Removal of ammoniacal nitrogen from landfill leachate by adsorption on activated zeolite

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Abstract

Landfilling is a widely applied method for Municipal Solid Waste (MSW) management. However, landfilling produces significant amounts of leachate, which should be collected and treated, to avoid contamination of the land and of the surrounding surface water and groundwater. A large number of processes have been employed to treat landfill leachates (e.g.: biological treatment, reverse osmosis), however, each of the proposed processes has its own disadvantages (Miao et al., 2019). Adsorption on active clay sediments, may be employed to treat landfill leachate, as it may irreversibly adsorb hazardous compound, present in the landfill leachate (Gikas and Argyropoulos, 2017). One of such compound is ammoniacal nitrogen (Temel and Kuleyin, 2016), which may reach concentrations of up to 5.000 mg ($N\text{-}NH_4^+$)/L.

In the current study, a detailed investigation on the removal of ammoniacal nitrogen (with concentration of about 2,100 mg (N-NH4+)/L) from landfill leachate, by adsorption on activated natural zeolite was carried out, aiming to propose the most efficient treatment pattern, so to maximize nitrogen removal.

The zeolite used in the research is clinoptilolite, one of the most suitable natural zeolites for ammoniacal nitrogen removal. Before the beginning of the main experimental procedure, the natural zeolite was crushed and sieved. The fraction retained had effective diameter between 355-600 μm (Fig. 1). After the pre-treatment, zeolite was chemically and thermally activated. In detail, chemical activation was carried out by treating the zeolite with aqueous solution of commercial grade sea salt (22.4 % w/v), for 2 h, at room temperature (Dong, Lin and He, 2017). Then, the chemically activated clinoptilolite, was washed with distilled water, dried and calcinated in a furnace at 500 °C for 2.5 h (Wang et al., 2007).

Figure 1. Raw clinoptilolite (left), pulverized clinoptilolite (right).

Adsorption experiments were carried out in 250 mL glass bickers. Thus, 100 mL of raw landfill leachate were inserted in each bicker, followed by calculated amounts of activated zeolite. The samples were agitated in a shaker for 1 h, at 200 rpm. Samples were taken after 2 min, 5 min, 10 min, 30 min and 1h, and the ammoniacal nitrogen concentration was determined using the Nessler method.

Initially, the effect of leachate dilution rate on the adsorption efficiency of ammoniacal nitrogen by activated zeolite was tested. Thus, raw leachate and aqueous solution with concentration 1:10 and 1:100 (leachate : water) were treated with 24 g, 2.4 g and 0.24 g of activated zeolite, respectively. Prior to adsorption, the pH was adjusted to 7 (Hankins et al., 2004). All experiments were carried out at room temperature (25 °C). The effect of agitation speed was also investigated, however, no significant correlation between agitation speed and ammoniac nitrogen adsorption was revealed. The tests resulted to ammoniacal nitrogen removal rates of 52.3%, 42.7% and 34.0%, respectively (Fig. 2i). Thus, our study was focused on the direct treatment of raw leachate.

Then, three individual treatment patterns for the treatment of 100 mL of raw landfill leachate with 40 g of activated zeolite were investigated:

- Treatment of 100mL of raw leachate with 40 g of activated zeolite.
- Treatment of 100mL of raw leachate with 20 g of activated zeolite, then, the supernatant was treated again with 20 g of activated zeolite.

- Treatment of 100mL of raw leachate with 13.33 g of activated zeolite, then, the supernatant was treated again with 13.33 g of activated zeolite and the resulting supernatant was treated again with 13.33 g of activated zeolite.

The results showed ammoniacal nitrogen removal rates of 83.7%, 93.6% and 93.8%, respectively (Fig. 2iiA-iiC). Thus the second scenario, of two successive treatment procedures appears as the most favorable. Similar adsorbance efficiencies have been reported by other researchers (Liang and Ni, 2009).

