach below ground surface in roughly 33 months (El-Gendy et al. para 9).

The conclusion of the Cabin Creek project has been that *phytoremediation* is functioning well at the site, although there were early complications due to unsatisfactory water levels that lead to unviable trees(El-Gendy et al. para 11 and 52). *Petroleum hydrocarbon* concentrations that were previously present in the soil and groundwater decreased, and in addition, concentrations of BTEX, collectively known as *benzene*, *toluene*, *ethylbenzene*, and *xylene*, as well as *gasoline range organics* (GRO), have occasionally fallen beneath the required action levels of the WVDEP. Unfortunately, the presence of *diesel range organics* (DRO) appears to be increasing (El-Gendy et al. para 52). One might speculate that the *hydrophobic high-molecular weight compound* reduced the poplar's ability to satisfactorily uptake and transport the DROs through the root system. This on-going trend of increasing DROs is currently being evaluated by the WVDEP in order to conclude what remedial actions should be taken to reduce the imminent health threat (El-Gendy et al. para 52)

10. El Dorado

No examples of *phytoremediation* for Superfund sites are present in the Midwest area, but there is one example of *bioremediation* being conducted by the EPA in El Dorado, Kansas (Wilson interview).

The aforementioned site in El Dorado was built in 1917, approximately two years after the unearthing of oil in the state of Kansas. In the year 1958, Fina Oil and Chemical Company purchased and acquired the land and a burn pond was dredged at the site. Petroleum-wastes that were generated through Fina's business were disposed by way of a pipe (waste products that did not burn entered the pipe) that ran from the refinery to the burn pond. The byproducts that were stored in this burn pond ranged from slop oil emission solids to heat exchanger bundle cleaning sludge ("Third-Five Tear Report: Pester Refinery Site" 4)

The El Dorado site was residence not only to the refinery and the burn pond, but also a storm water pond and a settling pond that was significantly smaller than the others. A dike had been initially installed to divide the burn pond and the storm water pond, as well as a dike to divide the storm water pond from the smaller settling pond ("Third-Five Tear Report: Pester Refinery Site" 4)

Systematically, and initially with the dike that had been installed to separate the burn and storm water ponds, every dike was breached ("Third-Five Tear Report: Pester Refinery Site" 4).

In reaction to this disaster, Fina installed an open interceptor trench. The trench's sole function was to avert seepage from entering the West Branch Walnut River from the breached pond that was now L shaped. Even though trenches of this variety typically proved to be effectual for projects of this scope and magnitude, the trench intermittently became flooded with contaminants and the trench would inadvertently discard waste materials into the West Branch Walnut River ("Third-Five Tear Report: Pester Refinery Site" 4).

In 1977, Pester purchased the site from Fina and continued refinery operations. Pester filed for debt protection by filing for bankruptcy in 1985. But prior to bankruptcy, Pester had sold off the refinery to Coastal Refining and Marketing, with the exception of the burn pond. To this day, Pester still has sole possession of the burn pond ("Third-Five Tear Report: Pester Refinery Site" 4).

The EPA's initial response to the El Dorado site was in 1980, and a preliminary assessment by the EPA determined the need to monitor the area for contaminants. In 1986, the KHDE issued an administrative order. In this order, monitoring, surface impoundment investigation, and burn pond closure was mandated. In reaction to the administrative order, Pester hired MWEC, or better known as Mid West Environmental Consultants, to conduct an investigation into the range of contaminants present at the site. ("Third-Five Tear Report: Pester Refinery Site" 5) This involved the "installation of monitoring wells, pond sludge volume determination, soil sampling, sludge sampling, and surface and water sampling" ("Third-Five Tear Report: Pester Refinery Site" 5). In 1989 the site was placed on the *NPL* list ("Third-Five Tear Report: Pester Refinery Site" 5).

After a consent order was signed by Pester, in 1990, additional monitoring wells were installed at the site in order to reveal the volume of sludge present. Other testing included a tracer test, sludge, soil, and groundwater collections, as well as sampling and testing subsurface water. 20,000 cubit yards of sludge was determined to be contaminating the Pester site. Oil staining went down as far as five feet above the *alluvial aquifer* ("Third-Five Tear Report: Pester Refinery Site" 5), which is a porous and permeable layer of underground rock that has the ability to store sizeable amounts of water (Faughn, Chang, and Turk G-1). The *upper alluvial* aquifer was found to have *volatile* and *semi-volatile organic compounds*, as well as *polycyclic aromatic hydrocarbons*, and the lower bedrock aquifer was not found to be contaminated due to a layer of shale ("Third-Five Tear Report: Pester Refinery Site" 5). The ability for the compound to vaporize is dependent on its volatility, and semi-volatiles evaporate less easily than volatiles. In soil vapor extraction (SVE), the soil contamination should be trapped, be highly permeable, and the contaminant should be highly volatile as is the case with benzene, toluene, and xylene (Wang, Shammas, and Hung 39)

As a remedy action, the sludge present on site was excavated via *ex situ; in situ* treatment for the soil was to be via soil flushing and *bioremediation*. This chiefly consisted of pond aeration, the addition of soil as well as nutrients, and the installation of subsurface interceptor trenches and extensions all of which helped to speed up the *biodegradation*. Aerating, and adding soil and nutrients were not dictated to be carried out in winter months due to the inefficient levels of *biodegradation* ("Third-Five Tear Report: Pester Refinery Site" 10).

