

Ferrate treatment of groundwater for removal of organic contaminants

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It is an important question nowadays, how to purify the polluted groundwaters. There are more treatment options, e. g. biodegradation, filtration, adsorption and oxidation. Our research group developed an electrochemical way for continuous production of sodium ferrate (FeVI) solution which can be mixed directly to the polluted groundwater.

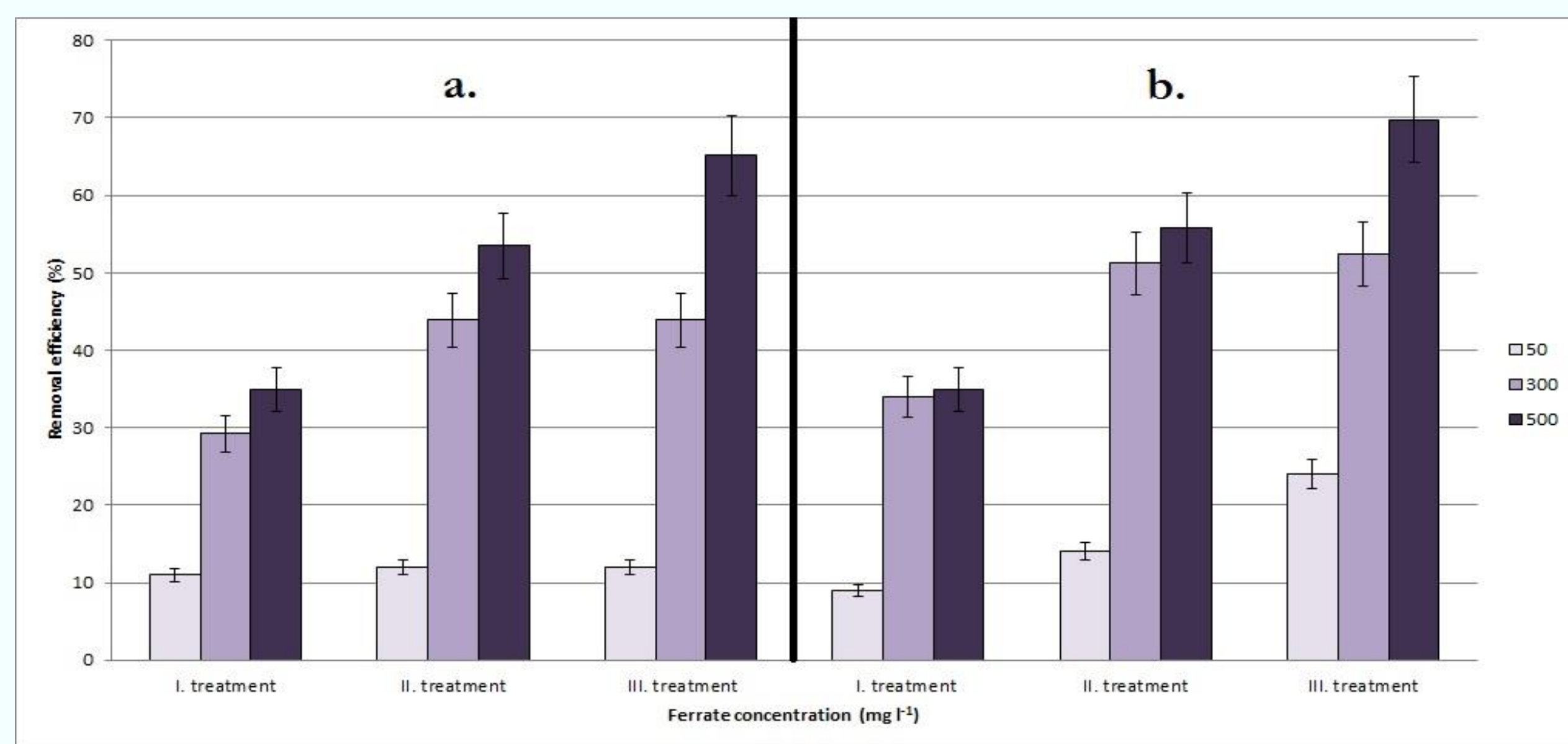


Fig. 1. Change of chemical oxygen demand during the three-steps ferrate treatment of groundwater applying 50, 300 and 500 mg/L ferrate concentration and 5 or 30 min treatment time

Ferrate treatment

The ferrate treatment was carried out in 3 steps applying 5 or 30 min treatment time in each treatment step and ferrate dosage of 50, 300 and 500 mg/L. During the treatment the water samples were agitated by Teflon coated magnetic stirrer bars. The pH value was adjusted to 7 in all cases by using 2M sulfuric acid. Between the 2nd and 3rd ferrate treatment a sedimentation step was applied in order to remove the Fe-oxhydroxide.

