

Studies regarding the Benzene, Toluene and o-Xylene Removal from Waste Water

P. Negrea, F. Sidea, A. Negrea, L. Lupa, M. Ciopec, C. Muntean

*University "Politehnica" Timișoara, Faculty of Industrial Chemistry and Environmental Engineering, Piața Victoriei, no. 2, 300006 Timișoara, Phone: +40 256 404164, Fax: +40 256 404192, E-mail address: petru.negrea@chim.upt.ro

Abstract: The consequences of pollution are more and more present, and are reflected especially in the public health, in the bio-diversity and balance of the ecosystems, by putting them in danger. Volatile organic compound (VOC) is defined as any organic compound of artificial origin, other than methane, able to generate photochemical oxidants in reaction with nitrogen oxides and in the presence of solar radiation. In the present paper, were studied the possibilities of benzene, toluene and xylene (BTX) removal from waste waters by air-stripping and adsorption on active charcoal. It was also investigated the possibility of using UV-VIS spectrophotometry as analysis method for BTX. We found that benzene, toluene and o-xylene dissolved in aqueous solutions can be analyzed by UV-VIS spectrophotometry; they present a very good absorbance in the wave length range 200-220 nm (benzene 190-212 nm). The BTX removal by air-stripping was studied for various air flow rates (20, 40 and 100 L/h). BTX removal degree increases with the increase of air flow rate; for all flow rates the removal degrees were higher than 96%. The removal of BTX from waste water by adsorption on active charcoal was studied using a column containing 4 g of granular active charcoal. The efficiency of the adsorption process was studied for three various water flow rates: 1 L at a flow rate of 0.26 L/h, 5 L at 1.66 L/h and 5 L at 3.65 L/h. BTX removal degree decreases as the waste water flow rate increases, and they are smaller than the removal degrees reached by air-stripping, due to the quantity, the sort of the used charcoal (granular), and the design of the adsorption column, which allowed the formation of preferential flow channels, especially at higher flow rates.

Keywords: volatile organic compound; waste water; benzene, toluene and o-xylene removal; air-stripping; adsorption on active charcoal

1. Introduction

Our planet is passing through a pronounced ecological crisis which affects the atmosphere and lithosphere but also the hydrosphere and biosphere. The consequences of pollution are more and more present, and are reflected especially in the public health, in the bio-diversity and balance of the ecosystems, by putting them in danger.

Volatile organic compound (VOC) is defined as any organic compound of artificial origin, other than methane, able to generate photochemical oxidants in reaction with nitrogen oxides and in the presence of solar radiation. The ozone and other photochemical oxidants are formed through the action of short wave length solar radiation on nitrogen oxides. In the presence of volatile organic compounds, the equilibrium favors the forming of higher levels of ozone [1-4].

The toxicity of ozone is manifested regardless its concentration; higher concentrations, longer exposure, increased activities during the exposure, produce stronger effects. The acute effects on short term include respiratory symptoms, alterations of pulmonary function and swelling of breathing passages [5].

In the present paper are presented studies regarding the possibilities of benzene, toluene and o-xylene (BTX) removal from waste waters by two widely used methods: air-stripping and adsorption on active charcoal. It was also

investigated the possibility of using UV-VIS spectrophotometry as analysis method for BTX.

2. Experimental

The studies on the possibility of using UV-VIS spectrophotometry as analysis method for BTX were carried out on aqueous solution of various concentrations (20, 40 and 60 $\mu\text{L/L}$) of each organic compound: benzene, toluene and o-xylene. The UV spectra of the solutions were registered in the wave length range 190-350 nm, using a Varian Cary 50 spectrophotometer.

The studies on the BTX removal were carried out on synthetic waste water containing a mixture of benzene, toluene and o-xylene, each in a concentration of 20 $\mu\text{L/L}$.

At the BTX removal by air-stripping various air flow rates were used (20, 40 and 100 L/h); the other conditions were identical: a volume of waste water of 600 mL and the temperature of 18°C. The studies were carried out in batch system, using equal volumes of synthetic waste water.

The studies regarding the BTX removal by adsorption on active charcoal were carried out on a column containing 4 g of granular active charcoal. The efficiency of the adsorption process was studied for three various water flow rates: 1 L at a flow rate of 0.26 L/h, 5 L at 1.66 L/h and 5 L at 3.65 L/h.

3. Results and discussion

3.1. Studies on the dependence of absorbance on the wave length for BTX-water solutions

At the beginning of the study it was investigated the possibility of using UV-VIS spectrophotometry as analysis method for BTX. This method is faster, less expensive and more available than other consecrated methods for the analysis of volatile organic compounds, such as gas-chromatography.

The UV spectra of benzene, toluene and o-xylene solutions of various concentrations are presented in Figures 1-3. From the registered spectra the parts with insignificant absorption were removed. The spectra were also registered 24 hours after the preparation of solutions; the results confirmed the stability of solutions in the hermetically closed flasks.

