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Feasibility of a Clay-Zeolite Media for Removal of Total Phosphorus from Wastewater

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Extended Abstract

Phosphorus is a major factor in the eutrophication process, and sensitive areas prone to contamination from domestic sewage must meet stringent effluent limits [6]. The Ontario Ministry of Environment standards, outlined in the Lake Simcoe – Phosphorus Reduction Strategy, must be consulted to comply with the current baseline limit of 0.30 mgP/L [9]. The objective of this study is to develop a unique clay-zeolite filter medium for its optimal removal efficiency through the adsorption of total phosphorus (TP), thereby contributing to eutrophication control. Factors governing the performance of the proposed technology include medium design (filter material, composition, formation, and size) [14], furnace exposure (temperature and duration), chemical conditioning, and influent concentrations with response-contact time.

For this study, a total of seven pellet types were formed; six with various bentonite-kaolin clay blends combined with fine gradations, and one with the encapsulation of a coarse zeolite inside a layer of moist, pliable clay. The pellet compositions varied based on ratios of clay:zeolite, clay:water, and benontite:kaolin. Once formed into spherical pellets [7], they were air-dehydrated prior to an incremental temperature increase from 100^{o}C to 600^{o}C. Based on a median atomic packing factor of 60% [1][11], and an adopted pellet diameter of 19.05 mm, a total of 100 pellets and 300 mL sump void space were configured into a small-scale testing unit to perform as a static batch system. Analysis by Procedure 326 – Total Phosphate was employed with a Hellige-Orbeco MC500 Colorimeter with a 0.02 to 1.1mgP/L detection range. A septic tank's effluent concentration of phosphorus ranges from approximately 7 to 20 mgP/L [10][13]. Based on this theoretical range, experimentation was carried out with synthetic standard stock to 6, 14, and 18 mgP/L influent concentrations.

As indicated in the research conducted by Ciosek and Luk (2014; 2016) [4][5], the pellet types were qualitatively and quantitatively analyzed in the preliminary stage. Based on the overall TP removal efficiency and pellets' structural integrity, it was decided that type 6 composed of 1:4 bentonite:kaolin clay ratio blended with fine -14+40 zeolite gradation and 1:1.25 clay:zeolite ratio (denoted as pellet type I ; Mixed), and type 7 made with the encapsulation of coarse -4+8 zeolite granules with the pliable PHB-G clay (denoted as pellet type II; Encapsulated) be carried through to the optimization stage. Approximately 300 pellets of pellet type I and II were formed; consisting of 100 non-conditioned (NC), 100 conditioned with calcium hydroxide [$Ca(OH)_2$] (L), and 100 conditioned with sodium chloride [NaCl] (S) [2][3][8].

Based on 45 minutes of contact time, it is observed that the performance of the non-conditioned and minimum salt brined (S_{min}) pellets were superior to the others, with pellet type II achieving 70 to 75% TP removal. The lime-treated pellet type II achieved greater removal when exposed to the higher influent concentration of 18 mgP/L. The influent concentration parameter analysis confirmed that pellet type II had a slight advantage in overall removal, also demonstrating that the extreme influent bounds provided similar removals; indicating a consistent and effective system. The research work presented an environmentally sustainable solution, and contributes to the development of a total phosphorus reduction strategy to restore, improve and protect our environment.

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