Purpose: Cerenkov emission is induced when a charged particle travels faster than the speed of light in a given medium. The Cerenkov effect occurs in everyday radiation therapy of tissue, yet this phenomenon has never been quantitatively characterized. In this study, an investigation of high-energy radiation from a linear accelerator was carried out, to quantify the induced Cerenkov emission in biological media. Furthermore, we demonstrate that the Cerenkov emission can excite a molecularly produced fluorophore, protoporphyrin IX (PpIX), embedded in biological phantoms. 

Methods: Electrons at 6-18 MeV energies and photons at 6 or 18 MV energies, from a linear accelerator, were used to induce Cerenkov emission in aqueous phantoms. First, a CMOS camera imaged a water tank in order to investigate the dose distribution of external beam radiation. Secondly, the fluorescent photosensitizer PpIX was mixed into the phantom. An optical fiber bundle, positioned at the phantom surface, collected the Cerenkov emission and the Cerenkov-induced optical fluorescence. 

Results: Images acquired in a water tank clearly shows the cross section of the electron (or photon) beam at all energies using a dose rate of approximately 4Gy/min. As expected from the Cerenkov theory the intensity increases as the energy of the radiation increases. Spectra acquired, either with photons or electrons, reveal that the Cerenkov emission excites the PpIX molecule, leading to optical fluorescence in the red spectral region. 

Conclusions: The results here indicate that molecular fluorescence monitoring during external beam radiotherapy is possible. This could potentially be used as a tool for treatment assessment through the evaluation PpIX production from e.g. high-grade glioma. 

Funding Support, Disclosures, and Conflict of Interest: 

This work has been funded by NIH grants RO1CA120368 and PO1CA084203.