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EDB Cleanup: Restoration Efforts at Brookhaven National Laboratory

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Introduction to the Contaminant

Ethylene dibromide, otherwise known simply as EDB, is a colorless liquid chemical with a mildly sweet odor that has been produced by humans, specifically for human use, but also naturally occurs in algae in relatively small amounts in the ocean. Ethylene dibromide is also commonly referred to as 1,2-Dibromoethane or glycol bromide. One of the major uses for EDB has been as a gas additive to prevent lead build-up in engines; it was especially popular on military bases. Since leaded gasoline is now banned, however, EDB is no longer used for this purpose. Due to its effectiveness as a fumigant, ethylene dibromide was also commonly used as an agricultural pesticide to guard against nematodes and fruit eating insects and worms (Brookhaven Science Associates [BSA] 1996). Farmers would spread EDB on their fields prior to the growing season.

In 1984, shortly after the potential hazards of this chemical were discovered, the U.S. Environmental Protection Agency banned the use of EDB as a pesticide (Steinberg 1987). The potential hazards that were discovered dealt mainly with human health. The effects of breathing low levels of EDB have been found to cause liver and kidney damage; breathing high levels can cause death. Its slow chemical conversion in aqueous solutions gives it the potential to leach into groundwater, possibly well-water, and if ingested in large quantities it will cause death and if exposed to skin it can cause severe blisters. Certain birth defects have also been found in studies done on mice.

Currently, ethylene dibromide is being used in the preparation of dyes and waxes, to protect wood from termites, and to control moths in beehives (Poelarends 1999). EDB is still being produced in some countries to reduce lead build-up, as a pesticide for stored grain, and as an intermediate in the synthesis of pharmaceuticals.

Introduction to Brookhaven National Laboratory

Brookhaven National Laboratory (BNL) is a U.S. Department of Energy laboratory located in Long Island, New York with a diverse mission including the fields of physics, biology and chemistry (Rau 1999). Among the many experiments performed at BNL were agricultural experiments that took place during the 1960s and 1970s. These experiments were conducted on 340 acres of what BNL refers to as the "Biology Fields" in the southeastern area of the site. For restoration purposes, this area of Brookhaven is also called Operable Unit VI (BSA 1996).

The experiments undertaken at the Biology Fields measured the effects of acid rain and ozone on agricultural crops. Before testing was done on this site, ethylene dibromide was used to sterilize the soil. When these experiments took place at BNL, the effects of EDB on the environment

were not yet known. Since then, however, it has been determined that the chemical has leached and become a hazardous component of the underlying groundwater in the area.

The contaminated groundwater has been found at depths of 90 to 130 ft below the surface of Operable Unit VI and is at concentrations higher than the New York Drinking Water Standard of 0.05 parts per billion (ppb) (BSA 1996). The ground water now threatens Long Island's sole source aquifer. Constant disputes from neighboring residents who fear their well-water is threatened, and a call from local legislators to have the laboratory shut down, resulted in major administrative changes; Brookhaven Science Associates, has led remediation efforts.

Initial Efforts to Remove EDB from the Site

In 1986, the first seven ethylene dibromide pools were discovered in the groundwater at Brookhaven National Laboratory. In an effort to remove the EDB, the lab set up a series of pumps to pull these contaminated pools out of the ground for decontamination. Soil testing prior to pumping and shortly after pumping showed that these pumps inadvertently pulled other EDB plumes (rising or expanding fluid bodies) closer to the area's surrounding neighborhoods. On top of this, when the cleaned water was put back in the ground, it pushed other pollutants even deeper below the surface (Rau 1999).

In 1989, BNL was placed on the U.S. Environmental Protection Agency's "National Priorities List" because of the environmental effects of past practices. The new team of directors has agreed that a restoration plan must be devised to reduce the EDB levels in the groundwater to a level that meets New York State standards. The proposed restoration plan includes the following two actions: to protect human health and the sole source aquifer, and if necessary, to control and provide appropriate treatment of contaminated groundwater to prevent its further migration (BSA 1996).

Under what has been called the Interagency Agreement, the U.S. Environmental Protection Agency is working with the U.S. Department of Energy to reduce amounts of EDB in the Biology Fields and restore the site to its state prior to contamination (Johnson 1998).

Current Efforts to Remove EDB from the Site

Because the original pumping system was doing more harm than good, it was decomissioned in 1990. Before the restoration team attempted other methods of EDB removal, they decided a more thorough investigation of the groundwater, soils, and sediments should be done to assure a restoration typical for this type of site would be applied (Department of Energy [DOE] 1997).

