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Development of New Concepts of Generating Pure Water from Dirty Water using AI – ML – DL with IoT Techniques

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***Abstract*— In this research paper, the development of composite technology-based method of generating pure water from dirty water using AI - ML & IoT techniques with composite-powdered concepts is provided with some experimentation results. These pollutants adversely affect aquatic ecosystems, soil fertility, and human health, thereby creating an urgent need for efficient, economical, sustainable, and environmentally friendly water purification technologies. In recent years, composite technology has emerged as one of the most promising approaches for advanced water purification due to the exceptional physicochemical properties of composite materials, including high surface area, enhanced adsorption capability, superior catalytic activity, and improved contaminant removal efficiency. The present work focuses on the design and development of a composite technology-based smart water purification system using Artificial Intelligence (AI), Machine Learning (ML), and Internet of Things (IoT) techniques for obtaining pure water from contaminated water sources. The green synthesis approach utilizes phytochemical compounds present in plant extracts as natural reducing and stabilizing agents, thereby minimizing the use of toxic chemicals and supporting environmentally sustainable composite particle synthesis. The synthesized CaO composite particles were utilized as composite- adsorbents and catalytic materials for wastewater purification and dye degradation applications. The synthesized composite materials were characterized using various analytical and material characterization techniques such as X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS), BET surface area analysis, and UV–Visible spectroscopy. The characterization studies confirmed the successful formation of crystalline calcium oxide composite particles with desirable structural, morphological, optical, and surface properties suitable for adsorptions.**

***Index Terms*— Composite technology, Water, Green synthesis, Calcium Oxide composite particles, Direct Nitrate Calcination (DNC), Oxalis corniculate, Dye removal.**

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I. INTRODUCTION

Composite technology has emerged as one of the most promising fields of research owing to the unique physicochemical properties of composite materials and their wide range of applications in catalysis, environmental remediation, energy storage, and biomedical sciences. In recent decades, composite materials have been extensively developed; however, many composite particles synthesized through conventional chemical and physical routes involve toxic reagents, hazardous by-products, and high energy consumption, making the synthesis process environmentally unsustainable (Osman et al., 2024). In addition, the increasing demand for economical and environmentally benign composite catalysts has created the need for sustainable alternatives to expensive and toxic composite materials. Conventional composite particle synthesis techniques often require harsh reaction conditions, elevated temperatures, and hazardous reducing or stabilizing agents, thereby limiting their large-scale eco-friendly applications [1].

II. NEED FOR SMART WATER PURIFICATION SYSTEMS

The increasing level of environmental pollution has created a strong demand for intelligent and automated water purification systems. Traditional purification systems generally depend on manual monitoring and fixed threshold-based operations, which may not provide accurate and real-time assessment of water quality. Smart purification systems combine sensing technologies, automation, composite technology, and AI-based analytics to achieve efficient purification and monitoring. IoT-enabled sensors continuously collect real-time water quality data such as pH, turbidity, temperature, conductivity, and Total Dissolved Solids (TDS). AI and ML algorithms process these data to predict contamination levels and automatically control purification processes. Such intelligent systems minimize human intervention and improve operational efficiency. Smart purification technologies also support remote monitoring through cloud platforms and mobile applications. The adoption of intelligent water purification frameworks is becoming increasingly important in smart cities, industries, healthcare sectors, and rural environmental monitoring applications, which can be seen in the Fig. 1 [2].

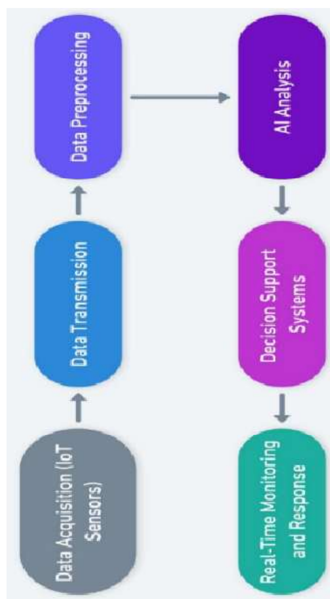

Fig. 1: Block-diagram of typical water purifier system & Process of filtering dirty water to get pure water

III. ROLE OF COMPOSITE TECHNOLOGY IN WATER TREATMENT

Composite technology plays an important role in modern water purification and environmental remediation applications. The synthesized composite materials exhibit excellent adsorption and photocatalytic characteristics. Composite technology-based systems provide high purification efficiency with low energy consumption and reduced chemical usage. These advantages make composite technology highly suitable for sustainable water treatment applications [3].

