Development and Evaluation of a Novel Smart Automated System for Chromogenic Bacterial Detection in Water Samples

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Water contamination poses a global challenge, particularly in regions relying on unlicensed artesian wells for agriculture and livestock without regulatory oversight. This study examines the impact of livestock on bacterial contamination, focusing on Coliform and E. coli bacteria. Water samples from wells with and without livestock were analyzed using traditional microbiological methods, including pour plate counting, chromogenic testing, and multiplex PCR. The results revealed significantly higher bacterial contamination in wells near livestock farms, indicating a direct correlation between agricultural activities and waterborne hazards. To address the need for rapid, accessible bacterial testing, this project developed and validated a smart automated system for chromogenic bacterial detection in water samples. The system integrates Arduino Uno-controlled pumps, Raspberry Pi-based AI image classification, and a mobile application for real-time analysis. Chromogenic test images were analyzed using two classification methods: (1) an AI-based image classification model in a mobile app and (2) preset color-code analysis using Python on the Raspberry Pi. Statistical comparisons confirmed that the AI-based system achieved higher detection accuracy, reducing human error and improving reproducibility. This cost-effective, scalable, and user-friendly system enables real-time analysis and remote contamination alerts, bridging the gap between unregulated water use and modern water safety standards. It provides a sustainable, practical tool for global water quality monitoring, especially in resource-limited areas.

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