This project is still being monitored by the Environmental Protection Agency, and site improvements have been made through the usage of *bioremediation*, although it is noted that efficiency levels using this technique started to wane in the year 2001. The next review of this site will be done in the year 2014 ("Third-Five Tear Report: Pester Refinery Site" 43)

11. Toxins at Cabin Creek and El Dorado Site

A small number of the toxins present at the Cabin Creek and El Dorado site, (e.g. see fig. 3) as well as their compound type and potential heath risks that are associated when exposed to these types of contaminants are listed below.

Table 1a

Toxic Compounds Found at the Cabin Creek and El Dorado Sites

Toxin	Category	Compound	Molecular Formula or Symbol	Appearance	Site	Health Risks include, but are not limited to:
Benzene	Aromatic Hydrocarbon	Volatile Organic Compound	C_6H_6	White, crystalline, and solid.	Cabin Creek and El Dorado	Respiratory, neurological, immunal disorders and leukemia.
Ethylbenzene	Aromatic Hydrocarbon	Volatile Organic Compound	C_8H_{10}	Colorless liquid	Cabin Creek and El Dorado	Neurological, pulmonary, and carcinogenic
Methylnaphthalene	Aromatic Hydrocarbon	Semi-Volatile Organic Compound	$C_{11}H_{10}$	Liquid	El Dorado	Anemia, cancer.
Naphthalene	Aromatic Hydrocarbon	Semi-Volatile Organic Compound	$C_{10}H_8$	White solid, and crystal flakes	El Dorado	Anemia, cancer.
Polycyclic Aromatic Hydrocarbons	Aromatic Hydrocarbon	Semi-Volatile Organic Compound	n/a	Varies by compound	Cabin Creek and El Dorado	Cancer
Toluene	Aromatic Hydrocarbon	Volatile Organic Compound	C_7H_8 or $C_6H_5CH_3$	Clear, colorless liquid	Cabin Creek and El Dorado	Neurological and kidney disorders
Xylene	Aromatic Hydrocarbon	Volatile Organic Compound	C_8H_{10}, $C_6H_4(CH_3)_2$, or $C_6H_4C_2H_6$	Clear, colorless liquid	Cabin Creek and El Dorado	Neurological and changes in kidney, as well as liver functions
Barium	Element	Metal	Ba	Silvery-white	El Dorado	Kidney damage
Fluorine	Element	Halogen	F	Yellowish-brown gas	El Dorado	Bone density and respiratory problems
Lead	Element	Metal	Pb	bluish-gray	El Dorado	Neurological, fertility problems
Arsenic	Element	Metalloid	As	Varies	El Dorado	Cardiovascular, respiratory, cancer
Chromium	Transition Metal	Metal	Cr	Steely gray	El Dorado	n/a

Source: Center for Disease Control Agency for Toxic Substances and Disease Registry, Tox FAQ's.

12. Conclusion

So why, ultimately, should we persist in exploring *bioremediation* and *phytoremediation* technologies if these remedial actions do not always eradicate the hazardous wastes present in their environment. How do we make sure that the process itself does not have the probability to cause health threats through food chain contamination? If these remedies are cost effective, and reduce contaminants within their environment, deployment of these techniques should not be ignored, and ridding cleaned up sites of hazardous vegetative material can be achieved. In the case of *phytoextraction*, contaminated plants not fit for consumption can be harvested, dried, and through a high-pressure compaction process can be reduced in volume (Erickson, Fuhrmann para 10). Once the plant has gone through this process it can be disposed of appropriately. Although *phytoextraction* is still under development, and is not as developed as other extraction methods, it is still a viable option (Erickson, Fuhrmann para 10).

Moral dilemmas and problematic decision-making that involve environmental regulation arise frequently, if not by the minute, for lawmakers and concerned citizens. When faced with daunting issues that can reap positive or negative fruits, specifically when quality of life is involved, it is crucial to systematically ascertain that the choices made reap positive benefits. However the goal should be to maintain equilibrium between economic progress and environmental friendliness. As we have witnessed in years gone by, goods certainly do have the ability to be manufactured in a more cost effective manner and this came with a price; industrial wastes were directly deposited into our ecosystem and the land that provided for crop nourishment, pristine water, and the air that we breathe became unsuitable (Faughn, Chang, Turk 520). Governments' role in regulating waste disposal is legitimate; but how much pollution control should companies have to pay for, and can there be such a thing as too much environmental regulation (Faughn, Chang, Turk 520-521)?

Environmental regulation in order to curb pollution control is not a back and white issue, yes or no question, and some proponents have argued that "pollution control measures should be applied only when it can be shown that there is a positive economic return on the investment" (Faughn, Chang, Turk 521). A counter argument, by opponents, is that money is not the only issue at stake and that quality of life should be measured rather than return on investment (Faughn, Chang, Turk 521). The latent effects from environmental pollutants include, but are not limited to, deteriorating health concerns, which leads to higher health care costs, as well as other potential long-term ramifications. When implementing any regulation, quality over quantity should be measured and it is government's legitimate right to take this course of action (Faughn, Chang, Turk 520). Quality of life should not simply be discarded like a waste product for monetary reasons. Can value really be placed on something as irreplaceable as our land, water, and air? What price will we ultimately pay if that is done? Everything has a price, and prices to be paid do not always equate to a monetary unit.

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