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PERFORMANCE EVALUATION OF COMPLIMENTARY SPLIT-RING RESONATOR (CSRR) IN DETECTING AMMONIACAL NITROGEN (NH_3-N) FOR WATER QUALITY APPLICATIONS.

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ABSTRACT

Ammoniacal Nitrogen (NH_3-N) is one of the major contents found in Malaysia's polluted water sources. This polluted water does not only affect the human who consumes the water, but it also causes harm to flora and fauna. Furthermore, according to Malaysia's National Water Quality Standards, the presence of 0.9 mg/L NH_3-N and above requires extensive treatment. Therefore, it is very important to have a sensor that can detect the presence of NH_3-N, especially at low concentrations. Compared to other types of sensors, microwave sensors are favourable for their low cost, design simplicity, and reusable capabilities. The complementary split-ring resonator (CSRR) has been chosen because it exhibits higher sensitivity compared to other types of microwave sensors. The main objective of this research work is to evaluate the performance of CSRR in detecting NH_3-N, especially at low concentrations. For that, five CSRRs were designed, and each of them resonates from 1 GHz up to 5 GHz, respectively. They were designed and simulated on an FR-4 substrate by using the CST Simulation software. The chemical solutions that were used in this work to load the CSRR are ethanol and NH_3-N, where the concentration of the solutions varies. The plexiglass container was used as a sample holder to prevent the sample from having direct contact with the metal ring of CSRR. The S-parameters responses of each CSRR unloaded and loaded with the samples were measured. The detection of the sample was based on the shift of the resonant frequency. In order to validate the detection of the NH_3-N by using the CSRR, the complex permittivity of the NH_3-N needs to be determined from the measured S-parameters. Therefore, a mathematical model of the CSRRs was developed by using the Debye relaxation model, which defines the relationship between the complex permittivity of any liquid sample and the measured resonant frequency and the Q-factor of the CSRRs. Then, the complex permittivity of the NH_3-N determined from the model was compared with the measured value obtained from the dielectric probe. Finally, the sensitivity of the CSRRs was analysed. Measurement results show that each CSRR shows a shift in resonant frequency when it is loaded with NH_3-N. However, at lower concentrations of NH_3-N, the detection performance of CSRR varies. The detectable lowest concentration of NH_3-N is 25 mg/l by using 3 GHz CSRR. Furthermore, the 3 GHz CSRR gives the closest value of complex permittivity, which implies that the best working frequency for the detection of NH_3-N using CSRR is 3 GHz. The sensitivity of 3 GHz CSRR is 0.26, which is comparable with the other microwave sensors already presented in the literature. Nevertheless, further investigations are required especially in improving the sensitivity of CSRR sensors for NH_3-N detection.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Water is an essential component of life and makes up more than 70% of the Earth's surface in the form of seas, rivers, and lakes. It plays a pivotal role in various ecosystems, supporting aquatic organisms, plants, and animals while being essential for human survival. Moreover, it is used in some biological, ecological, and industrial processes [1]–[9]. Lacking clean water can lead to various challenges, affecting diverse life forms by causing issues such as sanitation and health concerns, as most life forms rely on water to maintain cleanliness and hygiene. Clean water is necessary for cleaning the human body and ensuring the cleanliness of possessions and surroundings. Lack of access to water for sanitation can encourage the spread of pathogens, creating health hazards and affecting environmental cleanliness. Furthermore, people whose livelihoods depend on aquatic life, particularly fish, need access to natural water sources like rivers to survive. Through fishing and the sale of aquatic goods, these water sources provide both food and economic opportunities. Thus, natural water sources can be considered as a factor that can affect the economy of a person or country [10].

Uncontrollable water pollution can lead to many problems in the future. As the contaminated water is not usable, it can lead to the problem of water outage which can affect the daily lives of all living things that depend on clean water including humans. According to a report by the United Nations (UN) in 2017, there are about 785 million people around the world did not have basic drinking water [11]. In this report, it is also predicted that by 2030, around 700 million people will be affected by intense water scarcity. Recognizing the global importance of water quality and pollution control, the United Nations has developed the Sustainable Development Goals (SDGs) framework [12]. There are 17 goals in SDGs and one of them is the water and sanitation goal, which is to address water-related concerns and encourage sustainable practices, specific targets, and indicators. These goals also encompass a wide range of issues, including access to clean water and sanitation, pollution reduction, and the protection and restoration of aquatic ecosystems. To support the goals of preserving nature and ensuring the sustainability of water sources, it is essential for individuals to actively