Problématique: Canada is privileged with abundant natural resources. However, Canadians are among the largest water users in the world with about 1,650 cubic meters of fresh water per capita each year. With the expected growth of the population and urbanization, combined with climate change with its unpredicted consequences, Canadians are now becoming aware of the critical role water is having in their lives. To ensure sustainability of our fresh water resources, water intake reduction by industries is a key factor, and this will be achieved through higher process water recycling levels. However, to meet such challenges, advanced process technologies will be required to improve wastewater discharge quality before recycling it as process water. Adsorption onto activated carbon is widely used for heavy metal removal from wastewater. However, activated carbon is expensive. Therefore, there is a growing need to find cheap and effective alternative sorbents to activated carbon. Natural polymers such as chitosan and cellulose are attractive, especially for heavy metal removal. Although sorbents made from those biopolymers can be engineered into various structural forms (gel, powder, nanoparticle, fiber), they all present technical drawbacks for adsorption processes. Therefore, there is an urgent need to develop a sorbent media with appropriate structural and strength properties that will meet overcome technical drawbacks actually encountered with typical adsorption process systems.

L’objectif de la recherche: The overall goal is to development a 3D composite material with appropriate structural and strength properties that will be used for adsorption of metallic ions from aqueous solutions. To achieve the goal, several objectives have been defined. Objective 1: Synthesize a porous membrane sorbent (pre-filter) that will be used for adsorption of metallic ions in aqueous solutions. The material will be made of natural polysaccharides (chitosan and cellulosic fibers (including nanocellulose)), combined with zeolite fillers. Objective 2: Build the 3D nanostructured composite module using optimized membrane developed in 1. Objective 3: Develop a robust module for treatment of any type of wastewaters.

Méthodologie: 1) Electrospun nanofibers pre-filter membranes from chitosan/PEO and nanocellulose particles will be made using our bench scale electrospinning setup. 2) Nanofibers membrane will then be used to determine adsorption capacity towards metallic ions using a batch test procedure. Data will be used to determine the kinetics and isotherm models. 3) Phosphorylation of cellulosic pulp fibers will be investigated to test their adsorption capacity towards metallic ions. Studies conducted at CRML have shown that addition of phosphate groups on cellulosic fibers are very efficient to adsorb metallic ions. Therefore, cellulose and nanocellulose will be processed to modify their surface properties prior to their addition to the composite sorbent. 4) Zeolite fillers will also be added into the sorbent to determine their potential for adsorption of metal ions in a single application. 5) Results from steps 2 to 4 will then be used to design a robust structured adsorption module to determine adsorption capacity under continuous operations.

Applications potentielles et retombées industrielles: On a global perspective, the proposed project will contribute to the efforts required to find solutions to ensure sustainability of water resources, which will help governments and industries to address the problem. At the scientific level, the project will contribute to the development of a new 3D nanostructured composite adsorption module made from residues from the forest (cellulose) and fishing (chitosan) industries. Since there are no studies on biosorbent design combining both residues, we are expecting valuable information especially in the field of physico-chemistry, impact of phosphorylation of cellulose and nanocellulose, electrospinning of nanocellulose, effect of zeolites in the proposed sorbent, layout (optimization) of the 3D nanostructured composite module, capacity of the proposed module to adsorb both organic and metal ions contaminants (interferences, selectivity), and finally regeneration capacity of the module to establish its usable life under continuous operations. Overall, this project will provide information about the feasibility and application of the module for treatment of complex wastewater containing both organic and metal ions.