

Impact of Silicon Dioxide Nanoparticle on Fresh Water Fish *Clarius Batrachus*

Pooja Shree Somani¹, Dr. Ranu Sharma²

¹Assistant Professor, Zoology Department, ²HOD, Science Department,
^{1,2}MJRP University, Jaipur, Rajasthan, India

ABSTRACT

Clarias batrachus, a freshwater Indian air breathing catfish is one of the important fish species. It is treated as a typical example to deal with the alimentary canal of a teleost and a test animal in many laboratories of Indian Universities. However, the effect of silicon dioxide nanoparticles on Indian Air-breathing fishes is lacking. Therefore, the present work was designed to evaluate the median lethal dose of silicon dioxide nanoparticles on *Clarias batrachus*. The work will help in deciding the toxicity level of silicon dioxide nanoparticles for the higher yield of this fish. Nanotechnology an advanced tool to synthesis atomic level particles. Increased application of silicon dioxide nanoparticles results in the bioaccumulation of these particles in the environment. The fate and effect of nanomaterials in the environment has raised concern about their environmental risk to aquatic organisms. Silica nanoparticles (SiO₂-NPs) find its uses in various fields and are inevitably released into the environment. However, the ecotoxicological effects of SiO₂-NPs on the freshwater fish remain poorly understood.

KEYWORDS: clarias, batrachus, silicon dioxide, nanoparticles, bioaccumulation, toxicity

INTRODUCTION

Nanotechnology is the rapidly developing multidisciplinary science that includes the fields of physics, chemistry, biology and engineering, which involves the production and release of several nano-sized particles into the environment. Some nanoparticles are known to exist naturally and are therefore, in direct and continuous contact with the living systems. While several nanoparticles are synthesised artificially and the increase in the rate of synthesis and the intentional or unintentional release of nanoparticles into the ecosystem could adversely affect living organisms including bacteria, algae, insects, birds and mammals. The properties, behaviour and environmental fate of engineered nanoparticles are different, which lead to an unforeseen impact on environment and living system. Engineered nanoparticles include nanotubes, nanospheres, nanowires, quantum dots and are characterized for its novel physical, optical, thermal and biological properties. Among the creation of manipulated nanoparticles, silicon dioxide nanoparticles (SiO₂-NPs; nano silica) are widely used in engineering, industries and biomedicine, particularly as tools for targeted drug and gene delivery. However, the toxicity of silica nanoparticles may be due to altered physicochemical properties such as size, cell type, dose and even specific coatings, ligand incorporation, or surface modifications, which lead to health hazards in non-target organisms.

Discussion

Silicon dioxide nanoparticles are the intentionally produced nanoparticles having applications in the biomedical fields. It is widely used for in vitro and in vivo drug and gene delivery, siRNA delivery, biosensing, sunscreen lotions, food, nanomedicine, cancer therapy and chemical industries (Slowing et al. 2007; Li et al. 2012). The main route of exposure is from different sources like manufacturing laboratories, sewage treatment plants, landfills and runoff water. Owing to the small size, silica nanoparticles have possibilities of internalisation through different penetration routes and it has been reported that nanosized particles are more toxic than the bulked size (Kim et al. 2014). Silica nanoparticles are highly stable and persistent, where the particle size influences the toxicity, tissue distribution, metabolism and excretion. One of the studies has observed that submicron-sized silica particles (100 or 200 nm diameter) significantly increased the incidence and severity of liver inflammation, whereas the effects of nano-sized particles (50 nm diameter) were non-significant (Cho et al. 2009). On the contrary, silica nanoparticles of 7–14 nm size has been shown to cause potentially harmful effects on fish hepatocytes by the generation of reactive oxygen species (Vidya and Chitra 2015).