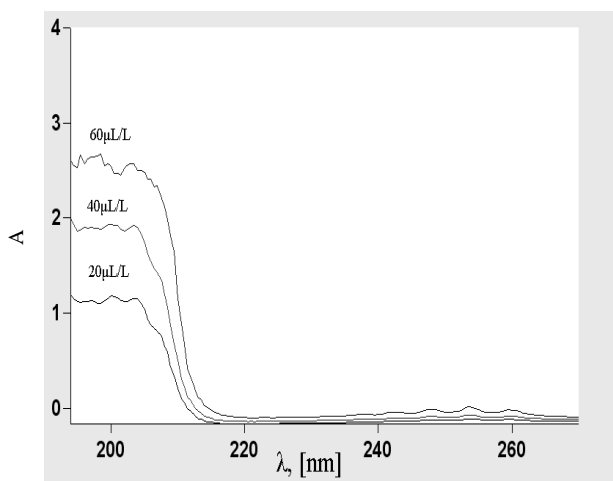


Figure 1. UV absorption spectra of benzene-water solutions

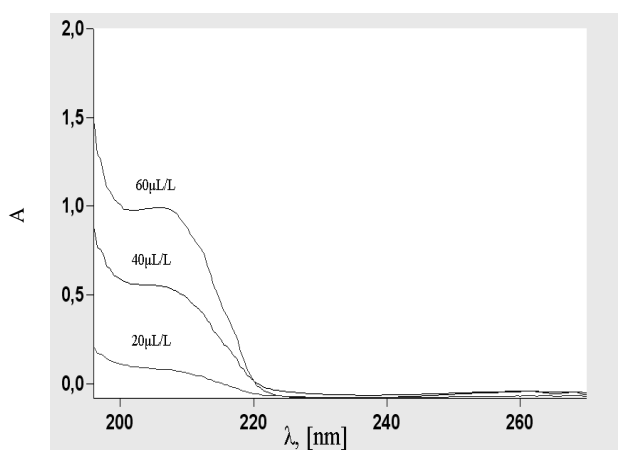


Figure 2. UV absorption spectra of toluene-water solutions

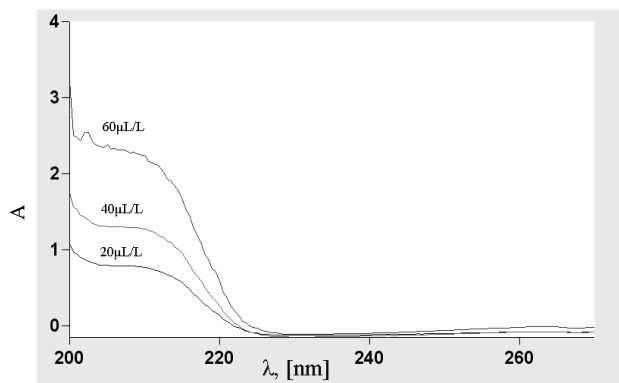


Figure 3. UV absorption spectra of o-xylene-water solutions

The UV absorption spectra show that all investigated compounds present a very good absorbance in the wave length range 200-220 nm (benzene 190-212 nm). One may conclude that the aqueous solutions of these compounds can be analyzed by UV-VIS spectrophotometry.

Since all investigated compounds present UV absorption maxima at close wave length or in overlapping ranges, it is difficult to determine the concentration of each component of the BTX mixture in the waste water. For this reason, in further investigations, it was determined the total concentration of BTX in the waste water.

3.2. Studies on the removal of BTX from waste water by air-stripping

Figure 4 presents the evolution in time of BTX removal degree from waste water, for three air flow rates. One observes that the BTX removal degree increases with the increase of air flow rate. For all three flow rates the air-stripping BTX removal was very efficient; the removal degrees were higher than 96%.

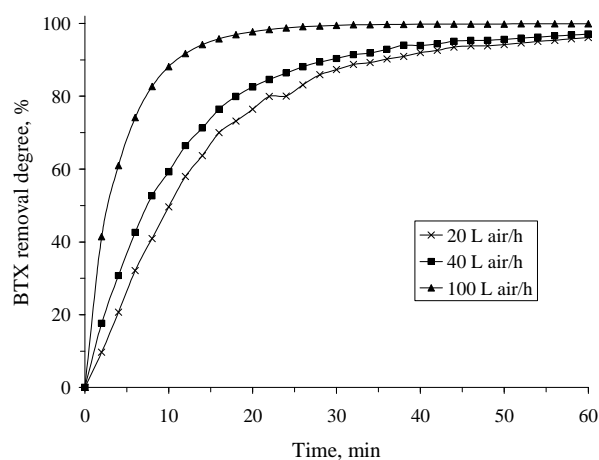


Figure 4. Evolution in time of BTX removal degree from waste water, by air-stripping

3.2. Studies on the removal of BTX from waste water by adsorption on active charcoal

The experimental data regarding the evolution in time of the BTX removal degree for three waste water flow rates are presented in Figure 5. One may notice that BTX removal degree decreases as the waste water flow rate increases.

