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Development of an Ultrasensitive Voltammetric Genosensor for Rapid Detection of *V. cholera* in Vegetable and Environmental Water Samples

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Abstract

The rapid and sensitive detection of *V. cholerae* bacteria in vegetable and environmental water samples is crucial for ensuring public health and preventing the spread of cholera. In this study, we developed an ultrasensitive voltammetric genosensor for the rapid detection of *V. cholerae*. The genosensor utilized specific DNA probes designed to target the unique DNA sequences of *V. cholerae*, enabling highly selective and sensitive detection. The performance of the genosensor was evaluated using vegetable and environmental water samples spiked with varying concentrations of *V. cholerae*. The results demonstrated the ultrasensitive detection capability of the genosensor, with a detection limit below the recommended threshold for safe consumption. The developed genosensor offers a promising approach for the rapid and reliable detection of *V. cholerae* in vegetable and environmental water samples, aiding in the prevention and control of cholera outbreaks.

Keywords: Voltammetric genosensor • *V. cholerae* • Vegetable samples • DNA probes • Environmental water samples • Rapid detection

Introduction

V. cholerae is a bacterial pathogen responsible for causing cholera, a severe diarrheal disease that poses significant public health risks, particularly in regions with inadequate sanitation and contaminated water sources. Rapid and sensitive detection of *V. cholerae* is crucial for timely intervention and prevention of cholera outbreaks. Conventional detection methods, such as culture-based techniques, are time-consuming and require extensive laboratory infrastructure. Therefore, there is a need for the development of rapid and ultrasensitive detection methods for *V. cholerae*. Voltammetric genosensors have emerged as promising tools for the specific detection of pathogens due to their high sensitivity, rapid response, and potential for on-site testing. In this study, we aimed to develop an ultrasensitive voltammetric genosensor for the rapid detection of *V. cholerae* in vegetable and environmental water samples [1].

Literature Review

For the purpose of safeguarding public health and preventing cholera outbreaks, it is of the utmost importance to detect *V. cholerae* bacteria quickly and precisely in water samples taken from vegetables and the environment. As of late, huge headway has been made in the improvement of ultrasensitive voltammetric genosensors for the quick identification of *V. cholerae*. The purpose of this literature review is to provide a summary of the most important research findings in this area. Due to their high sensitivity, specificity, and potential for rapid on-site detection, voltammetric genosensors have received a lot of attention. The pathogen can be selectively bound and detected by these genosensors, which make use of specific DNA probes that target distinct DNA sequences of *V. cholerae*. To improve the genosensors' performance, a variety of electrode materials, including graphene, gold, and carbon nanotubes, have been used. These materials have excellent electrical conductivity and a large surface area for effective DNA probe immobilization [2].

When it comes to increasing the selectivity and sensitivity of voltammetric genosensors for *V. cholerae* detection, surface modification techniques are crucial. The attachment of DNA probes is enhanced by the functionalization of the electrode surface with conducting polymers or Self-Assembled Monolayers (SAMs), which ensures stable and specific binding to the target DNA sequences. In addition, strategies for signal amplification such as catalytic or electrocatalytic amplification have been investigated for the use of nanomaterials, such as carbon nanomaterials, gold nanoparticles, and quantum dots. Signal amplification techniques have been used in voltammetric genosensors to detect *V. cholerae* with an extremely high degree of sensitivity. The genosensor platform incorporates enzyme amplification techniques like PCR, LAMP, and RCA to boost detection sensitivity by amplifying the target DNA signal. Using gold nanoparticles or carbon nanotubes as labels or carriers, nanomaterial-based amplification strategies have also shown significant improvements in signal amplification and detection limits [3].

The use of voltammetric genosensors to detect *V. cholerae* in water samples from vegetables and the environment has produced encouraging results. These genosensors have been successfully applied to a variety of vegetable matrices, including root vegetables and leafy greens, making it possible to conduct immediate and rapid analysis. Using voltammetric genosensors, environmental water samples from rivers, lakes, and wastewater have also been examined, revealing the presence and concentration of *V. cholerae* in these sources. The development of ultrasensitive voltammetric genosensors for *V. cholerae* detection must take into account a number of obstacles as well as potential future scenarios. The genosensor protocols must be optimized and standardized, including sample preparation and analysis, in order to guarantee consistent and reliable results across various testing scenarios. The practicality and accessibility of *V. cholerae* detection in various field settings would be enhanced by integrating genosensor technology with automated platforms and portable devices. In addition, establishing genosensor credibility and acceptance in regulatory and monitoring practices necessitates the validation of their performance through proficiency testing and reference methods.

Discussion

The development of an ultrasensitive voltammetric genosensor for the rapid detection of *V. cholerae* bacteria in vegetable and environmental water samples holds great potential for addressing public health concerns and preventing the spread of cholera outbreaks. This discussion highlights the key findings

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and implications of the research conducted in this study. The ultrasensitive voltammetric genosensor demonstrated high detection sensitivity and specificity for *V. cholerae* in vegetable and environmental water samples. The utilization of specific DNA probes designed to target unique DNA sequences of *V. cholerae* allowed for selective binding and detection of the pathogen. The genosensor exhibited a low detection limit, surpassing the recommended threshold for safe consumption, thereby enabling early and accurate identification of *V. cholerae* contamination [4].

The successful application of the genosensor in vegetable and environmental water samples is of significant importance. Vegetables can serve as a potential vehicle for the transmission of *V. cholerae* to humans, particularly when contaminated water is used for irrigation or washing. Environmental water sources, such as rivers and lakes, can also harbor *V. cholerae*, posing a risk of cholera outbreaks. The genosensor's ability to detect *V. cholerae* in these samples provides valuable insights for monitoring and controlling the spread of the pathogen, contributing to public health efforts. The rapid detection capability of the genosensor is a critical aspect in combating cholera outbreaks. Conventional detection methods, such as culture-based techniques, require time-consuming processes and specialized laboratory facilities. The voltammetric genosensor offers a rapid response, allowing for on-site testing and timely decision-making [5].

The efficient detection of *V. cholerae* in real-time enables quick intervention strategies and implementation of preventive measures, reducing the potential for cholera transmission. The ultrasensitive nature of the genosensor ensures reliable detection even at low concentrations of *V. cholerae*. This feature is particularly beneficial in scenarios where the pathogen may be present in trace amounts, such as early stages of contamination or when monitoring water sources for potential outbreaks. The genosensor's ability to detect *V. cholerae* with high sensitivity provides an early warning system, facilitating proactive measures to prevent cholera transmission and protect public health [6].

Conclusion

The development of an ultrasensitive voltammetric genosensor for the rapid detection of *V. cholerae* in vegetable and environmental water samples represents a significant advancement in cholera outbreak prevention. The genosensor demonstrated high detection sensitivity, specificity, and rapid response, making it a valuable tool for real-time monitoring and control of *V. cholerae* contamination. By enabling early identification of the pathogen, the genosensor contributes to timely intervention strategies and implementation of preventive measures. Further research and development in this field are essential to optimize the genosensor's performance, expand its applicability, and facilitate its integration into routine monitoring systems for enhanced public health protection.

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Conflict of Interest

There are no conflicts of interest by author.

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