Purification of Landfill Leachate by Microalgae

Cheung Kwai Chung

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ABSTRACT

(1) Landfill leachates were collected and their chemical properties analysed bimonthly over a one year period from the Gin Drinkers' Bay (GDB) and Junk Bay (JB) landfills. The JB leachate contained higher average contents of solids, inorganic and organic matter than those of GDB with the exception of heavy metals. Heavy metals were present in the two leachates in trace quantities (<1.0 mg/L). The chemical composition of the two leachates correlated positively (P<0.05) to seasonal effects of dilution by rainfall. Magnesium and pH of the leachates remained relatively constant with respect to sampling time. The contents of solids, inorganic and organic components fluctuated considerably with time. The contents of average ammoniacal nitrogen were 1040 and 549 mg/L while COD were 767 and 695 mg/L for JB and GDB leachates respectively. These results suggest that the leachates needed further treatment before they can be discharged.

(2) Leachates from both landfills were assessed for their acute toxicity using four green algal species, *Chlorella pyrenoidosa*, *C. vulgaris*, *Dunaliella tertiolecta* and *Scenedesmus* sp. Junk Bay leachate was more toxic to the four algal species tested than GDB leachate. Growth of all four species in 50% JB leachate were significantly lower (P<0.05) than those in control. In contrast, the growth of only two species (*Chlorella vulgaris* and *Dunaliella tertiolecta*) in 50% GDB were significantly lower than those in control. Values of 96h-EC50 of JB leachate for all four species were lower than those of GDB. The high contents of ammoniacal-nitrogen and organic compounds (such as volatile fatty acids) seemed to be the factors governing the toxicity of leachate on algae. There were differential sensitivities to leachate exhibited by the tested algal species. Susceptibility to leachates in terms of cell number were in the ascending order of *Chlorella pyrenoidosa*, *Scenedesmus* sp., *C. vulgaris* and *Dunaliella tertiolecta*.

(3) Ammonia stripping followed by the high-lime treatment process was investigated in aerated tanks in the laboratory to compare the effectiveness of ammonia stripping at different flow rates (0, 1 and 5 L/min) as a pretreatment to remove ammoniacal-nitrogen in the leachate, and also to evaluate the effect of lime precipitation (10 mg/L Ca(OH)_2) in removing organic load (COD) and phosphorus. Ammoniacal-nitrogen removal at 20°C with one day retention time was 70% for 0 L/min, 81% for 1 L/min and 90% for 5 L/min regardless of the origin of leachate. The majority of ammonia loss was due to desorption through surface area. The levels of phosphorus and COD were only reduced by lime precipitation process, with 85% and 93% phosphorus removal and 24% and 47% COD removed for JB and GDB leachates respectively. The highly significant difference (P<0.05) of COD removal between JB and GDB might be attributed to the elevated level of high molecular organic matter in GDB leachate.

(4) The efficiency of *Chlorella pyrenoidosa* and *Scenedesmus* sp. in removing
various pollutants containing in landfill leachate after pretreatment by ammonia stripping was tested in the laboratory by batch culture system. The results showed that *Chlorella pyrénoidosa* and *Scenedesmus* sp. had a similar removal efficiency for nutrients such as ammoniacal-nitrogen, oxidized-nitrogen, ortho-phosphorus and COD. The COD removal by algal cultures were better in JB leachate than in GDB leachate (14-21% versus 0.4-7% respectively). The two stabilized leachates were less amenable to biological treatment due to the high content of refractory organic matter. No significant difference (*P > 0.05*) was found in removing other nutrients including ammoniacal-nitrogen, oxidized-nitrogen and ortho-phosphorus between JB and GDB leachate, regardless of the different pretreatment used. The removal efficiency of ammoniacal-nitrogen and phosphorus were found to be higher in air stripped leachate than in free stripped one. Removal of ammoniacal-nitrogen and phosphorus in air stripped leachate were 30% and 87% respectively. Poor removal of ammoniacal-nitrogen was probably due to a deficiency in phosphorus (high N:P ratio) for algal growth in leachate. The two-stage leachate treatment resulted in overall reduction of COD (38-51%), ammoniacal-nitrogen (72-96%) and ortho-phosphorus (79-96%).
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