

### **Induction of histological alterations in Nile tilapia (*Oreochromis niloticus*) following water-borne exposure to nano-titanium dioxide and bulk titanium dioxide**

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Due to widespread use of nano-TiO<sub>2</sub> in many applications, significant release of the nano-TiO<sub>2</sub> to the environment can occur which may eventually reach aquatic ecosystems. Nevertheless chronic effects of nano-TiO<sub>2</sub> on freshwater fish especially under tropical conditions are little known. Nile tilapia (*Oreochromis niloticus*) could be used as a freshwater fish model for nano-ecotoxicity studies under tropical conditions as it is a widespread fish species in tropical waters. The present study was conducted to assess the effects of nano-TiO<sub>2</sub> water-borne exposure on histological structure of the gills, liver and intestine of Nile tilapia under chronic exposure conditions. Fish were exposed to a range of concentrations of nano-TiO<sub>2</sub> (<25 nm, anatase) viz 0.1 mg/L, 0.5 mg/L and 1.0 mg/L along with the controls for 21 days and alterations in histological structure were assessed qualitatively and quantitatively based on derived organ indices. The highest concentration (1.0 mg/L) of TiO<sub>2</sub> in the bulk form was also tested to examine whether potential histopathological effects are due to TiO<sub>2</sub> chemical itself or nano form of TiO<sub>2</sub>. The results showed that nano-TiO<sub>2</sub> exposures could induce significant histological alterations ( $P < 0.05$ ) in the gills, liver and intestine of the exposed fish. Even though consistent patterns of concentration dependent responses were not observed, proliferated goblet cells in the gills, fragmented nuclei in the liver and epithelial damage, necrosis and reduction of average number of goblet cells in the intestinal wall were the most conspicuous histological alterations observed in the fish exposed to nano-TiO<sub>2</sub>. Average number of goblet cells per fold in the intestinal wall was significantly reduced in the fish exposed to nano-TiO<sub>2</sub> ( $P < 0.05$ ) in comparison to the control fish. This study revealed that bulk TiO<sub>2</sub> is not inert as previously assumed as it could also induce histological alterations in the gills and liver of Nile tilapia. However, induction of histological alterations in Nile tilapia was more severe in the fish exposed to nano-TiO<sub>2</sub> compared to the bulk TiO<sub>2</sub> exposure. Histological alterations induced by the nano-TiO<sub>2</sub> and bulk TiO<sub>2</sub> could lead to serious ill health conditions which may eventually affect the survival, growth and reproduction of the exposed fish populations.

**Keywords:** Nano-TiO<sub>2</sub>; bulk TiO<sub>2</sub>; histopathology; Nile tilapia