Chapter 15
Copper and Copper Nanoparticles Induced Hematological Changes in a Freshwater Fish *Labeo rohita* – A Comparative Study:
Copper and Copper Nanoparticle Toxicity to Fish

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ABSTRACT

In the present study, fish Labeo rohita were exposed to 20, 50 and 100 µg/L of both Cu NPs and copper sulphate ($CuSO_{4,}$ bulk copper) for 24 h and hematological profiles were estimated. A significant (P< 0.01) change in the hemoglobin (Hb), hematocrit (Hct), white blood cells (WBC) and Mean Corpuscular Volume (MCV) levels were observed in all the three concentrations of both bulk and Cu NPs treated fish when compared to control groups. However a non significant change in red blood cells (RBC) (20 and 50 µg/L Cu NPs) and mean corpuscular hemoglobin (MCH) (20 and 50 µg/L bulk Cu) were observed. The alteration in Mean Corpuscular Hemoglobin Concentration (MCHC) value was found to be non significant both in bulk and Cu NPs treated fish. The alterations of these parameters can be used as a potential indicator to examine the health of fish in aquatic ecosystem contaminated with metal and metal based nanoparticles.

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INTRODUCTION

Nanotechnology is a new branch of science, deals with synthesis of nano-sized particles that enhance the physical, chemical and biological properties of the metals. It is the fast growing and one of the prominent technologies in the 21st century (Chen *et al*., 2012; Lee *et al*., 2014; Abdel-Khalek *et al*., 2015). Nanoparticles (NPs) ranges between 1 and 100 nm, dimensions from quantum dots to one, two or three dimensional nanoparticles (Handy *et al*., 2008a; Lee *et al*., 2014) which in turn increase its surface to volume ratio of the NPs and provide large surface area for binding of biomolecules. Moreover, nanotechnology has wide applications in industries, biomedical sciences, electronics, cosmetics, pharmaceuticals and research fields (Zhao *et al.,* 2011; Jovanovic and Palic, 2012). NPs have not only reached the markets, but also it is used for various domestic purposes and end up in the environment. In the environment these particles may pose a risk to the organisms.

In this juncture, the aquatic ecosystem is more susceptible to many kinds of pollutants including NPs (Scown *et al*., 2010; Jovanovi´c and Pali´c, 2012). NPs may enter the aquatic ecosystem from its manufacturing waste, nanoproducts and its byproducts (Moore, 2006; Navarro *et al.,* 2008). Fate of nanoparticles in aquatic ecosystem is mainly governed by its solubility, dispersibility, and their interaction between biotic and abiotic factors (Brar *et al.,* 2010). NPs are toxic to aquatic organisms when exposed to higher doses as these particles can cross biological cell membranes (Griffitt *et al.,* 2007; Brar *et al.,* 2010; Siddiqui *et al.,* 2015). Recently the wide production of engineered nanoparticles (ENPs) due to their applications in many industrial processes finds their way in to the aquatic environment and cause adverse effects in aquatic organisms (Zhu *et al.,* 2008; Binelli *et al.,* 2009; Lu *et al.,* 2011; Yokel and MacPhai, 2011; Sanchez *et al.,* 2012; Qiuli *et al.,* 2013; Baker *et al.,* 2014). However, due to their unique physical and chemical properties, their fate in the aquatic organism is not clearly understood (Zhu *et al*., 2009; Scown *et al*., 2010; Remya *et al*., 2015).

Copper nanoparticles (Cu NPs) have distinctive characters and commonly used as a substitute for noble metal catalysts (Cava, 1990; Tranquada *et al*., 1995; Xu *et al*., 1999; Zhou *et al.,* 2006; Chang *et al.,* 2012) and cheaper than the other metal oxide NPs (Machado *et al.,* 2008). Cu NPs find its application in textiles, skin products, ceramics, wood preservation, lubrication, nanofluids, bioactive coatings; electronic devices such as inkjet printing or integrated circuits; biocidal and antimicrobial activities (Yoon *et al*., 2007; Gomes *et al*., 2011; Santo *et al*., 2012; Wang *et al*., 2014; Nations *et al*., 2015; Siddiqui *et al*., 2015). Cu NPs are also used in medicine and as antifouling agents in paints used in boats (Kiaune and Singhasemanon, 2011; Perreault *et al*., 2012).

Due to their low production cost and easy availability, and other specific properties such as antibacterial potency, catalytic activity, optical and magnetic properties Cu NPs has attracted the scientific community and huge quantity of Cu NPs has been synthesized (Khanna *et al*., 2007; Kathad and Gajera, 2014). The extensive production and use of Cu NPs has led to entry of these particles in to aquatic environment and cause adverse effects in aquatic organisms (Griffitt *et al.,* 2008, 2009; Nations *et al.*, 2011; Chang *et al*., 2012; Al-Bairuty *et al.,* 2013; Wang *et al*., 2014; Song *et al.,* 2015; Hedayati *et al.,* 2016). While comparing with the other metal nanoparticles (MNPs) and nanotubes, Cu NPs showed greater toxicity in *in vitro* studies (Chang *et al.,* 2012). Griffitt *et al.* (2007) reported that Cu NPs produce acute toxicity in Zebra fish mainly in the gill. The LC50 value of Cu-NPs was 1.5mg/L in *Danio rerio* (Griffitt *et al.,* 2007). In addition, accumulation of these nanoparticles in aquatic organisms may transferred to higher trophic levels and poses a health hazard to animals and humans (Zhao *et al.,* 2011; Shaw *et al.,* 2012; Wang *et al.,* 2015).