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Water Flow and Pollutant Transport Through Clay Vadose Zone Underlying Dairy Farm Waste Lagoons

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Unlined earth lagoons are commonly used around the world to store liquid animal-waste. The impact of waste water percolation from such lagoons on the quality of groundwater recharge was investigated in a typical dairy farm. The study implemented unique vadose-zone monitoring systems that enable measurements of the temporal variation of the sediment's water content along with frequent sampling of the sediment's pore water in deep sections of the vadose zone. Four years of continuous monitoring revealed a substantial increase in the soluble salt concentration with depth in the clay sediment. A conceptual model of desiccation-crack-induced salinization (DCIS) was proposed to explain increased salinization with depth. The model suggests that evaporation through deep desiccation cracks triggers advective water flow from the wet sediment underlying the liquid waste source toward the dryer sediment at its margins, and back-diffusion of solutes from the evaporative zone to the wetter sections under the liquid waste source. It was further found that overflows from the waste lagoon as well as local runoff during high intensity rain events, preferentially infiltrate through the desiccation cracks around the waste source into deep sections of the vadose zone. This process accelerates groundwater contamination through rapid transport of contaminants through the vadose zone bypassing the sediment's most bio-geo-active parts. The spatial and temporal variations in the water content along the vadose zone had a strong impact on ammonium and nitrate transport and biodegradation in the subsurface. Intensive nitrification and denitrification processes within the vadose zone decreased the infiltrating nitrogen load by 85 to 100% and were expressed in the isotopic composition of the propagating nitrate. Our findings suggest that construction of unlined liquid waste storage facilities in highly dispersive clayey sediment has the potential to degrade groundwater quality, and that the margins of such facilities must be accounted for when assessing the environmental impact of waste storage facilities.