CHAPTER 5

SMART CONTROL FOR WARNING SYSTEM: WATER TREATMENT USING MAGNETIC MICROPARTICLE

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5.1 INTRODUCTION

Water pollution is an urgent global problem that poses serious threats to human health and environmental sustainability. In the following decades, challenges with acquiring adequate quality water are projected to worsen. Worldwide water shortages are expected to happen, even in areas that are currently thought of as water-rich. In order to find effective ways of purifying water at cheaper costs and using less energy while also reducing the overall environmental impact, addressing these issues has spurred a significant amount of study (Baresel et al., 2019). The contamination of water sources with organic and inorganic compounds, microbiological agents, and microplastics necessitates the development of effective and efficient water purification technologies. In recent years, a promising water purification technology involving a three-component composite system has emerged. A three-component composite allows the magnetic removal of organic, inorganic, microbiological, and microplastic contaminants from water. Magnetic Fe_2O_3/SiO_2 core–shell nanoparticles are functionalized with a polyoxometalate ionic liquid. The composite may be disseminated in water, binds numerous contaminants and can be fully retrieved with a permanent magnet (Misra et al., 2019). Figure 5.1 shows an overview of the water purification using the magnetic micro-particle and the use of magnet to remove the micro-particle.

Figure 5.1 Water treatment using magnetic microparticle

This project aims to design and implement a magnetic composite microparticle-based system. These composite particles possess exceptional adsorption properties, allowing for the efficient removal of a wide variety of water contaminants. The core-shell structure improves the particles' stability and reusability, while the ionic liquid functionalization improves their binding capabilities.

The water purification system consists of multiple components that operate in concert. Core-shell nanoparticles, which function as adsorbents, are introduced into a tank containing contaminated water. The water is stirred by a stirrer controlled by a controller to ensure thorough mixing and contact between nanoparticles and contaminants. After the purification process is complete, an electromagnetic field is induced to cause nanoparticles to adhere to the tank's walls, preventing their escape during the pumping phase.

To ensure the efficacy of the water purification process, a sensor is installed at the outlet valve to measure the water's cloudiness. The sensor measures the presence of any remaining microparticles and determines whether to cease pumping if the water remains cloudy or to continue if the water becomes clear. In addition, a powerful magnet is placed outside the output pipe to capture any stray microparticles that may escape the tank, thereby enhancing the removal efficiency.

An essential aspect of the project is the image analysis of the residue clinging to the walls of the tank. A camera mounted above the adhering particles captures an image of the residue, which is then analysed using machine vision techniques. The image is sent to a Raspberry Pi, where OpenCV and Python-based image processing algorithms calculate the area of the residue. Based on the specified area of 8 cm × 5.6 cm, the system classifies residue into three different warning levels: green (area less than 3.97 cm^2), yellow (area between 3.97 cm^2 and 11.11 cm^2), and red (area greater than 11.11 cm^2).

This project offers a promising solution for efficient and cost-effective water purification by combining cutting-edge technologies such as magnetic nanoparticles, electromagnetic fields, image analysis, and machine vision. The development of such a system has significant implications for resolving the global water management crisis and ensuring that all communities have access to clean, safe water.

5.2 RELATED WORKS

Nanomaterials have a wide range of current and future usage in industries like manufacturing, electronics, energy production and storage, sensors, biomedicine, and environmental processes. Every time nanomaterials are a primary or secondary component of a structure or device; their existence is crucial for the duration of the intended operational lifetime (Martinez-Boubeta & Simeonidis, 2019). However, after serving their purpose in a process, nanomaterials are typically viewed as an undesirable by-product. The requirement for high purity in the process output, the high value of the employed nanomaterial itself, or potential negative impacts on human health and the environment typically determine the necessity to separate or recover nanomaterials.

The proposed framework for real-time automated defect detection in the municipal drainage system is based on the analysis of CCTV