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Review Article

TOXICOLOGICAL IMPACTS OF PAPER MILL EFFLUENT ON AQUATIC ANIMALS: A REVIEW

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ABSTRACT

Paper mill effluent is a complex mixture of chemicals, including pulping agents, bleaching agents, and other pollutants, which can harm aquatic life (Environment Canada, 2013). This review summarizes the toxicological effects of Paper mill effluent on aquatic animals, including fish, crustaceans, and molluscs.

Keywords: Aquatic animal, Effluent, Lethal and Toxicity.

INTRODUCTION

Paper mills generate large volumes of wastewater, which can contaminate aquatic ecosystems if not properly treated (Kumar *et al.*, 2018). Paper mill effluent contains various toxic substances, including dioxins, furans, and phenolic compounds (National Research Council, 2013). Heavy metal namely cadmium, copper, zinc, chromium are also present pulp and paper mill effluent that are directly release in the aquatic environment (Zahrim *et al.*, 2007). Hence the present investigation was undertaken with a view to reviewing toxic effect of paper mill effluent in aquatic animal.

Chemical composition of paper mill effluent

Paper mill effluent contains a mixture of organic and inorganic pollutants, including pulping agents (World Health Organization, 2018), bleaching agents (Lankinen *et al.*, 2017), phenolic compounds (Bajpai *et al.*, 2017), dioxins (Singh et al. 2018), furans (Zhang *et al.* 2019), and heavy metals (Mishra *et al.*, and Li *et al.*, 2020).

Toxicity of paper mill effluent

Acute Toxicity

Paper mill effluent has been shown to cause lethal effects on fish and crustaceans, with LC50 values ranging from 0.1 to 100 mg/L (Kumar *et al.*, 2019). The LC50 values of the prepared concentration of paper mill effluent for 24, 48, 72 and 96-h were found at 11, 10.5, 10.1 and 9.5% respectively in *Rasbora daniconius* (Pathan *et al.*, 2009). Mishra *et al.*, (2011) determined the acute toxicity of paper mill effluent on the behavioural responses in *Mystus vittatus.*

Chronic Toxicity

Sub-lethal effects on growth, reproduction, and development have been observed in fish and crustaceans exposed to Paper mill effluent (US EPA 2020).

Effects on Growth and Development

Paper mill effluent exposure has been shown to reduce growth rates, alter developmental patterns, and cause morphological abnormalities (Scott *et al.*, 2019). The paper mill effluent exposure fish larvae of *Cyprinus carpio* showed abnormalities including conditions wherein, the yolk sac get protruded up to the head region, deformities in eyes, spinal curvature, abnormal head and overall stunted growth were observed during the a study (Tyor *et al.*, 2012). The paper mill effluent might cause 50% growth reduction for experimental downstream brown trout fish, compared with the group upstream of the mill (Johnsen *et al.*, 1998)

Impact on Hematology

Paper mill effluent exposure can alter hematological parameters, including reduced red blood cell count,

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hemoglobin concentration, and hematocrit values (Bioaccumulation of pollutants in tissues, EU 2019).

Genotoxicity

Paper mill effluent contains genotoxic compounds that can cause DNA damage, chromosomal aberrations, and mutations (Singh *et al.*, 2019). The genotoxic effects of a "complex mixture" of anthropogenic chemical toxins and reveals a significant level of genetic damage in Androscoggin River smallmouth bass that increases in a downstream gradient in parallel with toxic equivalent concentrations. Individual concentrations of recognized, chemical toxins in Androscoggin River fish tissues are measured on an annual basis as part of a State monitoring program (Chamberland *et al.*, 2002). Gravato and Santos (2002) studied the effects of pulp mill effluent on population genetic structure of redbreast sunfish *Lepomis auritus*.

Reproductive Dysfunction

Paper mill effluent exposure has been linked to reproductive impairment, including reduced fertility, altered sex ratios, and developmental abnormalities (Kumar *et al.*, 2020).

Histopathology

Exposure to Paper mill effluent has been shown to cause histopathological changes in aquatic animals, including Liver damage, characterized by necrosis, inflammation, and fibrosis (Singh *et al.*, 2019), Kidney damage, characterized by tubular necrosis, inflammation, and fibrosis (Kumar *et al.*, 2020), Gill damage, characterized by hyperplasia, inflammation, and edema (Zhang *et al.*, 2020), Intestinal damage, characterized by inflammation, edema, and ulceration (Lankinen *et al.*, 2020). These histopathological changes can lead to impaired organ function and increased susceptibility to disease. Ovary of *Rasbora daniconius* showed marked degenerative changes like complete absorption of *oocytes*, broken zona radiata, degeneration of oocytes, cytoplasmic liquification and clumping, thickening of ovarian wall and disappearance of nucleus in mature oocytes on exposure to paper mill effluent (Pathan *et al.*, 2012). *Rasbora daniconius* revealed swollen hapatocytes, nuclear hypertrophy, rupture sinusoids, hemorrhages, and vacuolation in hepatic cells and broken central vein in liver, kidney showed hypertrophy of hematopoietic tissues, cell necrosis Pathan *et al.*, 2010).

Mechanisms of Toxicity

Paper mill effluent can cause oxidative stress (Zhang *et al.*, 2020), disruption of ion balance and osmoregulation (Lankinen *et al.*, 2020), neurotoxicity (Bajpai *et al.*, 2020), and behavioural changes (Singh *et al.*, 2020).

Impacts on Aquatic Ecosystems

Paper mill effluent can alter community structure and biodiversity (Kumar *et al.*, 2020), nutrient cycling and primary production (Zhang *et al.*, 2020), and food web dynamics (Li *et al.*, 2020).

Mitigation Strategies

Improved wastewater treatment technologies (US EPA 2020), reduction of chemical use in paper mills (World Health Organization, 2018), and implementation of best management practices (National Research Council, 2013), can help minimize the toxicological impacts of Paper mill effluent.

CONCLUSION

Paper mill effluent poses a significant threat to aquatic animals and ecosystems (Environment Canada, 2013)). Further research is needed to understand the toxicological effects of Paper mill effluent and to develop effective mitigation strategies (Kumar *et al.*, 2020).

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