By 1995, Brookhaven National Laboratory had come across five plumes, containing both solvents and ethylene dibromide, which were beginning to move beyond the southern boundary of the Biology Fields. They were too deep to have much affect on residential wells, but as a precautionary measure, the Department of Energy offered public water hookups to residents south of the site (Mukerjee 1998). Over 900 homes and businesses have been connected to public water since 1995. Current information reveals that groundwater is moving in a southeasterly direction (BSA 1996). The closest residential drinking water well lies about 1000 feet east of the

contaminated site and is believed to be out of the contaminant's path. The property above the EDB plumes is currently undeveloped and has been zoned for commercial use (BSA 1996).

Among some of the removal methods tried by the restoration team was a relatively new in-situ technique called phytoremediation. This technique, which implemented plants with deep roots, is intended to draw EDB out of the soil through the root system and then expel the contaminant as a non-hazardous gas into the atmosphere. With the exception of a few species of *Brassica* (mustard plant) and *Carex* (grasses), this procedure proved relatively unsuccessful because most plants did not readily accept the contaminant into their root system. Plants that did absorb the ethylene dibromide became hazardous waste themselves and had to be contained so that birds and wildlife would not ingest the contaminant and spread it through the food chain. Containment of the plants was attempted by harvesting and fencing off the affected plant. Complete containment was not feasible, however.

Another in-situ technique, called vitrification, was also applied for a short time to remove the EDB (Rau 1999). In-situ vitrification is a thermal treatment process for the in-place destruction and immobilization of contamination in soils. Electricity produces temperatures of up to 2000 ° C, which is high enough to melt the soil. The result of vitrification is a chemically stable, leach-resistant, glass and crystalline material similar to basalt rock. Contaminants such as ethylene dibromide are then trapped in the solid product and consequently become non-hazardous because it can't leach any further (Ames laboratory 1994). While the method is effective, widespread use is not economically feasible and has forced the lab to look into, yet, other options.

Pumps similar to those installed in 1986 have been installed again but with significant improvements. The contaminated water is being pumped out of the ground at a rate of 1,300 gallons a minute and is piped to a treatment facility where the EDB is separated out through carbon filters situated above ground. Clean water is then released to a recharge basin approximately one mile north of BNL's southern boundary, and the contaminant is released into the air at levels that meet New York guidelines. While the "pump and treat" method can effectively reduce contamination in groundwater, it isn't always the most efficient in removing lower concentrations of contaminants such as the ethylene dibromide found at BNL. More pumps may be added as they are needed if this method proves successful. Continuous monitoring would be expected to last until the year 2030 (Rau 1999).

In the future, BNL hopes to establish the construction and operation of an air sparging / soil vapor extraction system to also treat the soils on site (DOE 1997). Air sparging is the process of injecting air directly into groundwater, which then volatilizes contaminants and enhances biodegradation. Similar to blowing bubbles through a straw, as the bubbles in the groundwater rise, the contaminants are removed from the groundwater by physical contact with the air and are carried into the soil. A vapor extraction system is then used to remove the harmful vapors.

Soil and groundwater data have shown that the EDB has migrated as a pocket of contaminated water and is not coming from a continuous source. Many of the team members are optimistic that natural attenuation over time will aid in the dilution and dispersal of EDB to safer, less toxic levels. The restoration plan considers "safe" to be at a level within federal drinking water standards. EDB contamination that is within government standards or is in an area that is not an

immediate threat to humans is not a priority at this time. The restoration is expected to be complete by either 2004 or 2006 depending on the amount of funding. By "complete" they mean all remediation is achieved and all groundwater treatment systems are operational. Monitoring of these systems, however, is expected to go on for at least two more decades.

Conclusion

The soils of the southeastern area of Brookhaven National Laboratory were exposed to EDB for 10-15 years. While EDB levels in the groundwater at BNL are higher than the New York standard, it is not at an extremely high concentration. Phytoremediation seemed to be successful with certain species of *Brassica* and *Carex*, but these plants alone may not have extracted enough ethylene dibromide to be worth carrying on this procedure any longer. If the Environmental Protection Agency decides to try air sparging and vapor extraction, they should be cautious with their methods. Airflow of the harmful vapors through the soil once they are pushed out of the groundwater may not be uniform, could become uncontrolled, and would therefore still pose a threat on the environment. Of these methods, it seems that the "pump and treat" method is the most successful and economically feasible. However, close attention would have to be given to the procedure to assure significant amounts of EDB are being removed from the groundwater to the point that public health would no longer be at risk.

The current restoration of Operable Unit VI has only been going on for approximately three years and it is difficult to see, this early in the process, which methods of EDB removal have had the best results, and the best long term effects, on this particular site. Until the best method is put to use throughout the entire site, natural attenuation should play a significant role in decreasing the toxicity of ethylene dibromide in groundwater. With continued research and experimentation, growing support from local residents, and intensive treatment, the land around BNL will some day be restored to its original, non-hazardous state.

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