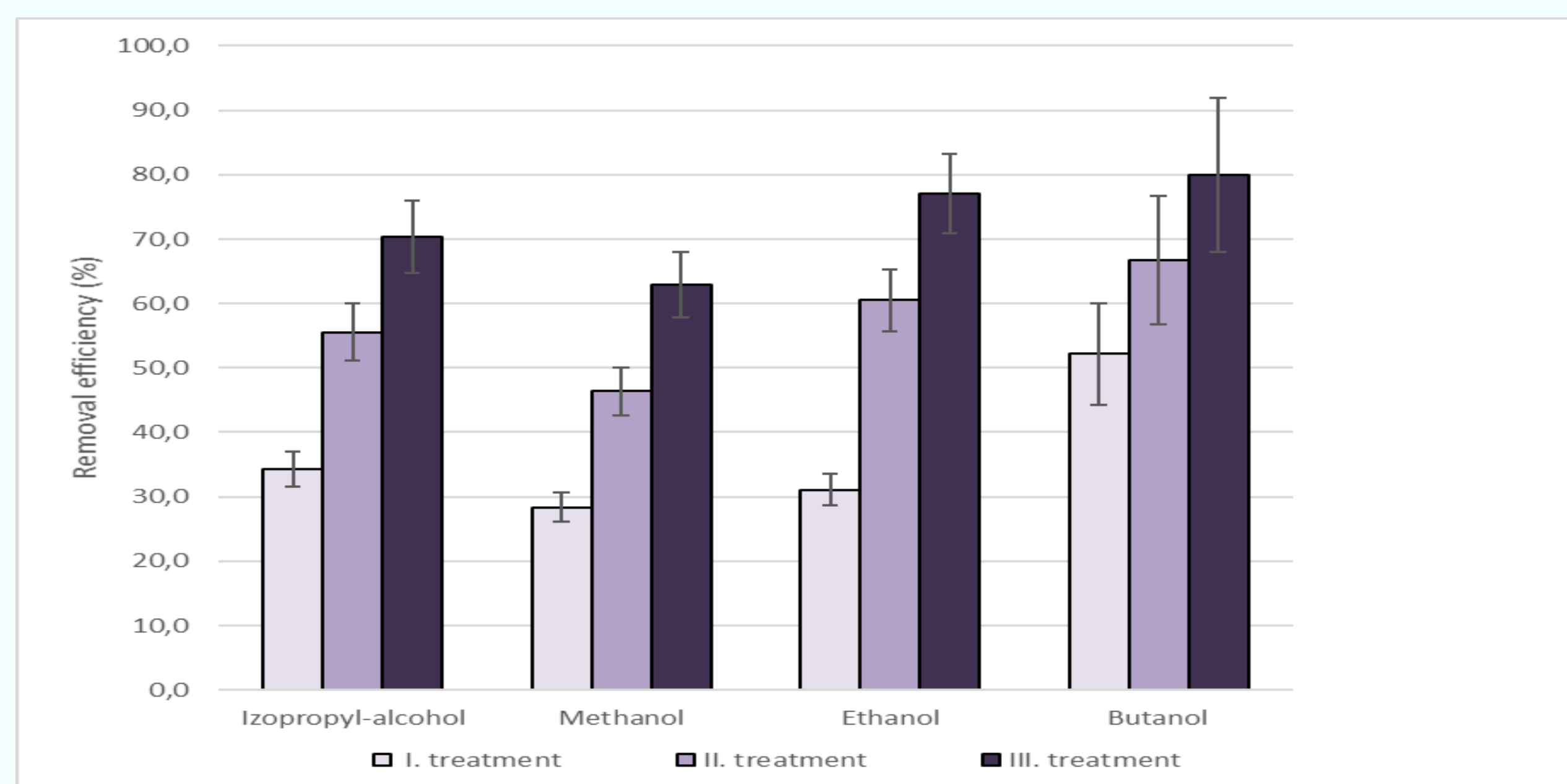


Fig. 3. Removal of 4 aliphatic alcohols after the three-step treatment applying 500 mg/L ferrate dosages and 5 min treatment time

