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Geospatial and Statistical Evidences of Non-Engineered Landfill Leachate Effects on Groundwater Quality in a Highly Urbanised Area of Nigeria

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Abstract : An investigation was carried out on underground water system dynamics within Ilorin metropolis to monitor the subsurface flow and its corresponding pollution. Africa population growth rate is the highest among the regions of the world, especially in urban areas. A corresponding increase in waste generation and a change in waste composition from predominantly organic to non-organic waste has also been observed. Percolation of leachate from non-engineered landfills, the chief means of waste disposal in many of its cities, constitutes a threat to the underground water bodies. Ilorin city, a transboundary town in southwestern Nigeria, is a ready microcosm of Africa's unique challenge. In spite of the fact that groundwater is naturally protected from common contaminants such as bacteria as the subsurface provides natural attenuation process, groundwater samples have been noted to however possesses relatively higher dissolved chemical contaminants such as bicarbonate, sodium, and chloride which poses a great threat to environmental receptors and human consumption. The Geographic Information System (GIS) was used as a tool to illustrate, subsurface dynamics and the corresponding pollutant indicators. Forty-four sampling points were selected around known groundwater pollutant, major old dumpsites without landfill liners. The results of the groundwater flow directions and the corresponding contaminant transport were presented using expert geospatial software. The experimental results were subjected to four descriptive statistical analyses, namely: principal component analysis, Pearson correlation analysis, scree plot analysis, and Ward cluster analysis. Regression model was also developed aimed at finding functional relationships that can adequately relate or describe the behaviour of water qualities and the hypothetical factors landfill characteristics that may influence them namely; distance of source of water body from dumpsites, static water level of groundwater, subsurface permeability (inferred from hydraulic gradient), and soil infiltration. The regression equations developed were validated using the graphical approach. Underground water seems to flow from the northern portion of Ilorin metropolis down southwards transporting contaminants. Pollution pattern in the study area generally assumed a bimodal pattern with the major concentration of the chemical pollutants in the underground watershed and the recharge. The correlation between contaminant concentrations and the spread of pollution indicates that areas of lower subsurface permeability display a higher concentration of dissolved chemical content. The principal component analysis showed that conductivity, suspended solids, calcium hardness, total dissolved solids, total coliforms, and coliforms were the chief contaminant indicators in the underground water system in the study area. Pearson correlation revealed a high correlation of electrical conductivity for many parameters analyzed. In the same vein, the regression models suggest that the heavier the molecular weight of a chemical contaminant of a pollutant from a point source, the greater the pollution of the underground water system at a short distance. The study concludes that the associative properties of landfill have a significant effect on groundwater quality in the study area.

Keywords : dumpsite, leachate, groundwater pollution, linear regression, principal component
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