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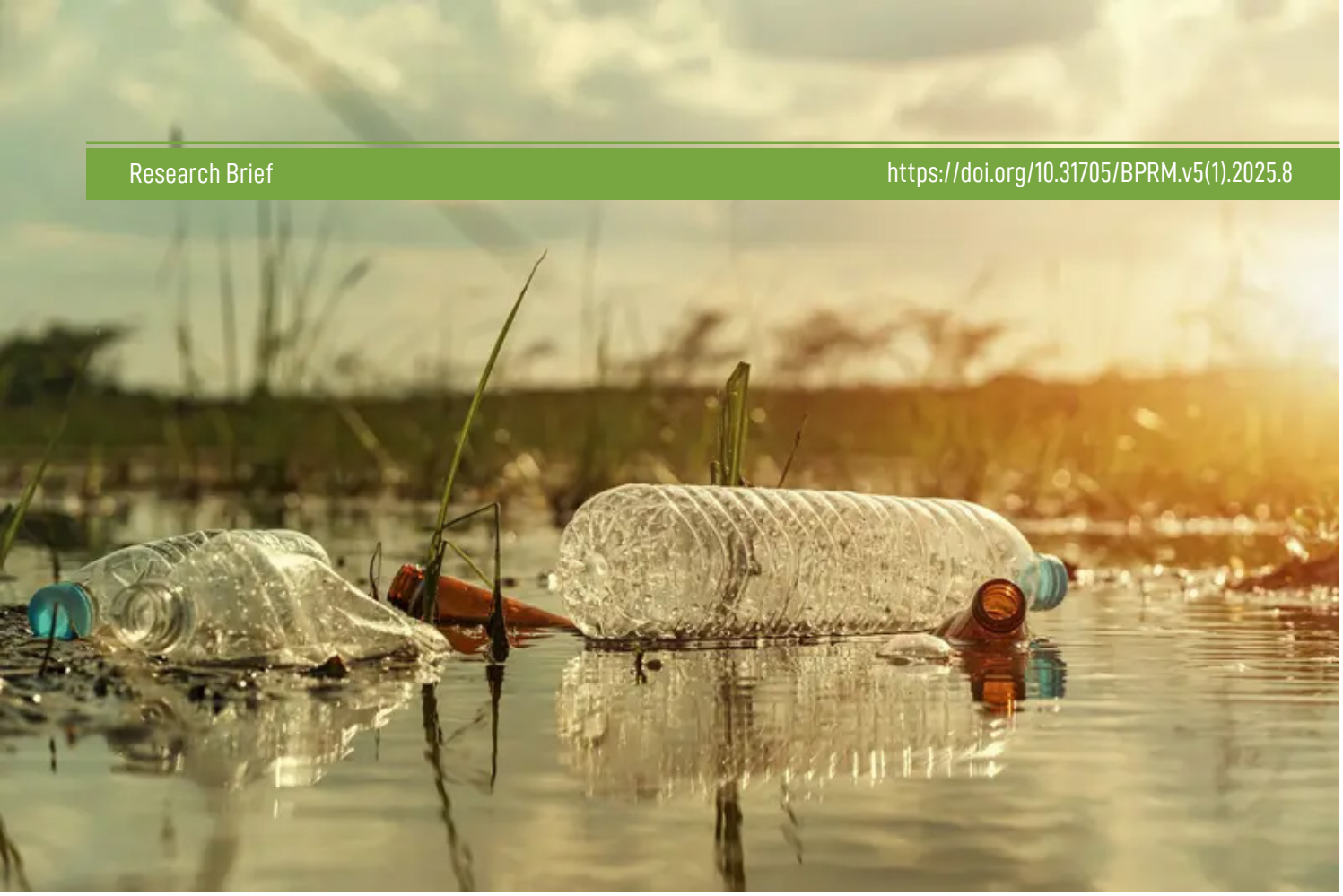

Unveiling the Water Pollution in the Kelani River:

Engineering Insights for a Sustainable Future

The growing pressures of climate change, urbanisation, and population growth have escalated challenges related to water quality and the availability of clean water in source catchments. These factors lead to pollution, habitat loss, and altered hydrological patterns, which complicate the supply and quality of usable water for various purposes [1]. Rivers are increasingly contaminated by multiple pollutants, including domestic and industrial sewage, agricultural runoff with fertilisers and pesticides, and urban stormwater. Alarmingly, around 80% of domestic, municipal, and industrial wastewater worldwide is discharged into water bodies without any prior treatment, contributing to the pollution of rivers and other freshwater systems [2]. It has significant concerns for human health and negative impacts on ecosystem health and biodiversity. However, water quality in many rivers remains poorly monitored, potentially exposing more than 3 billion people globally to waterborne diseases [3].