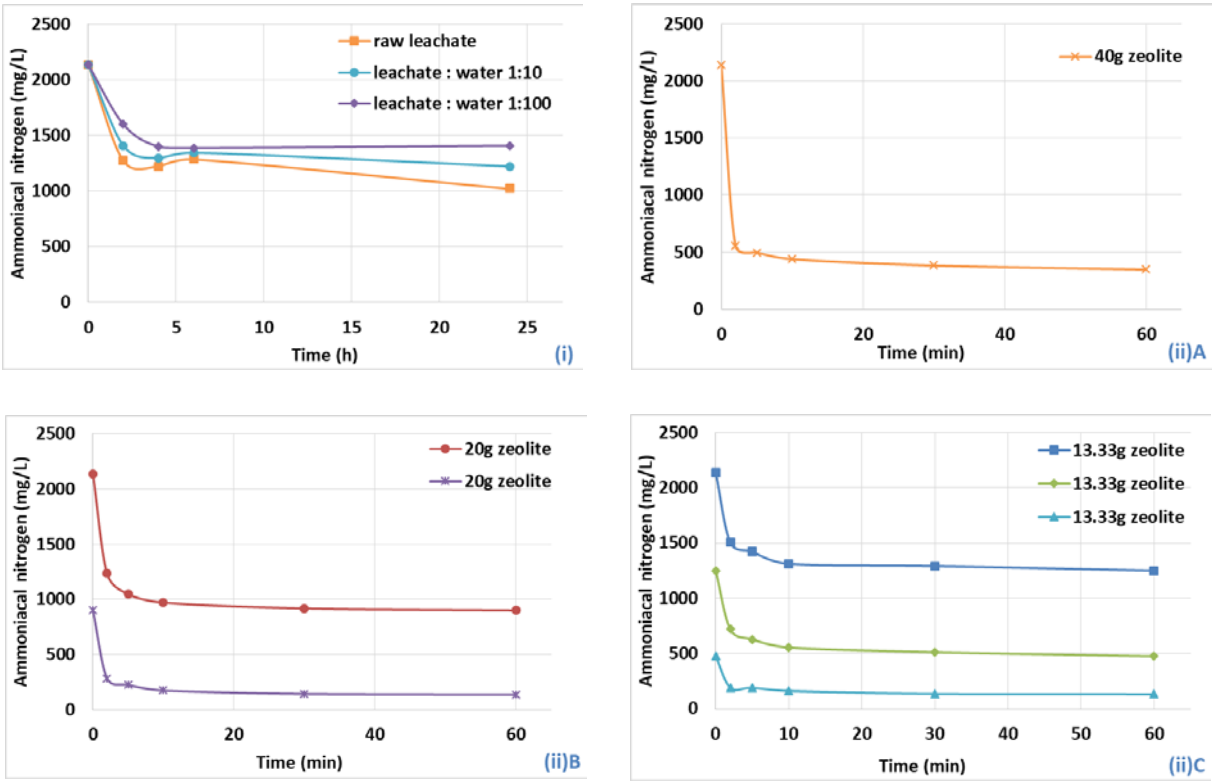

Figure 2. (i) Final concentration of ammoniacal nitrogen, following treatment of raw leachate and aqueous solutions with concentrations 1:10 and 1:100 (leachate : water) with 24 g, 2.4 g and 0.24 g of activated zeolite. (ii) Final concentration of ammoniacal nitrogen, following treatment of raw landfill leachate by: (A) 40 g of activated zeolite; (B) 20 g followed by 20 g of activated zeolite; (C) 13.33 g followed by 13.33 g and again by 13.33 g of activated zeolite

All things considered, the management of landfill leachate by adsorption on activated zeolite appears to be a promising process for the efficient removal of the ammoniacal nitrogen (reaching removal rates of up to 94%). The proposed treatment process appears easy to apply and involves raw materials of low cost, as both, zeolite and sea salt are abundant in nature.

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