The removal efficiency values obtained by the 3-step treatment of 500 mg/L ferrate concentration for three different molecule groups are demonstrated in Fig. 3-5. With increasing length of carbon chain (CC) of the aliphatic alcohols the removal efficiency values increased if the OH-group is located at the end of CC (Fig. 3). Investigating the degradation of toluol and the xilol isomers, it can be stated, that the toluene is a less degradable compound (82 %) than the xilenes (92-93%). (Fig. 4). If three methyl groups are substituted on the aromatic ring, the degradation of parent isomers became a little higher. The increasing number of methyl groups on the aromatic ring resulted in the following degradation order: benzene 30%, toluol 82%, xilenes >90%, trimethyl compounds >95% (Fig. 5).

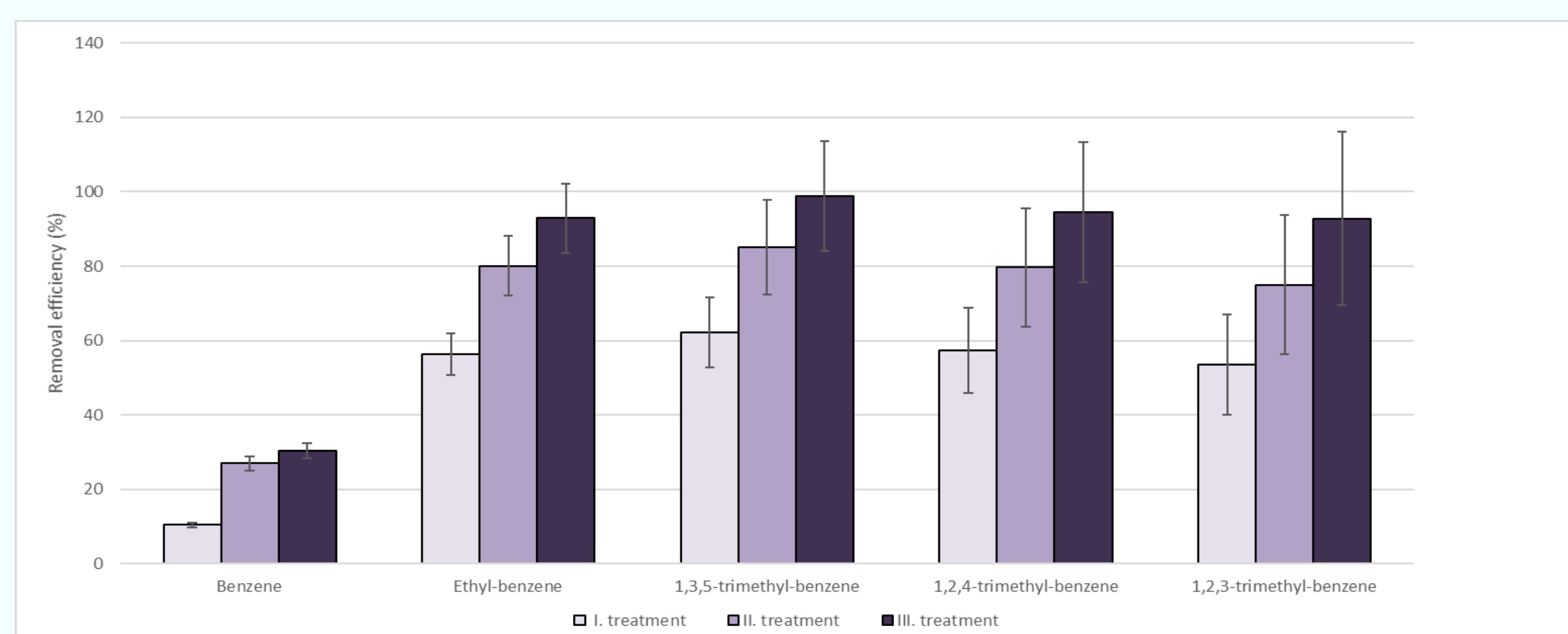


Fig. 5. Removal efficiency of benzene, ethyl-benzene and trimethyl-benzene compounds after the three-step ferrate treatment applying 500 mg/L ferrate dosage and treatment time of 5 min

Characterization of groundwater

Groundwater was sampled in a contaminated industrial area. The contamination of groundwater was characterized by chemical oxygen demand (COD) measurements and subsequently 45 organic pollutants were identified and quantified by headspace- gas chromatograph – mass spectrometer (HS/GC-MS) system. The main compound was isopropyl-alcohol, about 50% of the total organic pollutants. The halogenated hydrocarbons and aromatic hydrocarbons formed the other 50%. The initial COD amounted to 4050 ± 142 mg/L.