Addressing the issues related to the pollution of river bodies is important to promote the sustainability of the water resource for use by aquatic organisms and humans, especially in developing countries with inadequate rules and regulations to prevent pollutants from flowing into rivers, lakes, and groundwater systems. Water pollution has become a significant environmental issue in Sri Lanka, especially in densely populated and industrial areas [4]. Rivers and lakes in the country are facing considerable pressure from both urban and rural activities. Domestic sewage and industrial effluents in urban areas are released without treatment into rivers, while chemical fertilizers and other pollutants in agricultural runoff from rural areas are also released into water bodies. The Kelani River Basin (KRB) is considered the most polluted watershed in the country, as identified by the Central Environmental Authority [4]. Industrial waste from two major industrial zones, Biyagama and Seetha-

wake, as well as pollution from domestic sewage, has led to the contamination of this critical waterway, which serves as the primary water source for over 80% of the population of Colombo, which is close to a quarter of the population in Sri Lanka. The water quality of the river is deteriorating, posing risks not only to public health but also to biodiversity and economic activities reliant on the river, such as fisheries, irrigation, and transportation. The KRB is highly susceptible to pollution due to the intense rainfall patterns influenced by monsoon seasons, which lead to high river discharge and the spread of contaminants across the river system. Given the critical role of the Kelani River in providing drinking water, supporting agriculture, and sustaining the local economy, addressing water pollution in the basin is a pressing issue. Current efforts to manage water quality in the KRB are hindered by challenges in accurately identifying pollution sources and assessing the severity of contamination.

The current study was conducted using a combination of machine learning techniques, including Factor Analysis, Cluster Analysis, and Long Short-Term Memory (LSTM) Artificial Neural Networks (ANN), alongside hydrological modelling with HEC-HMS, hydrodynamic modelling with HEC-RAS, and water quality modelling using the Water Quality Analysis Simulation Program (WASP). The water pollution levels in the river were calculated through the novel Kelani River Basin-Industrial Pollution Index and the Kelani River Basin-Sewage Pollution Index. The measured concentrations of Electrical Conductivity (EC), Turbidity, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Phosphate, Nitrate, Lead, Cadmium, Iron, Zinc, and Total Coliform for the period 2016-2020 were used for the analysis. It was identified that urban runoff, salinity intrusion, and industrial, municipal, and domestic sewage are the primary types of pollution in the KRB. Among these, pollution from industrial, municipal, and domestic sewage was found to have the most significant impact on water quality degradation, as it exhibited a more extensive spatial distribution across the basin compared to other pollution sources. A spatial variation analysis was carried out to identify the spatial patterns of water pollution, and it highlighted that the stations near industrial zones and urbanized areas showed higher water quality variations. Similarly, a seasonal variation analysis revealed strong relationships between water quality and monsoonal patterns. It was identified that Cadmium, Iron, and Zinc as the main industrial pollutants, while Dissolved Oxygen (DO), Total Coliform, and Chemical Oxygen Demand (COD) as the main parameters influencing municipal and domestic sewage pollution. The study highlighted that industrial wastewater was discharged into the tributaries of the Kelani River (Figure 1), where pollution levels were alarmingly high. However, it was observed that upon merging with the main river, the pollutant concentrations were diluted, reducing their impact downstream. Sewage pollution was found to be more severe in the highly urbanized areas towards the downstream section of the Kelani River (Figure 2). Additionally, the results revealed that increased pollution was observed during periods of increased rainfall and streamflow, suggesting a significant increase in pollutant loads during heavy rainfall or that the runoff is mobilizing pollutants from the surrounding areas.

The findings of this study highlight the significant pollution challenges in the Kelani River, which are closely linked to monsoonal patterns, with increased pollution observed during periods of high rainfall and streamflow. Industrial wastewater discharge into tributaries, along with widespread sewage pollution in urbanized downstream areas, poses a serious threat to water quality. To address these issues, it is crucial to implement regular monitoring programs, particularly at high-risk locations, to control industrial, municipal, and domestic pollutant discharge. Additionally, monitoring water quality near existing water intakes for treatment plants is essential, as heavy metal contamination poses severe risks to public health. Authorities should develop targeted remediation and management strategies to mitigate pollutant discharge, while the local community should be informed about the worsening pollution levels during heavy rainfall and the associated health risks. Strengthening pollution control measures and ensuring sustainable river management through collaborative efforts between policymakers, researchers, and the public is imperative to safeguarding the Kelani River ecosystem.