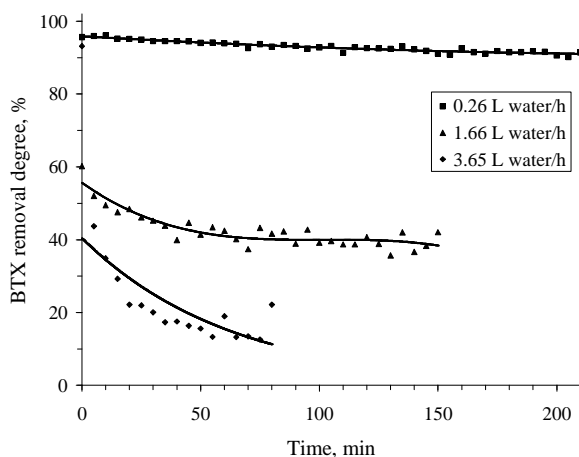


Figure 4. Evolution in time of BTX removal degree from waste water, by adsorption on active charcoal

For the adsorption column were determined the volume of the adsorption bed and the volume of holes; the data were used to calculate the column parameters presented in Table 1, for each waste water flow rate.

TABLE 1. Column parameters for BTX adsorption on active charcoal

Flow rate, m ³ /s	Fictive rate, m/s	Real rate, m/s	Contact time, s	Removal degree, %
0.072·10 ⁻⁶	0.64·10 ⁻³	1.73·10 ⁻³	238	90-95
0.46·10 ⁻⁶	4.0·10 ⁻³	10.8·10 ⁻³	37.3	35-40
1.0·10 ⁻⁶	97.3·10 ⁻³	0.26	17.2	12-18

The variation of BTX removal degree in wide ranges for the three water flow rates may be explained by the decrease of water-adsorbent contact time, but also by the column design; preferential flow channels are formed at higher flow rates.

Comparing the experimental data obtained with the BTX removal methods we used, one observes that although the adsorption on active charcoal is known as very efficient for the removal of VOC in low concentrations in water both on low flow rates and high flow rates, we reached smaller removal degree using the adsorption on active charcoal. These results may be explained by the quantity, the sort of the used charcoal (granular), and the design of

the adsorption column, which allowed the formation of preferential flow channels, especially at higher flow rates.

4. Conclusions

In the present paper are presented studies regarding the possibilities of benzene, toluene and o-xylene (BTX) removal from waste waters by air-stripping and adsorption on active charcoal. It was also investigated the possibility of using UV-VIS spectrophotometry as analysis method for BTX.

The UV spectra show that all studied compounds present a very good absorbance in the wave length range 200-220 nm (benzene 190-212 nm). One may conclude that the aqueous solutions of these compounds can be analyzed by UV-VIS spectrophotometry.

At the BTX removal by air-stripping, BTX removal degree increases with the increase of air flow rate (20, 40 and 100 L/h). For all three flow rates the air-stripping BTX removal was very efficient; the removal degrees were higher than 96%.

The removal of BTX from waste water by adsorption on active charcoal was studied using a column containing 4 g of granular active charcoal. The efficiency of the adsorption process was studied for three various water flow rates: 1 L at a flow rate of 0.26 L/h, 5 L at 1.66 L/h and 5 L at 3.65 L/h. BTX removal degree decreases as the waste water flow rate increases.

Comparing the experimental data obtained with the BTX removal methods we used, one observes that although the adsorption on active charcoal is known as very efficient for the removal of VOC in low concentrations in water both on low flow rates and high flow rates, we reached smaller removal degree using the adsorption on active charcoal. These results may be explained by the quantity, the sort of the used charcoal (granular), and the design of the adsorption column, which allowed the formation of preferential flow channels, especially at higher flow rates.

REFERENCES

1. Shim H., Shin E.B. and Yang S.-T., A continuous fibrous-bed bioreactor for BTEX biodegradation by a co-culture of *Pseudomonas putida* and *Pseudomonas fluorescens*. *Advances in Environmental Research*. **2002**. Vol. 7. Iss. 1. pp. 203-216.
2. Vasanth Kumar K., Subanandam K., Ramamurthi V. and Sivanesan S., Solid-liquid adsorption for wastewater treatment: principle design and operation. **2004**. <http://www.eco-web.com/editorial/040319.html>.
3. World Health Organization, Air Quality Guidelines for Europe. Second Edition. Copenhagen. **2000**.
4. Dunn R.F. and El-Halwagi M.M., Design of cost-effective VOC-recovery systems. Tennessee Valley Authority. **1996**.
5. Vasanth Kumar K., Subanandam K., Ramamurthi V. and Sivanesan S., GAC Sorption process: problems and solution. **2004**. <http://www.eco-web.com/editorial/040319.html>.