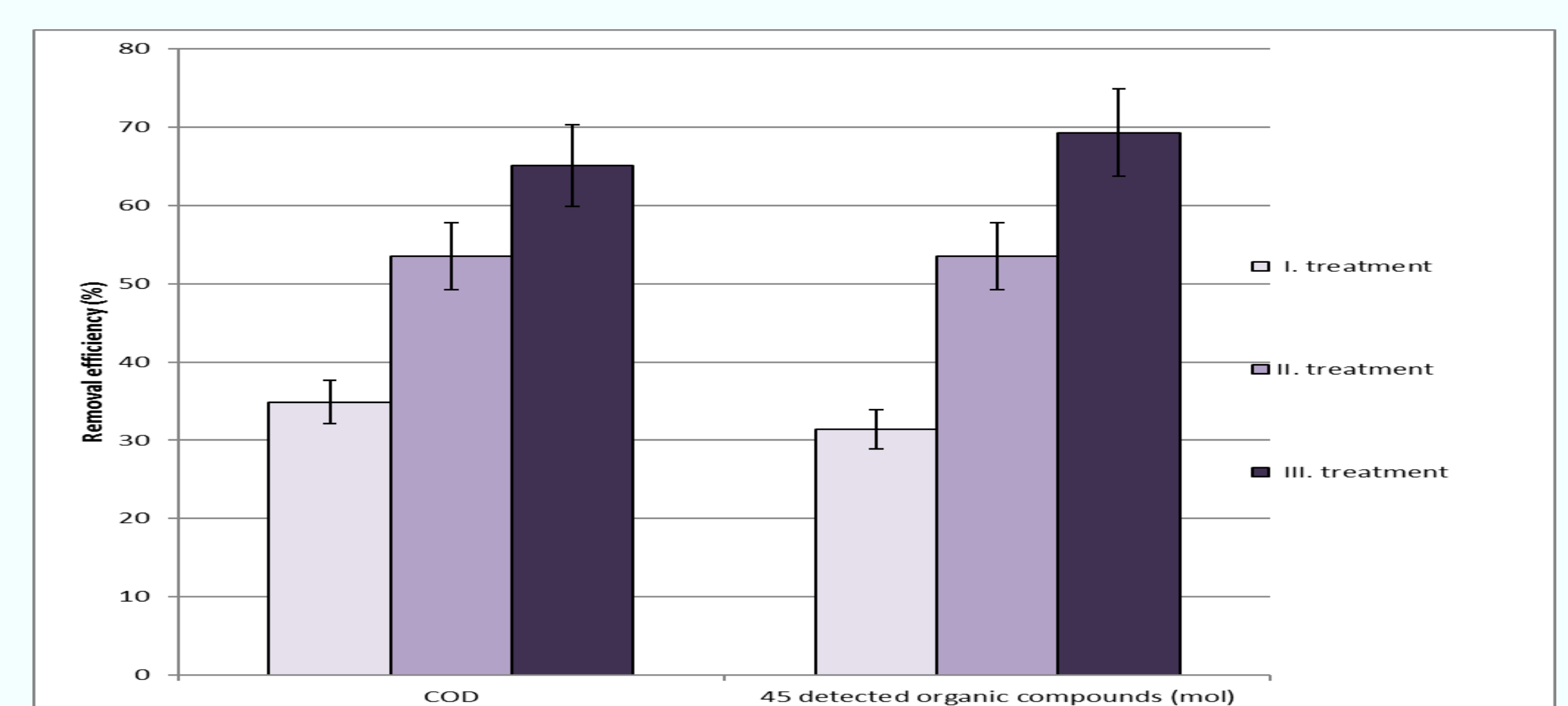


Fig. 2. Relative change of chemical oxygen demand and the sum of 45 volatile organic compounds after the three-step ferrate treatment applying 500 mg/L ferrate concentration and treatment time of 5 and 30 minutes

Results

Fig. 1. demonstrates the reduction of COD values after the treatment steps applying ferrate concentration of 50, 300 and 500 mg/L and treatment time of 5 (a) and 30 minutes (b). The COD values decreased in all treatment steps with increasing concentration of ferrate. The longer treatment time resulted in only a moderate increment in the reduction of COD values. Therefore the 5 min treatment time was selected for the further experiments. Comparing the changes of COD and the total concentration of 45 identified and quantified organic contaminants, similar trend can be observed. (Fig. 2).

