Research Journal of Environmental Sciences

ISSN 1819-3412

Academic
Journals Inc.

www.academicjournals.com

Research Journal of Environmental Sciences 5 (5): 394-398, 2011
ISSN 1819-3412 / DOI: 10.3923/rjes.2011.394.398

BTEX: A Serious Ground-water Contaminant

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ABSTRACT

Organic compounds can be a major pollution problem in groundwater. Their presence in water can create a hazard to public health and the environment. One of the most common sources for BTEX-contamination of soil and groundwater are spills involving the release of petroleum products such as gasoline, diesel fuel and lubricating and heating oil from leaking oil tanks. Because of their polarity and very soluble characteristics, the organic chemicals (BTEX) of petroleum products will be able to enter the soil and groundwater systems and cause serious pollution problems. In present study, we report about the BTEX contaminant and their characteristics and also try to provide information on what BTEX's are, why they are a risk to human and environment and how they might be removed through bioremediation from the contaminated site.

Key words: BTEX, bioremediation, gasoline

INTRODUCTION

A considerable amount of gasoline enters the environment as result of leakage from underground storage tanks, accidental spills, or improper waste disposal practices (Bowlen and Kosson, 1995). When gasoline is in contact with water, benzene, toluene, ethylbenzene and the xylene isomers (BTEX) account for as much as 90% of the gasoline components that are found in the water-soluble fraction (Saeed and Al-Mutairi, 1999). Consequently, these chemicals are some of the most common contaminants found in drinking water. BTEX are toxic to humans and their removal from polluted environments is of special interest (Mehlman, 1992). BTEX is not one chemical, but are a group of the following chemical compounds: Benzene, Toluene, Ethylbenzene and Xylenes. BTEX are made up of naturally-occurring chemicals that are found mainly in petroleum products such as gasoline. Besides gasoline, BTEX can be found in many of the common household products we use every day. BTEX are in a class of chemicals known as Volatile Organic Compounds (VOCs).

The purpose of this study is to provide information and a visual understanding of BTEX contaminants and their characteristics how they might be removed from the groundwater through bioremediation. The strain 2479 was isolated from the soil of industrial belt, situated at Rajbandh (West Bengal, India) where the use of polychlorinated hydrocarbons (including TCE) is abundant

Composition of BTEX: The BTEX group of contaminants consists of benzene, ethylbenzene, toluene and three isomers of xylene. These organic chemicals make up a significant percentage of petroleum products (Fig. 1).

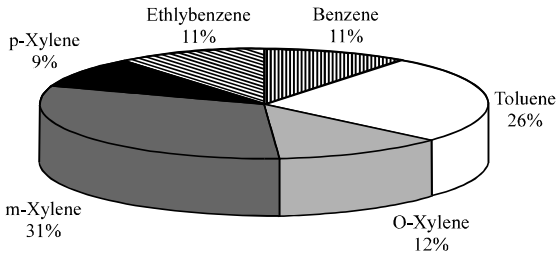

Fig. 1: The percentage (weight) of BTEX components of gasoline

Table 1: The physico-chemical properties of BTEX

Parameters	Benzene	Toluene	Ethylbenzene	Xylenes
Formula	C_6H_6	$C_6H_5CH_3$	$C_6H_5CH_2\ CH_3$	$C_6H_4(CH_3)_2$
Molar weight	78.12	92.15	106.18	106.18
Density (g mL^{-1})	0.8765	0.8669	0.8670	0.8685
Polarity	Non-polar	Non-polar	Non-polar	Non-polar
Solubility (mg L^{-1})	1780	500	150	150
Soil-water partitioning coefficient	97	242	622	570
Henry's law constant (25°C) {kPa*m^3/Mole}	0.55	0.67	0.70	0.80

- **Benzene** can be found in gasoline and in products such as synthetic rubber, plastics, nylon, insecticides, paints, dyes, resins-glues, furniture wax, detergents and cosmetics. Auto exhaust and industrial emissions account for about 20% of the total nationwide exposure to benzene. Benzene can also be found in cigarette smoke. About 50% of the entire nationwide exposure to benzene results from smoking tobacco
- **Toluene** occurs naturally as a component of many petroleum products. Toluene is used as a solvent for paints, coatings, gums, oils and resins
- **Ethylbenzene** is used mostly as a gasoline and aviation fuel additive. It may also be present in consumer products such as paints, inks, plastics and pesticides
- **Xylene** is a member of the BTEX group of pollutants. Ortho-xylene is the only naturally-occurring form of xylene; the other two forms are man-made. Xylenes are colourless liquids, used in gasoline and as a solvent in printing, rubber and leather industries

Physico-chemical properties: The physico-chemical properties of BTEX is shown in Table 1.

