Sustainable landfill leachate treatment by resource recovery

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The concept of sustainability is slowly acquiring a new dimension in the management of emissions from landfills. This is clearly seen by the adoption of resource recovery as one of the key aspects of sustainability. Harnessing energy from landfill gas is widely accepted as it provides environmental, economic and social benefits. However, **the use of landfill leachate as a potential source of nutrients remains untapped**. As a result, landfilling facilities only focus on treatment of landfill leachate to the required environmental standards, in order to avoid any negative effects to human and ecosystem health. Using our research, we demonstrate that by using coagulation-flocculation followed by granular activated carbon (GAC) and ion exchange, important resources such as organic matter and ammonium can be recovered from landfill leachate while reducing their concentration in the effluent stream to the set discharge limits.

Raw landfill leachate was first treated with coagulation-flocculation with Iron (III) chloride ($FeCl_3$) and polyaluminium chloride (PACl) to recover organic matter as sludge and determine the best coagulant for subsequent treatments. Supernatant from the coagulation step was passed through a GAC column and finally through a cation exchange column for ammonium removal and recovery. The performance of this treatment sequence was evaluated using parameters such as COD, α_{254}, ammonium nitrogen (NH_4^+- N) and nickel (Ni). The captured ammonium was eluted from the ion exchange using HCl.

In coagulation flocculation, the best results were obtained using $FeCl_3$. At an optimum concentration of 2.2 mg $FeCl_3$/mg COD_o (COD_o: initial COD concentration), coagulation flocculation preferentially reduces the original concentration of metals (79% Ni removal) and organic matter (50% COD removal, 66% α_{254} removal). Possibly, nickel readily forms insoluble precipitates than organic matter. Coagulation-flocculation was found ineffective in reducing ammonium from raw leachate.

Significant reduction in COD, α_{254} and nickel concentration and longer breakthrough times were observed after passing coagulated leachate through a GAC column compared to raw leachate. No COD, α_{254} or nickel breakthrough from GAC occurred during the experimental time. On the contrary, lower breakthrough times for COD, α_{254} and Ni were observed upon GAC treatment of raw landfill leachate. This shows that leachate pretreatment by coagulation-flocculation affects the performance

of GAC to remove COD, α_{254} and nickel. Better percentage removals were observed for $FeCl_3$ (79% COD, 92% α_{254} , 91% Ni) compared to raw leachate (40% COD, 31% α_{254}, 44% Ni) treated after 12,8 bed volumes (BV).

From the coagulated and raw leachate streams up to 98% and 19% ammonium was captured respectively after 10.6 BV upon passing the GAC effluent through a cation exchange column. Moreover, the ion exchange column treating coagulated leachate could be operated 1.6 times longer than that treating raw leachate. Our results further show that ion exchange column fed with leachate from coagulation and GAC steps required 2.6 BV of regenerant to elute the captured ammonium. In comparison, the column fed with raw leachate treated previously with GAC only needed 1.7 BV HCl to sufficient reduce the ammonium concentration to zero. This is an indication that ion exchange resin can adsorbs more ammonia from streams with less interfering species such as organic matter and nickel.

To optimize this process, further studies will focus on the amount of ammonium recovered from the ion exchange column. Subsequently the degree of regeneration of the ion exchange resin. Cost is an important aspect of sustainability, therefore, an economic analysis of the treatment sequence will be done. Given that the concentrated ammonium solution can be a valuable resource for non – agricultural industries, the economic analyses will consider the revenue generated from sale of the ammonium solution.