Remediation Options for 444 Hebron Road

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Introduction

The brownfield site at 444 Hebron Road, previously a Meritor manufacturing plant, consists of two major contamination zones. The first zone is a former landfill area located on the northeastern corner of the property. The second zone is located on the southern end of the existing building foundation and consists of a Polychlorinated Biphenyl (PCB) oil plume. Chlorinated solvents from this contamination have also leeched into the groundwater and spread across the eastern portion of the property and into the residential communities located adjacent to the Meritor property.

The redevelopment plans for the site also took the existing foundation of the factory building into account. For now, the slab that acted as the building's foundation will be left in place during demolition, so I address the possibility and mitigation of vapor intrusion from unknown contaminants that may be under the slab. There is no concrete knowledge of the conditions under this foundation, or if vapor intrusion will occur; however, the mitigation options outlined can be utilized whether the slab is eventually removed or not.

Some remediation of the site has already occurred, but more can be done to ensure the long-term health and sustainability of this property, as well as the environment surrounding it. As seen with the spread of the chlorinated solvents, contamination is often not contained to the site of its initial occurrence, and remediation is crucial to preventing the spread of its ill-health effects to the healthy environment surrounding it.

Remediation of PCBs

PCBs are persistent pollutants that cause a number of health effects and are often hard to remove from soil because of their hydrophobic properties that allow them to strongly bond to soil particles. Research on the remediation of PCBs typically lays out two forms of remediation: microbial degradation and phytoremediation. Forms of microbial degradation have already been implemented at the Meritor site; however, remediation tactics like phytoremediation can be added to continue these processes and optimize the amount of PCB removed from the soil.

Microbial Degradation

There are two types of microbial degradation that can be used in the remediation of PCBs. The first is anaerobic dechlorination, which degrades PCBs that are more highly chlorinated by removing the meta and para chlorines of the PCB congeners (Abramowicz, 1995). Aerobic bacteria are able to degrade less chlorinated PCBs, and aerobic biodegradation is much more widely studied than anaerobic dechlorination. Certain microorganisms aerobically degrade PCB congeners and convert them into chlorobenzoic acids. These acids can then be broken down by native bacteria into “carbon dioxide, water, chloride, and biomass” (Abramowicz, 1995).

Phytoremediation

Another way to approach the removal of contaminants from a brownfield site is through the use of plants, otherwise known as phytoremediation. Since plants are often exposed to a number of toxins, both manmade and naturally occurring, many have developed systems to prevent effects of exposure to these harmful compounds (Aken, Correa, & Schnoor, 2010). Phytoremediation harnesses these plants' natural abilities to degrade toxins that exist in the soil.

There are six types of phytoremediation: phytosequestration, rhizodegradation, phytohydraulics, phytoextraction, phytovolatilization, and phytodegradation (Phillips, 2019). Each term refers to the different processes in which plants take up and store contaminants. For the remediation of PCB compounds and groundwater, rhizodegradation is the most effective process. This process occurs in the soil and groundwater that surround the plant's roots (Phillips, 2019). As mentioned before, PCBs are hydrophobic and bond strongly with soil particles, meaning they are not easily remediated by plant roots (Aken, Correa, & Schnoor, 2010). Instead, the microbes that exist in the rhizosphere play a large role in the successful remediation of PCBs.

The process for rhizoremediation works when plants release compounds into the soil, which stimulate the bacteria in the rhizosphere. These bacteria then contribute to the microbial degradation of the PCB compounds in the soil (Aken, Correa, & Schnoor, 2010). Although phytoremediation of PCBs can take longer and is more difficult than with other toxins, studies show that the presence of certain plants leads to better remediation of PCBs than areas without these plants (Chekol, Vough, & Chaney, 2004).

Types of plants.

Specific plant species are needed to successfully remediate PCB compounds from the soil. Phytoremediation works best with plants that have fibrous root systems, making grasses the perfect candidate for the process (Shahsavari, Aburto-Medina, Taha, & Ball, 2016). The root systems of grasses have the highest root surface area of other plants, and an ability to develop up to three meters into the soil, generating a very large surface area for the microbial degradation to occur. Grass species also have a high genetic diversity, making them more resilient in harsh environments like those with contaminated soils. Another benefit to grasses is their fast-growing ability, and their ability to cover a wide area of land (Shahsavari, Aburto-Medina, Taha, & Ball, 2016). Phytoremediation is typically a slower process than other remediation options, so the ability of grasses to grow rather quickly is an advantage.