Silicon dioxide nanoparticles toxicity

Since the recent past, scientific studies are focusing on Silicon dioxide nanoparticles toxicity. The toxicity of Silicon dioxide nanoparticles in living organisms range from µg/l–1

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to mgl-1 including major carps and other fish [1-4]. Fish exposed to Silicon dioxide nanoparticles led to deformation of the embryo, inflammation, cytotoxicity, dampened mitochondrial activity, oxidative stress mechanism and apoptosis [5]. Acute toxicity may be defined as the adverse effect occurring after the administration of a toxicant within 24 hours [6]. The assessment of the median lethal concentration (LC50) has been used as an important parameter to measure acute toxicity and an initial procedure to screen toxicity of a substance. The study gives information about LC50, therapeutic index, degree of safety level and toxicity status of a substance [7]. Various methods are used in determination of LC50. It seems that improvement of the conventional methods through application of software is the need of the present day [7]. But, sometimes software used may not provide 95% confidence limit. However, some countries including UK have taken steps to ban the LD50. *Clarias batrachus*, a freshwater Indian air breathing catfish is one of the important fish species. It is treated as a typical example to deal with the alimentary canal of a teleost and a test animal in many laboratories of Indian Universities [3]. However, the effect of Silicon dioxide nanoparticles on Indian Air-breathing fishes is lacking. Therefore, the present work was designed to evaluate the median lethal dose of Silicon dioxide nanoparticles on *Clarias batrachus*. The work will help in deciding the toxicity level of Silicon dioxide nanoparticles for the higher yield of this fish. The study will also be helpful to evaluate variation in health of the fish due to toxicity of Silicon dioxide nanoparticles, suitability of environmental conditions for fish, relative sensitivity of fish to Silicon dioxide nanoparticles and also physico-chemical conditions of water bodies.

Details on *Clarius batrachus* as experimental material

"*Clarius batrachus* has a broad, flat head and an elongate body which tapers toward the tail. It is readily recognizable as a catfish with four pairs of barbels whiskers and fleshy,

papillated lips. The teeth are villiform, occurring in patches on the jaw and palate. Its eyes are small. The dorsal fin is continuous and extends along the back two-thirds of the length of the body but there is no dorsal spine. The dorsal, caudal, and anal fins together form a near-continuous margin; the caudal fin is rounded and not eel-like though it is occasionally fused with the other fins. Its pectoral spines are large and robust and finely serrate along the margins with which it walks accompanied by a back and forth flexion. Their coloration is olive to dark brown or purple to black above, blue green on the sides and white below, with white specks on their rear side. *C. batrachus* may be easily distinguished from many of the North American Ictalurid catfishes in that the walking catfish lacks an adipose fin (Masterson, 2007; Robins, undated; GSMFC, 2006)." From CABI (2017): "*C. batrachus* has an elongated body, broad at the anterior and narrow at the posterior. *C. batrachus* is similar in size and appearance to *C. macrocephalus* but can be distinguished from the latter species by the shape of the occipital process in the head portion. The occipital process is round-shaped in *C. macrocephalus* but pointed in *C. batrachus*. Unlike *C. macrocephalus*, *C. batrachus* does not have large numbers of small white spots along the sides of its body (Teugels et al., 1999). *C. batrachus* lacks an adipose fin. Dorsal and anal fins are without spines, pectoral fins are strong with fine serrations on both edges, pelvic fins are small and the caudal fin is not confluent with dorsal or anal fin. The mouth is wide and has four pairs of well-developed barbels, with the maxillary barbels reaching to the middle or base of the pectoral fin (Talwar and Jhingran, 1991)." "The body of the normal coloured variety is greyish to olive in colour with a whitish underside. Other varieties include albino with a white body and reddish eyes, and a pink variety with normal coloured eyes (Axelrod et al., 1971). Various multi-coloured varieties are becoming more common in the tropical fish aquarium trade."