Contaminant properties:

- **Molecular weight:** The molecular weight of compound is measured in g $mole^{-1}$. Generally, the higher the molecular weight the less soluble in water. Molecular weight also effects the density of a compound
- **Water solubility:** Solubility is the measurement of the maximum concentration of a chemical that will dissolve in pure water at a specific temperature, measured in mg L^{-1}. Water solubility causes great effects on chemicals movement and distribution through soil and groundwater
- **Polarity:** Benzene is non-polar because of its almost neutral charge. It is not as non-polar as the other contaminants in the BTEX group and has the ability to dissolve in water

- **Specific density:** The density is measured as dry mass per volume (kg m^{-3}). The density of the contaminants effects the organic compound's ability to float on water
- **Octanol-water partitioning coefficient:** It is the ratio of the concentration of a dissolved substance in a two-phase system at equilibrium. After a chemical has been mixed in a octanol and water solution the system is allowed to reach equilibrium. This is also a measurement of the hydrophobicity of an organic. The more hydrophobic the more the contaminant will adsorb to soil and have a low solubility
- **Henry's law constant:** It describes about chemicals movement from water to air and also air to water. High values mean that the chemical will move more toward the gas phase where as low values will stay in the aqueous phase (Table 1)

Exposure and effects of BTEX: Exposure to BTEX can occur by either drinking contaminated water (ingestion), by breathing contaminated air from pumping gas or from the water via showering or laundering (inhalation) or from spills on your skin.

Acute (short-term) exposure to gasoline and its components benzene, toluene and xylenes has been associated with skin and sensory irritation, central nervous system-CNS problems (tiredness, dizziness, headache, loss of coordination) and effects on the respiratory system (eye and nose irritation). On top of skin, sensory and CNS problems, prolonged exposure to these compounds can also affect the kidney, liver and blood systems.

Bioremediation of BTEX: Bioremediation is a technique to remediate contaminated soil and groundwater. Using this technique microorganisms are degrading the organic components to CO_2 and water. Oxygen and nutrients might be injected to promote the degradation rate. If nothing is being added the biodegradation is called intrinsic. The degradation may occur under the use of different electron acceptors than oxygen. For instance toluene may degrade via an anaerobic pathway using nitrate as an electron acceptor (Soerensen, 1996).

It has been assumed that soil bioremediation of BTEX pollution relies upon indigenous bacterial populations; the significance of fungi has been overlooked. Fungi generally withstand harsher environmental conditions than bacteria and could play an important role in the degradation of petroleum hydrocarbons in the soil (Bossert and Bartha, 1984). Nevertheless, fungal degradation of BTEX mixtures has been studied only to a limited extent with white-rot fungi (Braun-Lullemann *et al*., 1995; Yadav and Reddy, 1993). BTEX were mineralized but did not support fungal growth when they were supplied as the sole source of carbon and energy. The extracellular lignin-degrading enzymes are capable of oxidizing a wide range of aromatic hydrocarbons, but they appear not to be involved in BTEX degradation. The low degradation rates and the requirement of an additional carbon source limit the use of white-rot fungi in bioremediation. When hydrocarbon-degrading microbes are used for bioremediation of gasoline pollution, it is very unlikely that they encounter a sole substrate. We report first, *Bacillus cereus* group being used in biodegradation of TCE (Trichloroethylene) (Mitra and Roy, 2010) and it was also tested that TCE degradation could enhance in presence of Toluene. Some studies dealing with substrate interactions during degradation of BTEX mixtures by bacteria (*Rhodococcus rhodochrous*, *Arthrobacter* sp. *Pseudomonas* sp.) have been published (Alvarez and Vogel, 1991; Chang *et al*., 1993), but analogous data for fungi are still very scarce.

A mixed bacterial culture (*Paenibacillus pabulli, Micromonospora* sp., *Proteus mirabilis, Bacillus pumilus, Burkholderia* sp., *Xanthomonas* sp., *Bacillus coagulans, Bacillus*

stearothermophilus, Bacillus pallidus, Bacillus smithii and Klebsiella pneumonia) was isolated heavily polluted site in Eastern region of Saudi Arabia, capable of degrade BTEX efficiently (Mohamed Arafa, 2003).

The soil fungus *Cladophialophora* sp. strain T1 (Prenafeta-Boldu *et al*., 2002) was capable of growth on a model water-soluble fraction of gasoline that contained all six BTEX components (benzene, toluene, ethylbenzene and the xylene isomers). Benzene was not metabolized, but the alkylated benzenes (toluene, ethylbenzene and xylenes) were degraded by a combination of assimilation and co-metabolism.

CONCLUSION

This study summarizes the BTEX contaminants and their characteristics and to be removed from the groundwater through bioremediation. Because bioremediation is one of the environment friendly means of degrading toxic chemicals. BTEX contaminated soil may harbour some microorganisms which would degrade BTEX and use it as its nutrient. Using this simple logic, we screened the soil microorganisms in the soil of an industrial area, the Indian Oil Corporation depot at Rajbandh near Durgapur. Our isolate, strain 2479 was isolated from the soil of industrial belt, situated at Rajbandh (West Bengal, India) where the use of polychlorinated hydrocarbons (including TCE) is abundant (Dey and Roy, 2009). TCE also an environmental pollutant and as well as hepato-carcinogen. The reason why the BTEX's, entering our soil and groundwater system, are considered such a serious problem is that they all have some acute and long term toxic effects. All the compounds of BTEX are acutely toxic and have noticeable health effects at high concentrations. Exposure to these compounds from groundwater systems is usually minimal but the exposures can be persistent over a long period of time (long time effects). So, this study suggests that exposure to BTEX from an oil spill is correlated with an increased risk of health effects need to take proper measures. In the present study, we emphasis on bioremediation of BTEX as it is cheaper and more environment friendly than other means like Vapour Phase Extraction, Air Sparging, Air Striping etc.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Dr. Ashis Kumar Mondal for generously supporting the program. The authors are indebted to Sri Sushil Kumar Sinha to provide technical assistance during computer work.

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