Another studied option for phytoremediation of PCBs is the planting of legumes. One advantage of the use of legumes over grasses is their ability to fix nitrogen, which, unlike grass species, can add much-needed nutrients to poor quality soil (Shahsavari, Aburto-Medina, Taha, & Ball, 2016). Overall, both grasses and legumes showed success in removing PCBs and other toxins from the soil when compared to areas that were unplanted (Chekol, Vough, & Chaney, 2004). When tested, reed canary grass, switchgrass (which is native to Ohio), tall fescue, and deer tongue all showed improvements in contamination levels of the soil. Shahsavari et al. found that when these grasses were planted, 62% of PCB removal was observed compared to only 18% in unplanted soils. Canary grasses, along with alfalfa species for legumes, had the highest success rates. Other studies by Chekol et al. found even higher rates of PCB removal when the same species were planted, compared to unplanted soil tests.

Planting and removal.

Once soil has been tested and the best type of plant for the site's remediation has been determined, the plants can be transplanted onto the site. After about 14 weeks, plants will be saturated with contaminants and toxins, in this case PCBs (Kühl, 2010). The plants must be removed, with roots included, and disposed of as hazardous waste. New plants can then be reintroduced once the climate permits for ideal growing conditions. The use of plants on the PCB-contaminated area is ideal, because the space cannot be utilized for much else. Considering our previous proposals to implement photovoltaics on this portion of the land, the planting of species like grasses or legumes is a great way to utilize the space around the panels, while also contributing to the remediation of toxins.

Landfill Remediation

Unlike the PCB contaminated areas, the landfill zones on the property cannot be breached; therefore, remediation options are focused more on creating a barrier between the contamination and surface, rather than the removal of contaminants. The remediation of these areas also relies heavily on the use of the land. The contaminants on this site are capped with a membrane, meaning the actual contamination is presumably already contained. Assuming this portion of the property is to be used for solar panels as proposed by our ENVS Practicum class, the most logical option is to bring in soil fill to place on top of the landfill areas. This type of remediation was already done at Newark's Wastewater Treatment Plant, which is a great example of how the space at 444 Hebron Rd. can be remediated and utilized.

At the Newark Wastewater Treatment Plant, a geofabric was used to cover and contain aluminum waste materials left at the site. Two feet of fill were then brought in and placed on top of this cap, similar to the one at the Meritor site. The soil can be graded, in this case it was graded 5%, to optimize the property's capabilities to produce solar energy. The capping of the contamination with two feet of soil took about a year to cover 15-20 acres of land at the Water Treatment Plant. Once the soil fill is imported and placed, nothing can be built or planted on top, so as to not breech the membrane on top of the contaminants, making the implementation of solar one of the most logical uses of this portion of the site.

Vapor Intrusion

Vapor Barriers

One way to mitigate the possibility of vapor intrusion is the use of a barrier that is applied under a new foundation or over a pre-existing one to seal in any contamination and prevent vapors from rising into the new structures developed on the site (Carvalho & Martin, 2007). These membranes come in the form of polyethylene sheet liners, like the geomembrane mentioned in the landfill section, or a liquid-applied barrier like Liquid Boot ®. The sheet liner systems are rolled out and secured to grade beams and footings, and the seams are sealed with heat by welding them together (Carvalho & Martin, 2007). Liquid-applied barriers like Liquid Boot ® are much easier to use and more cost effective for foundations that have complexities or irregularities. This type of barrier is made from an asphalt emulsion, which is applied by spraying the emulsion in two parts onto the foundation surface, allowing the two parts to chemically react to create a solid membrane. The ability of this type of barrier to conform to almost any surface would most likely make it the best option for the Meritor site, still assuming the slab is left in place. Because the slab has deep pits and irregularities from now-removed production equipment, the application of a liquid barrier would be ideal to cover all possible surfaces in which vapors could escape.

Vacuum Systems

Another way to mitigate vapor intrusion is through the use of depressurization systems that work to keep the vapors sealed beneath the slab (Peeples, 2019). This system works by implementing a permeable layer beneath the new foundation and using a depressurization system to create a vacuum. The application of this system is ideal for new foundations, but if there is already a permeable layer beneath the pre-existing slab, air can still be extracted to create the needed vacuum. With this method, ports are also able to be installed to occasionally check for the presence of a vacuum (Peeples, 2019). As long as a vacuum is created, there is no risk for vapor intrusion into the newly built structures. These systems are also useful when used in conjunction with the vapor barrier methods described above.

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