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Application of Local Adsorption Material in Treating Municipal Solid Waste Leachate

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Abstract

In this research study, Palygorskite (PAL) from Shuwaymiyah in Dhofar governorate in the Sultanate of Oman has been used for the adsorption isotherm of two pollutants (i.e. Total Organic Carbon (TOC) and Ammonia Nitrogen (NH3-N)) in Municipal Solid Waste (MSW) leachate from Al-Amerat landfill site. The leachate sample was characterized for all parameters mentioned in Ministerial Decision of wastewater re-use and discharge (MD 145/93) to identify the level of contaminants in the leachate. The batch adsorption experiments were performed to evaluate the adsorption behavior of Shuwaymiyah Palygorskite (SPAL) on the removal of TOC and NH3-N in three different forms (i.e. raw, washed & calcinated at 550oC). Also, the US commercial PAL was used in this research to compare the observations and findings of SPAL with the commercially available PAL for the adsorption process. The X-ray diffraction (XRD) analysis of SPAL and US PAL was conducted to identify the mineralogical composition of clay. The effect of adsorbent dosage and the initial concentration of the pollutants in the sample on the adsorption behavior of SPAL and US PAL were studied.

The leachate characterization showed that the organic pollutants are present in the leachate sample in high concentration comparing to heavy metals. The XRD analysis showed the availability of PAL in the raw and washed SPAL and US PAL while it was absent in calcinated SPAL due to the destruction of the structure of the clay by thermal treatment at high temperature and conversion of the PAL minerals to another type of minerals. The results of the experiments revealed that the amount of TOC and NH3-N adsorbed by SPAL decreased as the dosage of adsorbent increased. This is because the relationship between adsorbent dosage and adsorption amount is inversely proportional. On the other hand, the removal efficiency of SPAL in removing TOC and NH3-N increased as the adsorbent mass increased due to increase of the surface area of the clay to adsorb more particles and molecules. Furthermore, the adsorption amount of TOC and NH3-N decreased, and the removal efficacy increased as the initial concentration decreased. However, the equilibrium concentration of TOC and NH3-N decreased as the vi

initial concentration decreased. The study showed that the equilibrium concentration of NH3-N reached to the limit specified in MD 145/93 especially with washed and calcinated SPAL. There was a reduction in TOC and NH3-N equilibrium concentration by 99 % from raw leachate to 1:100 diluted leachate using SPAL. This finding proved that the SPAL is a capable adsorbent that could be an alternative to the expensive adsorbent in Gulf region and worldwide.

The equilibrium isotherms for TOC for all types of clay were best fitted by the Langmuir isotherm model which indicate the process of TOC adsorption is monolayer and the adsorption takes place at the surface of the clay and at the homogenous surface. The maximum adsorption capacity of TOC was 4.401 mg/g by raw SPAL. The adsorption isotherm for NH3-N were best fitted with the Freundlich isotherm model with all type of clay except with raw SPAL which is fitted to both models. This indicate that the adsorption process of NH3-N was followed the interlayer adsorption process and the adsorption takes place at the heterogenous surface. The maximum adsorption capacity of NH3-N was 1.167 mg/g by raw SPAL. In conclusion, the SPAL is a capable adsorbent for treating TOC and NH3-N from the leachate sample which could substitute the expensive activated carbon.

Pre-treatment of the leachate sample is recommended because the adsorption behavior is affected by the initial concentration and the seasonal variation and different landfill sites to be considered in the adsorption research. Also, the thermal treatment at lower temperature is recommended and the effect of pH, temperature and contact time on the adsorption behavior are advisable.