

8.1 COMPARING THE EFFICIENCY OF SYNTHETIC VS NATURAL-BASED LIQUID ACTIVATED CARBON IN REMOVING ORGANIC POLLUTANTS FROM CONTAMINATED WATER

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ABSTRACT

In recent years, more attention was given to the use of the in-situ injection of liquid activated carbon (LAC) to clean contaminated groundwater sources. This lab-scale study is carried out to investigate the capacity of synthetic and natural-based LAC adsorbents coated on solid materials (i.e. sand and limestone) for the removal of organic compounds such as MTBE and BTEX. The synthesized LAC material was characterized using SEM/EDXS, XRD and FTIR to study its morphological and chemical features. Batch treatment runs were conducted under various treatment conditions such as LAC dosage, pH and conductivity. Results showed that LAC may reach more than 95% removal of BTEX compounds by both types of LAC. However, the removal of MTBE was not high with a maximum removal of around 50% only. The study demonstrated that LAC can be used effectively in removing BTEX compounds, but more work is still needed to reach the same level of removal of MTBE.

KEY WORDS: liquid activated carbon (LAC); biochar; MTBE; BTEX; adsorption; groundwater

INTRODUCTION

BTEX and MTBE are common organic pollutants frequently encountered in contaminated groundwater sources near underground fuel leaking storage tanks. These compounds may impose serious health risks to humans [1] and thus are regulated for drinking purposes [2]. The high solubility of MTBE has resulted in contaminated water supplies around the world. Moreover, MTBE has low biodegradability rate, low log K_{ow} (1.24) and low Henry's constant (0.022) makes it difficult to remove with traditional treatment methods such as biodegradation, adsorption or air stripping [3]. Advanced oxidation processes (AOPs) were successfully applied to treat water contaminated with BTEX and MTBE but with high energy and chemical costs [4]. Adsorption is still an attractive method when considers the removal of both BTEX and MTBE from contaminated waters. In groundwater remediation, both ex-situ (pump & treat) and to a lesser extent in-situ adsorption treatment methods were applied using synthetic-based AC [5] or naturally-based AC [6] or polymeric materials [7]. However, due to the high cost of ex-situ adsorption and varying rates of efficiencies, more attention was given, in recent years, to using the in-situ adsorption method through injecting nano-sized AC in liquid form (i.e. LAC) downstream of the contaminated groundwater plume forming a film on the subsurface material to act as a permeable reactive barrier. Limited studies investigated the efficiency of LAC in remediating contaminated aquifers and no reports were found that address the use of in-situ

LAC adsorption for multiple contaminants, such as BTEX and MTBE in the middle east region. Therefore, this study was carried out to demonstrate the efficiency of using biochar and commercial-based LAC in treating groundwater contaminated with MTBE and BTEX compounds for their removal through lab-scale batch experiments.

METHOD and APPLICATION

The natural-based LAC was produced from local palm fibres that were cleaned, grinded ($\phi = 1-2$ mm), and combusted at 450°C under N_2 gas (99.9%). 5% H_2O_2 solution was added to the prepared biochar, treated with 1.0 M HNO_3 and then heated to 90°C while stirred for 3 hours. after which it was cooled down to room temperature. The biochar-based LAC was then liquefied with distilled water at wt. %, ratio of 1:10 and 0.5% poly-ethyleneimine. The commercial AC was crushed to a very fine powder ($d_{99} < 10\mu\text{m}$) to prepare the LAC. One g of the powder commercial AC was sonicated in 100 mL of water for 1 hr. Then, 10 mL of polyethyleneimine solution at a concentration of 0.5 % was added to the sonicated AC. After that, the volume of CCAC was made up to 250 mL and mixed for 1 hr, using a high-shear mixer at 3660 rpm to obtain a homogeneous mixture. Both types of LAC were characterized using SEM/EDXS, FTIR, and XRD techniques. Moreover, different subsurface materials (i.e. Ottawa sand (OS), limestone (LS) and mix (OS/LS)) were used in the experiments. The LACs were mixed with these materials to mimic the in-situ injection of LAC. Highly pure BTEX and MTBE solutions were prepared in distilled-deionized water at concentrations of 2000 ppb and their concentrations levels before and after adsorption were measured using GC/MS instrument. In each run, certain amounts of material (OS, LS, 1 OS/LS, and GAC) were well mixed with certain amounts of LAC. The mixed materials were then added to the conical beakers and shaken at 150 rpm for 60 minutes. Samples were taken every at 0, 15, 30, 45 and 60 min for analysis of residual pollutants

DISCUSSION and RESULTS

The main characteristics of natural-based LAC were: Total C (86%), N (2%), O (12%), O/C (0.14), ash content (5%), surface area ($786 \text{ m}^2\cdot\text{g}^{-1}$) and total pore volume ($0.68 \text{ cm}^3/\text{g}$). The commercial LAC, particle distribution analysis showed that the sample that was ground using the balls mill have the smallest particle sizes $d_{99} < 10 \mu\text{m}$. The SEM images (Fig. 1) indicate that the LAC is slides-like shape of the prepared carbon, while the EDXS EDXS shows that the main elements are C and O, which indicates the presence of the oxygen functional groups on the carbon surface.

