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Diverse and metabolic active biofilms on activated carbon for efficient *in situ* regeneration

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Motivation

Activated carbon (AC) is a porous carbonaceous material with high sorption capacity (Figure 1). Many drinking water and wastewater treatment facilities use either powdered AC (PAC) or granulated AC (GAC) for the removal of large and small organic pollutants in minute quantities. Removal of these compounds is crucial for the improvement of the biological stability of water and prevention of any possible adverse effect of the pollutants to humans and the environment [1-3].

As the operation continue, the adsorption sites of the AC will be saturated with organic compounds and can be either discarded or regenerated. Regeneration of saturated AC is aimed for prolonging AC service life and can be achieved by means of biological process. In the biological activated carbon (BAC) system, microorganisms will colonize the surface of the GAC particles, utilizing the adsorbed organics for growth and biofilm formation. The active biofilm surrounding the GAC particles will regenerate the carbon surface through a combination of adsorption/desorption and biodegradation of the organics adsorbed [1, 3]. BAC process has been widely applied, including in the ultrapure water (UPW) plant in Emmen, but a comprehensive study about the underlying physical and biological mechanisms involved has yet to be done. Such information is crucial to improve the overall BAC process efficiency.

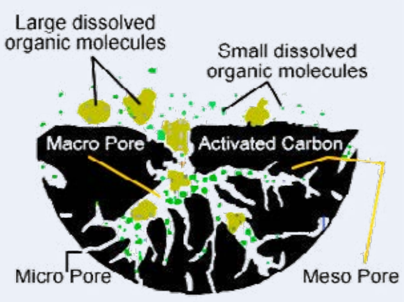

Figure 1 Activated carbon pore structure and adsorption sites [4].

Challenges

Achieving a consistent process performance in BAC system is challenging due to various reasons. Stimulation and regulation of the right biofilm population and metabolic activity are expected to be essential to achieve a successful organic compounds removal and bio-regeneration of BAC particles. Thus, a clear role for the GAC, the biofilm, their interactions, and their influences on the removal of organic pollutants should be characterized in detail (Figure 2 and 3). The results will identify the impact of various operating conditions on the performance and maintenance on BAC adsorption process.

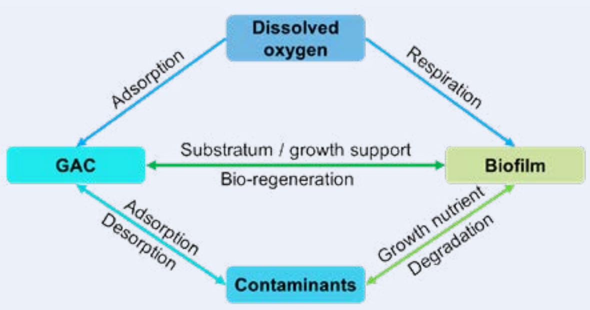

Figure 2 Theoretical interactions in BAC system [2].

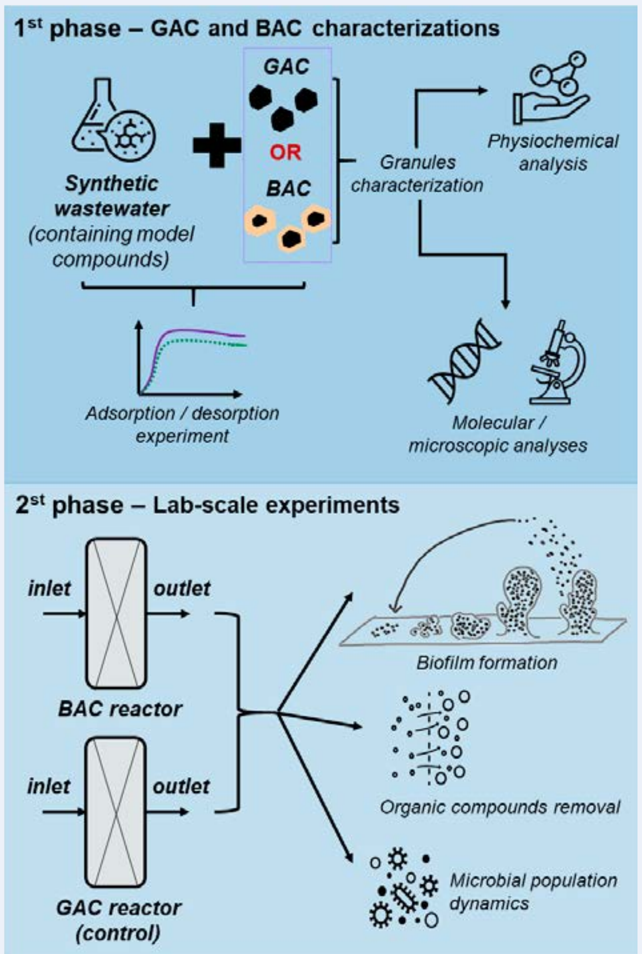

Figure 3 Graphical abstract of the project (some illustrations were adapted from [5, 6]).

Approach

This research will be divided into two parts. In the first phase, a thorough physical and biological characterization of raw GAC and BAC granules used in UPW plant will be done. Adsorption/desorption experiments of model organic pollutants by GAC and BAC will also be investigated. These experiments will give light to the underlying mechanism of organic compounds removal by GAC and BAC and the possible role of biofilm on organics removal and BAC regeneration.

Subsequently, a lab-scale BAC reactor together with a control reactor will be set up. This experiment will enable real-time observation of biofilm formation, organic compounds removal and microbial population dynamics in the system.

Once the reactor reaches a steady state, it can be subjected to various operational conditions to evaluate their effects on biofilm fitness and organic compounds removal. The obtained data will be used to control the process conditions for efficient organic compounds removal and bio-regeneration.

References

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