



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
SHORT ABSTRACT OF THESIS

Name of the Student : Fatima Banoo

Roll Number : 206121103

Programme of Study : Ph.D.

Thesis Title: Development of Optical Fiber Sensors for Environmental Engineering and Homeland Security Employing Evanescent Wave Absorption and Localized Surface Plasmon Resonance Spectroscopy.

Name of Thesis Supervisor(s) : Prof. Sunil K Khijwania

Thesis Submitted to the Academic Division : Department of Physics

Date of completion of Thesis Viva-Voce Exam : 09/10/2025

Key words for description of Thesis Work : Fiber sensor, Water contamination, Explosive sensing, Localized surface plasmon resonance

---

**SHORT ABSTRACT**

This thesis focuses on the development of optical fiber sensors for detecting water contaminants, specifically mercury ( $\text{Hg}^{2+}$ ), arsenic ( $\text{As}^{3+}$ ), and explosive trinitrophenol (TNP), which are crucial for environmental monitoring and homeland security respectively. The primary objective is to develop highly sensitive sensors with exceptionally low limits of detection (LOD), rapid response times, high selectivity, and high degree of stability, repeatability and reliability. The novelty of this research lies in the innovative integration of various nanocomposites, polymers, and composite materials with fiber optics to develop optical fiber  $\text{Hg}^{2+}$ ,  $\text{As}^{3+}$ , and TNP sensors. Two key sensing techniques were employed: intensity modulation through evanescent wave absorption and wavelength modulation using localized surface plasmon resonance (LSPR). The research begins with the development of a U-shaped optical fiber LSPR based sensor for  $\text{Hg}^{2+}$  detection, utilizing graphene oxide and chitosan (GO-CS) composite as the sensing material. This sensor demonstrates outstanding sensitivity of 0.0728 nm/ppb, an ultra-low LOD of 0.29 ppb. It also exhibits high selectivity towards  $\text{Hg}^{2+}$  and a rapid response time of 0.6 s. In order to further enhance the sensing performance, a second  $\text{Hg}^{2+}$  sensor is developed incorporating carbon nanotube/polyvinyl alcohol (CNT/PVA) nanocomposite as the sensing material. This sensor offered even higher sensitivity of 0.2458 nm/ppb and a lower LOD of 0.08 ppb, while maintaining high selectivity and an improved response time of 0.4 s. Next, an optical fiber LSPR sensor for detecting another highly toxic water contaminant  $\text{As}^{3+}$  ion is developed, employing  $\text{Al}_2\text{O}_3/\text{GO}$  nanocomposite as the sensing material. This sensor exhibits high sensitivity of 0.217 nm/ppb, a remarkably low LOD of 0.09 ppb. The sensor also exhibits a fast response time of 0.5 s and high selectivity towards  $\text{As}^{3+}$ . To further enhance sensing performance, another  $\text{As}^{3+}$  sensor is developed using lauryl-functionalized gold nanoparticles. This sensor offered an enhanced sensitivity of 0.3073 nm/ppb, even lower LOD of 0.06 ppb, while maintaining high selectivity and rapid response time of 0.5 s. For TNP detection, an optical fiber sensor based on evanescent wave absorption is developed, utilizing a novel polymer (PFTPA) film. The sensor exhibits high sensitivity of 0.0032/ppb, a remarkably low LOD of 1.06 ppb, rapid response time of 2 s and shows high selectivity towards TNP. In order to further enhance the sensing performance, another TNP sensor is developed using a LSPR configuration, incorporating zinc oxide quantum dots (ZnO QDs) as the sensing film. This sensor offers a much lower LOD of 0.19 ppb and significantly higher sensitivity of 0.1288 nm/ppb, while maintain the rapid response time of 2 s and high selectivity towards TNP. It is worth mentioning that, all the novel sensors developed in this research exhibits excellent reversibility, repeatability, stability and reliability. Moreover, their real-world applicability is validated through successful detection of  $\text{Hg}^{2+}$ ,  $\text{As}^{3+}$ , and TNP in real water samples, demonstrating their potential for environmental monitoring and homeland security applications.