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Assessment of pollutant removal efficiencies of municipal landfill leachate treatment techniques in the tropics

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Leachate generation is a major problem for municipal solid waste (MSW) landfills and causes a significant threat to surface and groundwater. Therefore, the treatment of leachate is essential to ensure the protection of both environmental and human health. Different treatment techniques as individual or integrated techniques, are being used in the world prior to the discharge of the leachate into the environment. This study was planned i) to explore the individual and integrated leachate treatment techniques used in the tropical region of the world, ii) to compare the percentage removals of key pollutants among leachate treatment techniques considered, iii) to determine the factors affecting the selection of appropriate leachate treatment technique/s and, iv) to evaluate the removal efficiencies of the key pollutants of the leachate discharged at the sanitary landfill at Dompe by the integrated technique of sequential batch reactors (SBR) and constructed wetland (CW). The first three the objectives were achieved through a comprehensive literature survey. The leachate samples for the fourth objective were collected at three locations within the treatment system and analyzed for selected parameters using standard methods. The statistical analysis for the data obtained from the sanitary landfill at Dompe was done using Minitab 17. Results revealed that, the aerated lagoons, aerated sludge reactor, SBR, and reverse osmosis (RO) were the more effective methods in removing the key pollutants such as chemical oxygen demand (COD), bio-chemical oxygen demand ($BOD_{5)}$, phosphate and sulfate, while adsorption, coagulation-flocculation, and membrane filtration were effective in removing COD, ammonia, heavy metals as well as total suspended solid (TSS) and total dissolved solid (TDS). The integration of leachate treatment techniques showed higher removal efficiencies than any individual (physical, chemical, or biological) treatment technique. In addition, the composition, age of the waste material, precipitation, and climate were the determinants for an appropriate leachate treatment facility identified in the literature survey. Results further revealed that the leachate treated with SBR at Dompe showed significant reductions of BOD_5, COD, TDS, phosphate, and sulfate compared with influent leachate ($p>0.05$; One way ANOVA). Nevertheless, integration of SBR with CW produced effluents with significant reductions of BOD_5 (79.84%), COD (69.57%), TDS (38%), TSS (35.73%), phosphate (56.35%), sulfate (61.16%), and Pb (84.46%) ($p>0.05$; Student's t-test). Results revealed that the selected parameters were within the maximum permissible limits of effluent water quality standards for discharge into inland surface water bodies. Although the appropriate integration of leachate treatment techniques showed higher removal efficiencies of the key pollutants than any individual treatment technique, taking into consideration of-factors including age, leachate volume and composition of waste are recommended for future designs of MSW leachate treatment plants.

Keywords: Biological, Integrated treatment methods, Landfill leachate, Physiochemical, Pollutant removal efficiency