IV. LITERATURE SURVEY

A large number of researchers had worked on the proposed topic chosen for the project work, but here, only a few of the base papers had been chosen and surfed upon here. This study concluded that green synthesized composite particles are environmentally safe, cost- effective, and suitable for wastewater treatment applications. The work also highlighted the importance of plant extracts in sustainable composite technology, which can be seen in the Fig. 2 [4].

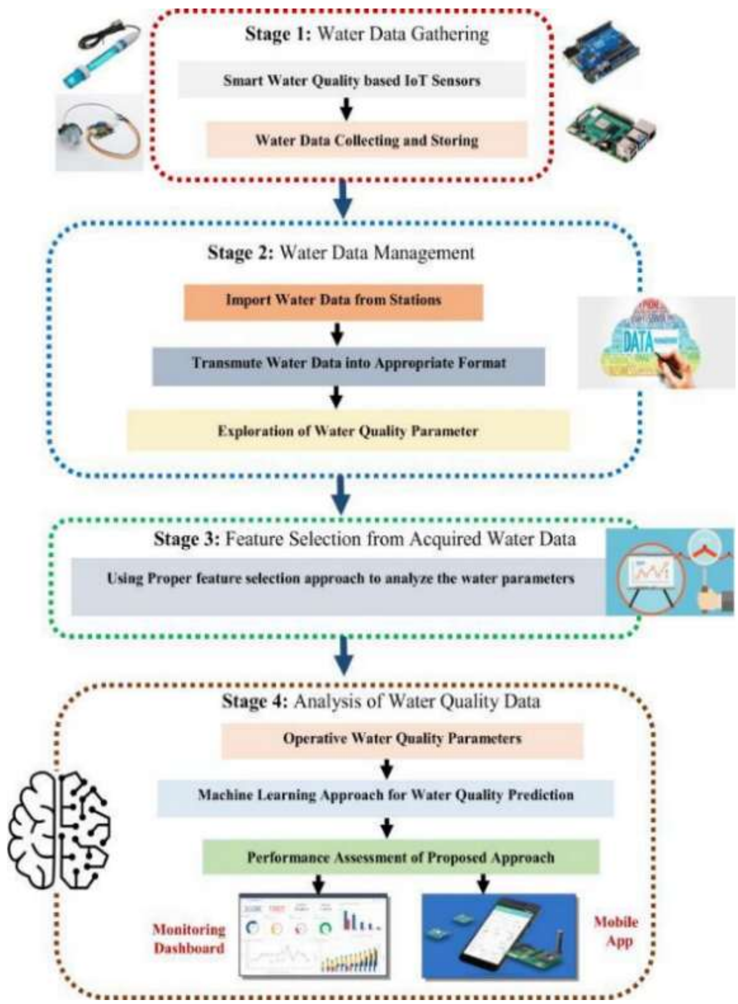

Fig. 2: Implementation process of purification with the help of AI-IoT system

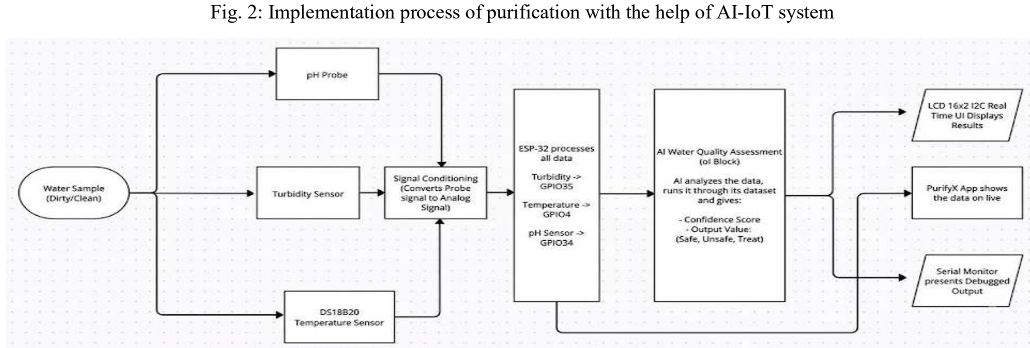

Fig. 3: Implementation process of purification with the help of AI-IoT system

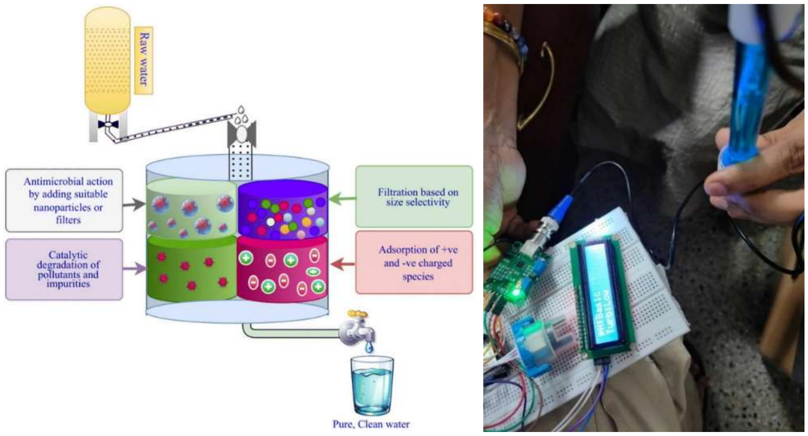

Fig. 4: RT experimental set up of water quality monitoring system on a bread board / pH testing process performed on a collected dirty water sample / Complete prototype of the h/w arrangements

This photograph shown in the Fig. 4 the real-time experimental setup of the water quality monitoring system connected on a breadboard platform. The pH sensor probe is immersed in a water sample while the LCD display shows measured water quality parameters obtained from the sensor interface circuit. The image illustrates the pH testing process performed on a collected water sample using the integrated sensor module. The LCD screen displays the detected pH value and water condition, indicating successful sensor calibration and real-time data acquisition [10]. This photograph presents the complete prototype hardware arrangement consisting of the pH sensor, turbidity sensor, microcontroller unit, relay interface, and LCD display module. The system is actively measuring water quality parameters and displaying the output values continuously during experimentation. The image demonstrates simultaneous monitoring of pH, temperature, and turbidity values using the developed embedded monitoring circuit. The LCD display clearly indicates measured values, confirming successful integration of multiple sensors into a single water analysis platform & the testing procedures could be seen in the Fig. 5 [8].

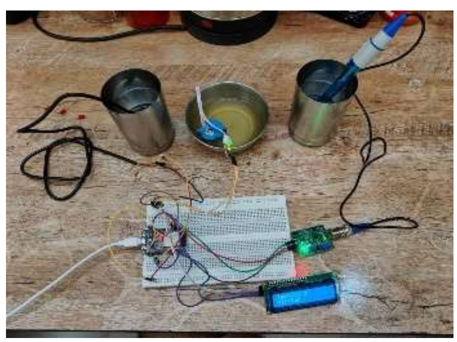

Fig. 5: Testing procedures