Observations

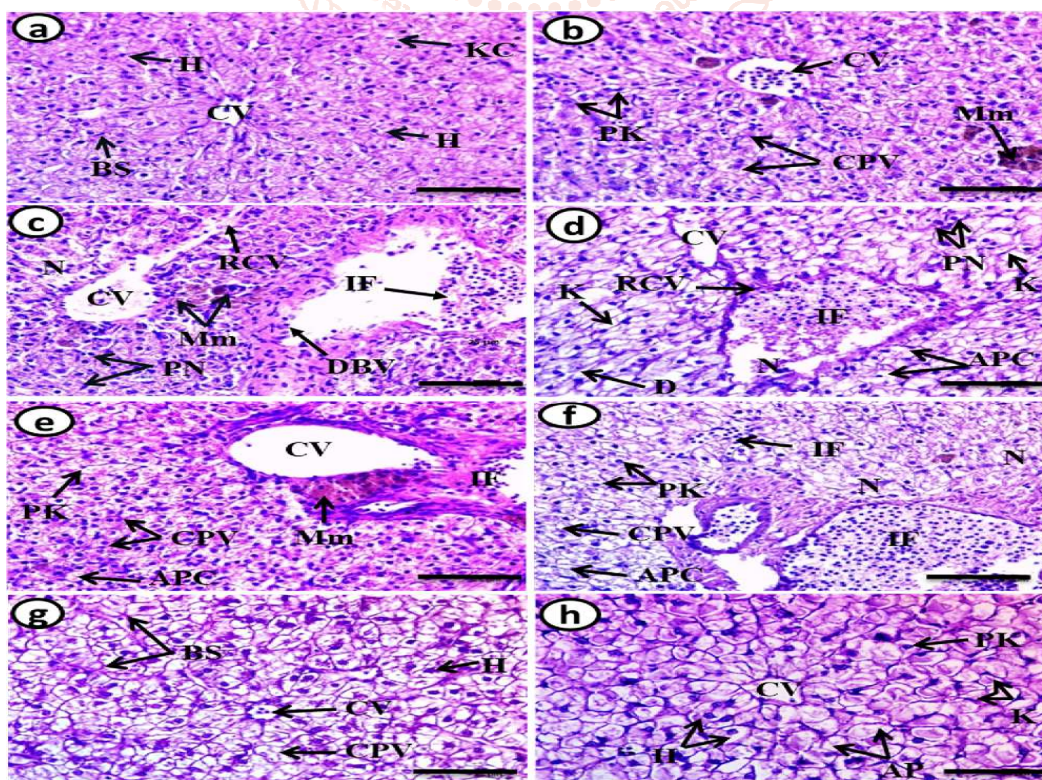


Fig. showing hepatotoxic effects due to silicon dioxide on African catfish

The current study investigates the hepatotoxic effects of two acute doses of silicon dioxide nanoparticles (AgNPs) and silver nitrate (AgNO₃) on African catfish (*Clarias batrachus* garepinus) using biochemical, histopathological, and histochemical changes and the determination of silicon dioxide in liver tissue as biomarkers. AgNPs-induced impacts were recorded in some of these characteristics based on their size (20 and 40 nm) and their concentration (10 and 100 µg/L). Concentrations of liver enzymes (Aspartic aminotransferase; AST, Alanine aminotransferase; ALT), alkaline phosphatase (ALP), total lipids (TL), Glucose (Glu) and Ag-concentration in liver tissue exhibited a significant increase under stress in all exposed groups compared to the control group. The total proteins (Tp), albumin (Al), and globulin (Gl) concentrations exhibited significantly decrease in all treated groups compared to the control group. At tissue and cell levels, histopathological changes were observed. These changes include proliferation of hepatocytes, infiltrations of inflammatory cells, pyknotic nuclei, cytoplasmic vaculation, melanomacrophages aggregation, dilation in the blood vessel, hepatic necrosis, rupture of the wall of the central vein, and apoptotic cells in the liver of AgNPs-exposed fish. As well as the depletion of glycogen content in the liver (feeble magenta coloration) was observed. The size and number of melanomacrophage centers (MMCs) in liver tissue showed highly significant difference in all exposed groups compared to the control group. Recovery period for 15 days led to improved most alterations in the biochemical, histopathological, and histochemical parameters induced by AgNPs and AgNO₃. In conclusion, one can assume liver sensitivity of *C. garepinus* for AgNPs and the recovery period is a must.

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