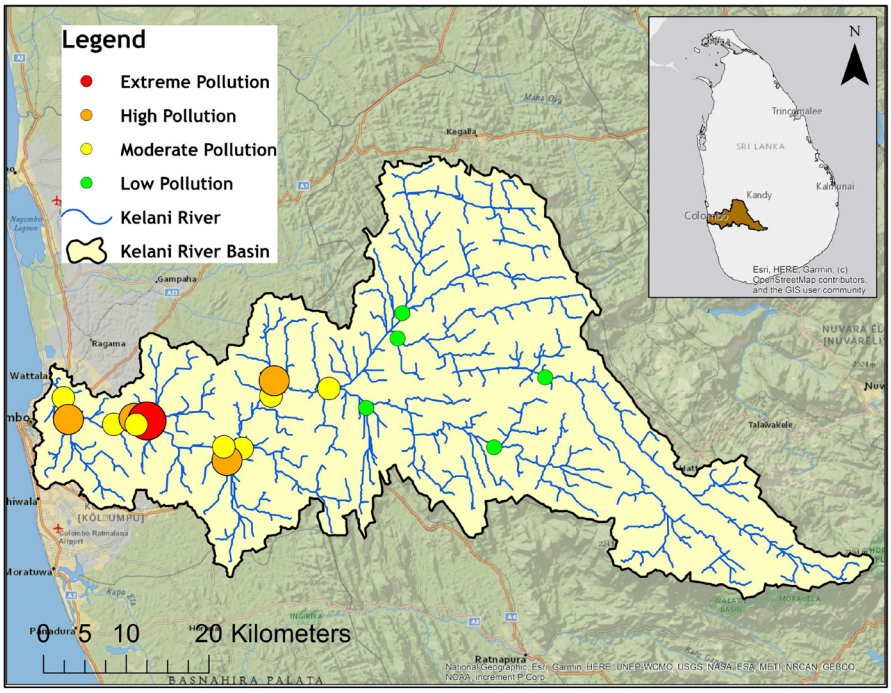

Figure 1: Spatial distribution of industrial pollution sources in the Kelani River Basin

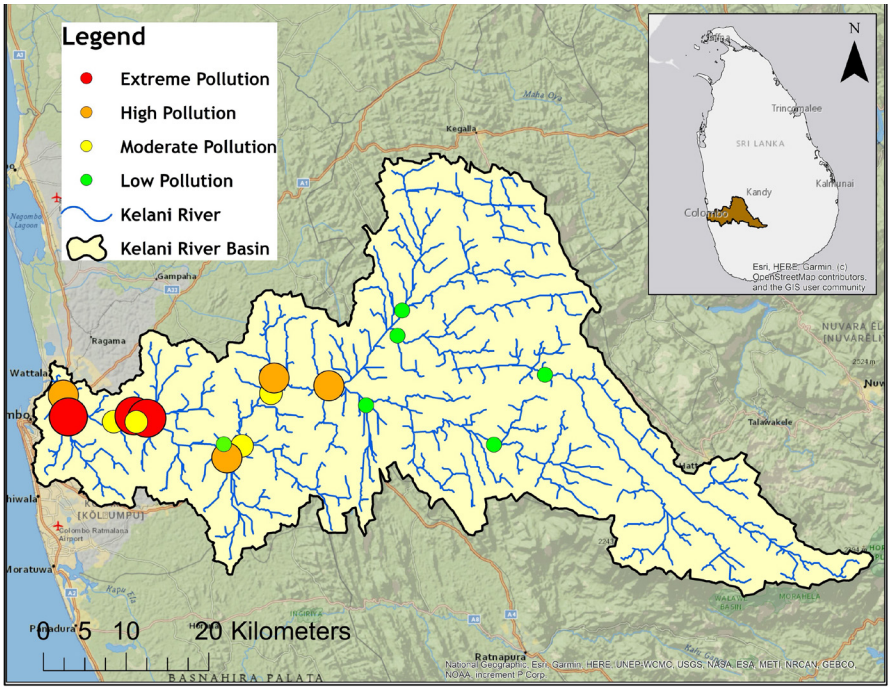

Figure 2: Spatial distribution of sewage pollution sources in the Kelani River Basin

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