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Modelling Groundwater Contamination Trends in Lahti, Finland

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Extended Abstract

Legacy pesticide atrazine continues to persist in groundwater systems despite the ban in EU since 2004 due to its long-term retention in subsoil layers [1]. Groundwater monitoring data from the Laune aquifer in Lahti, Finland, has shown relatively stable, elevated concentrations of atrazine for over two decades, indicating sustained subsurface contamination [2]. The study investigated the long-term behaviour of atrazine in the Laune aquifer by applying numerical flow and transport modelling. The MODFLOW groundwater flow model and the MT3D transport model were used to simulate and analyse the movement and attenuation of atrazine under varying source conditions. The migration of atrazine through the groundwater system and the variation in its concentration under different depletion scenarios were investigated.

The study area covered a 2 × 3 km area in Lahti. Groundwater flow conditions were based on a calibrated model of the Laune aquifer, supported by long-term monitoring data collected from local groundwater observation wells over the past 20 years. These data provided both historical concentration trends and hydrogeological context for the simulations. Three conceptual scenarios were modelled to explore future trends in atrazine concentrations. The first scenario assumed a steady release of atrazine from historical application sites over 30 years, representing persistent contamination. The second scenario involved sudden depletion, where atrazine leaching ceased entirely, simulated over 20 years. The third scenario considered gradual depletion, with atrazine concentrations halving every 10 years, representing natural attenuation, and was modelled over 30 years. These scenarios provided insights into how different source behaviours affect long-term contamination trends in the aquifer.

The results highlighted notable differences in contaminant behaviour under each scenario. The steady release scenario predicted prolonged elevated concentrations, consistent with historical observations, with atrazine levels remaining above the EU drinking water limit of 0.10 µg/L across the main flow zone for the full simulation period. In contrast, the sudden depletion scenario led to a rapid decline in concentrations, with most monitoring points falling below the safe limit within five years, still levels exceeding the limit value in the main flow zone after about 10 years. The gradual depletion scenario showed a more complex pattern, with concentrations decreasing over time but still exceeding regulatory thresholds near the railway area after 30 years, while southern parts of Laune approached safe levels.

The findings demonstrated that while natural processes will eventually dilute and deplete atrazine concentrations, the timeline for recovery is highly dependent on the nature of residual sources. In areas with persistent contamination, atrazine may remain a concern for decades without intervention [3]. The modelling approach provided a valuable framework for predicting long-term trends and planning targeted remediation strategies.

References

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