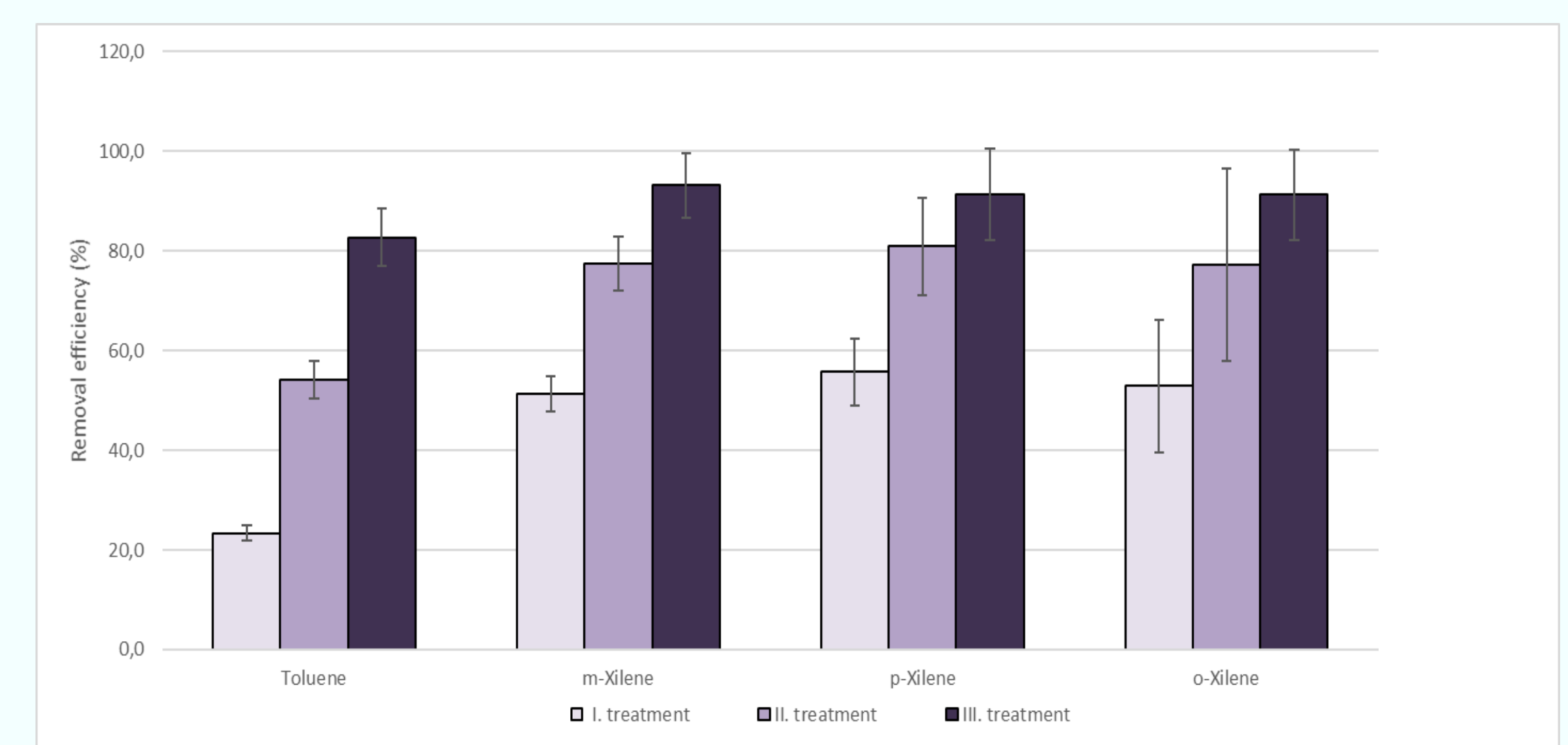


Fig. 4. Removal efficiency of toluene and xilene compounds after the three-step treatment applying 500 mg/L ferrate dosage and 5 min treatment time

Conclusions

The simultaneous degradation of different organic contaminant in groundwater can be realized by addition of electrochemically produced ferrate solution in three steps into the contaminated groundwater and mixed for 5 minutes. On basis of these results and observations, it can be established that the ferrate treatment is an effective technology to reduce the COD below to a prescribed limit value and then the treated groundwater can be introduced into the wastewater pipes as a sewage.