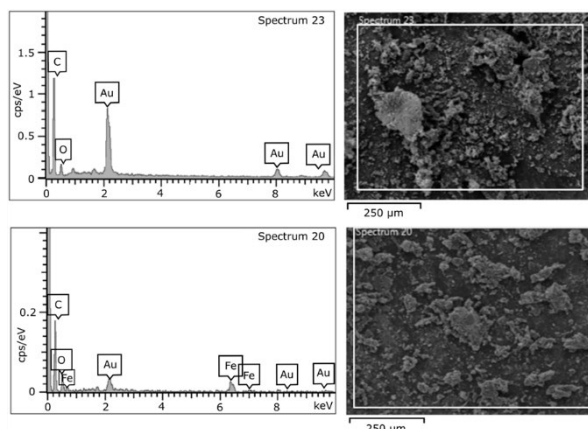


Figure1 SEM and EDX of LAC

The adsorption performance of bio and commercial LAC are presented in Figs.2 and.3 respectively. Fig.2 shows that the adsorption by the bio-LAC-coated materials were generally low, compared to GAC. On the other hand, the adsorption performance of commercial LAC presented in Fig.3 shows better removal of the 3 pollutants, compared to bio-LAC. The maximum removal efficiencies by the coated with bio-LAC were 2, 25 and 40% for MTBE, Benzene and Toluene, respectively.

CONCLUSION

While commercial LAC showed maximum removal efficiencies of 45, 75 and 95 % for MTBE, Benzene and Toluene, respectively. It was also noticed that both bio and commercial LAC have low adsorption behaviour for MTBE, compared to Benzene and Toluene.

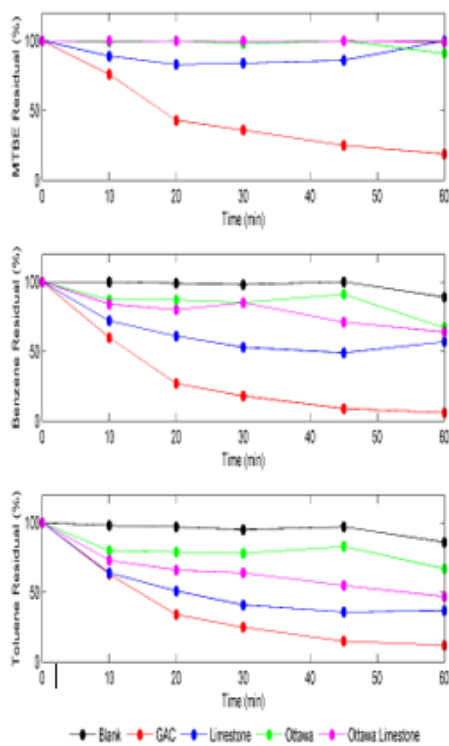


Figure 2

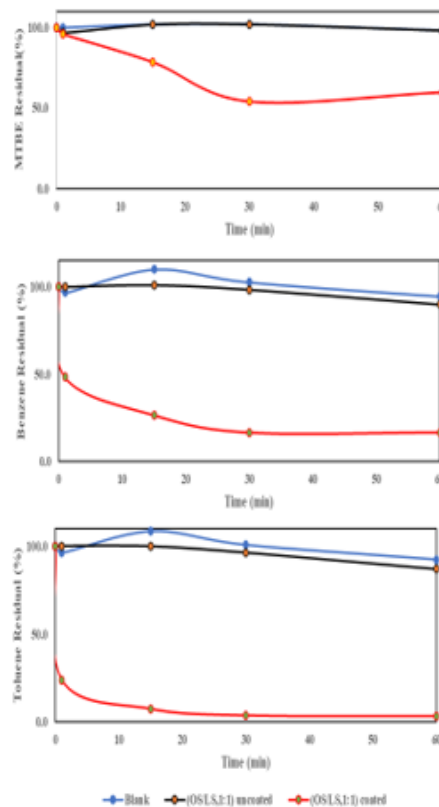


Figure3

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