# Eco-Friendly CQDs/ZnO Nanocomposite for Dual Environmental Applications in Heavy Metal Sensing and Organic Dye Degradation

**Mohammad Mujahid**
Department of Physics, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia

**Ali Imam Jafri**
Department of Electrical Engineering, Faculty of Engineering, Aligarh Muslim University, Aligarh

## Abstract

In this study, carbon quantum dots (CQDs) were synthesized from apple peel waste using a one-step hydrothermal process and incorporated into a ZnO nanocomposite. The synthesized product was characterized using various analytical techniques, including Fourier-transform infrared (FTIR), X-ray Diffractometer (XRD), Scanning Electron Microscopy (SEM), and TEM (Transmission Electron Mivcroscopy). FTIR analysis revealed the presence of functional groups such as -COOH, C-O-C, and Zn-O, while XRD analysis confirmed the wurtzite crystalline structure of the nanocomposite. The CQDs/ZnO nanocomposite exhibited UV-Vis absorption peaks at 280 nm and 330 nm, attributed to the $\pi$-$\pi^*$ and n-$\pi^*$ transitions, respectively, indicating its optical activity. The calculated bandgap of 3.87 eV suggests the involvement of ZnO in its wurtzite phase, known for its wide bandgap properties. Adsorption studies showed that the CQDs/ZnO nanocomposite followed pseudo-first-order kinetics, demonstrating its efficiency in the adsorption process. Moreover, the fluorescence intensity of the nanocomposite significantly decreased in the presence of $Pb^{2+}$ ions, enabling selective detection of $Pb^{2+}$ over other metal ions. The fluorescence probe exhibited a linear response in the concentration range of 0–300 µM, with a detection threshold (DT) of 0.21 µM, highlighting its high sensitivity for $Pb^{2+}$ detection. Additionally, the CQDs/ZnO nanocomposite was successfully applied to detect $Pb^{2+}$ ions in real water samples, demonstrating its practical applicability.

## Keywords

Hydrothermal Process, Photocatalytic efficiency, Fluorescence quenching, Sensing of $Pb^{2+}$.

## Graphical Abstract