The images illustrate an IoT-based smart water quality monitoring and soil analysis prototype designed for environmental and agricultural applications. The setup consists of a soil bed integrated with multiple sensors, electronic circuitry, and a microcontroller-based monitoring system mounted on a breadboard. Different water samples labeled as clear water, salt water, and mud water are placed in separate containers to analyze variations in water quality parameters. Sensor probes inserted into the soil and liquid samples help detect characteristics such as moisture content, conductivity, and contamination levels in real time. The system demonstrates how embedded electronics and sensor technology can be utilized for intelligent environmental monitoring, precision agriculture, and water management applications [12]. The prototype highlights a low-cost and practical approach for real-time sensing, data acquisition, and automated monitoring in smart farming and sustainable resource management systems. The image shows an IoT-based smart water quality monitoring system designed for real-time analysis of different water samples. The setup includes multiple sensor probes immersed in containers containing water samples, interfaced with a microcontroller circuit assembled on a breadboard [9].

VIII. CONCLUSIONS

The present study successfully demonstrated synthesis of calcium oxide composite particles using green route via aqueous leaf extracts of Oxalis Corniculata as reducing and stabilizing agents, providing an environmentally benign alternative to conventional chemical synthesis routes. XRD analysis confirmed the formation of highly crystalline cubic-phase CaO composite particles for all synthesized samples, with dominant diffraction peaks corresponding to the characteristic (111) and (200) planes of CaO. The calculated crystallite sizes revealed composite scale particle formation, where CaO synthesized using leaf powder exhibited comparatively smaller crystallite sizes (52 nm for the (200) plane and 62 nm for the (111) plane) than fresh leaf and DNC-derived samples. The smaller crystallite size suggests enhanced nucleation and controlled particle growth due to phytochemical-assisted synthesis. UV–Visible spectroscopy and Tauc plot analysis revealed wide optical band gap energies in the range of 5.4–5.7 Ev. The slight variation in band gap values may be associated with crystallite size variation, surface defects, and residual phytochemical interactions. FTIR analysis verified the presence of Ca–O stretching vibrations in the lower wavenumber region, confirming successful CaO formation. Additional hydroxyl and carbonate bands suggested slight atmospheric hydration and carbonation due to the hygroscopic nature of calcium oxide compositeparticles.

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