Regeneration of granular activated carbon by microwave (MW) irradiation and its application in a novel in situ regenerating permeable reactive barrier (PRB) approach (MW-PRB)

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Permeable reactive barrier (PRB) is considered one of the most effective in-situ alternatives for the remediation of contaminated groundwater and Granular Activated Carbon (GAC) a very performable material used in PRB systems. PRB reduced longevity due to ~~a~~ GAC saturation is the major problem affecting full-scale treatments (Ghaeminia and Mokhtarani, 2018). Landfill disposal of exhausted GAC is considered a further problem, which can also lead to secondary contamination paths. The investigation of *in situ* regenerating PRB to extend its longevity is a frontier and active research field. This approach may include the use of barriers coupled with other process or regenerating technologies in order to enhance PRB longevity.
Microwave (MW) heating is a growing interest issue in several energy and environmental applications. It is based on the ability of some dielectric materials in converting the MW energy into a very large and rapid heat production. Then, the excellent MW-absorbing features of GACs can enhance their thermal regeneration by MW irradiation (Falciglia et al., 2018). The present study evaluates the novel concept of PRB coupled with MWs (MW-PRB) as *in situ* regenerating technology. Experimental batch and column tests were carried out to assess the potentiality of the MW-PRB system as combined treatment for Cesium (Cs) impacted groundwater.
Batch experiments investigated the effects of 10 adsorption-MW regeneration cycles under different MW irradiation conditions. Column tests were carried investigating different irradiation times (5-15 min, power 300 W) using a custom-made bench-scale setup. It is mainly made up of a Pyrex glass column (50 mm inner and 450 mm high) filled with a commercial GAC and inserted in a MW oven cavity equipped with a MW generator (1 kW) for column irradiation. The system was feed with a peristaltic pump using a Cs-contaminated solution to simulate the groundwater dynamics. Effluents were collected at set intervals for Cs concentration analysis before and after the regeneration phases.
Batch test results showed a very rapid increase in GAC temperature up to over 650 °C, confirming the GAC strong ability to convert MW power into heat due to GAC excellent dielectric properties. Physical tests showed that GAC pore volume and specific surface area do not significantly change with the number of regeneration cycles. GAC regeneration ability was shown to increase over multi-cycle regeneration with a maximum value of ~110% (5th cycle). The final GAC weight loss of ~7% further demonstrates GAC life span preservation during MW irradiation.
Results from column tests confirm that GAC can be regenerated by MW also in dynamic condition, due to sublimation/vaporization and vapour stripping Cs removal mechanisms and that the regeneration process strictly depends on the irradiation time. The breakthrough curves after the regeneration phases demonstrate significant benefits from MW irradiation proving the feasibility of the proposed MW-PRB concept and providing essential data to guide its scaling-up application.

References

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Contribution Type: Oral presentation. **Participation:** online.