CHEMSENSE-EcoWatts: An ESP32-Based IoT Framework for Energy Recovery and Chemical Waste Mitigation in Petrochemical Effluents

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Abstract

Industrialization has accelerated pollution of the environment and energy wastage, especially in the petrochemical industry. Effluent wastewater from these industries carries chemical pollutants and still holds significant thermal energy not harnessed. CHEMSENSE-EcoWatts is a modular IoT-based platform for real-time monitoring and eco-friendly energy recovery from petrochemical effluents, as introduced in this work. The platform utilizes an ESP32 microcontroller, coupled with pH, temperature, gas, and flow sensors, and a PCF8574 I/O expander for expandable input management. The data are transmitted over the SIM800L GSM module using MQTT and HTTP protocols for cloud visualization. At the same time, residual thermal energy of the effluent is utilized to generate electrical power through a micro steam turbine generator. The combined system exhibits twofold functionality—chemical waste reduction and green energy production—improving treatment effectiveness by 40% and harvesting up to 2.4 W of recoverable power. Experimental results show promising environmental and operational gains, confirming the viability of CHEMSENSE-EcoWatts for intelligent industrial wastewater management.

Keywords

ESP32, IoT, Energy Recovery, Petrochemical Effluents, Chemical Wastewater, Steam Turbine, Smart Monitoring.