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DEVELOPMENTAL AND BIOCHEMICAL DISRUPTIONS TRIGGERED BY TRACE LEAD EXPOSURES IN ZEBRAFISH (*Danio rerio*) EMBRYOS AND LARVAE

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Abstract

Lead is a ubiquitous toxic heavy metal that poses substantial threats to biodiversity and aquatic ecosystems. Despite its critical impacts on the environment and human health, literature on lead-induced toxicities at trace concentrations remains scarce. Hence, this study aimed to elucidate the toxicities induced by trace concentrations of Pb^{2+} (2.5 – 40.0 μgL^{-1}) on zebrafish embryos and larvae. Embryos at 2 hpf were exposed to a series of Pb^{2+} concentrations for 24, 48, 72, and 96 hours following the OECD guideline No. 236. Survival, hatchability, lethal concentration 50 (LC_{50}), and toxicological endpoints were determined. A sublethal Pb^{2+} concentration (8.79 μgL^{-1}) was then employed to assess heart rate, morphological parameters, morphological deformities, and biochemical alterations. The LC_{50} value decreased from 137.081 ± 62.114 μgL^{-1} at 24 hpf to 87.863 ± 24.546 μgL^{-1} at 96 hpf, reflecting increasing toxicity with prolonged exposure. Pb^{2+} exposure increased embryo coagulation and led to notable declines in survival and hatchability, indicating elevated embryonic sensitivity during early development. Sublethal Pb^{2+} exposure significantly reduced heart rate at 72 hpf, resulted in marked reductions in multiple morphological parameters (total body length, tail area, and trunk area) and induced substantial morphological deformities, including spine deformity and uninflated swim bladder, both at 96 and 120 hpf. Biochemical analyses revealed elevated liver-specific enzymes (alkaline phosphatase, and glutamate pyruvate transaminase), increased creatinine levels, reduced total protein content, suppressed catalase activity, and lowered T helper 2 cell (IL-10) levels in tissue lysates, implying significant hepatic, renal, oxidative, and immune dysfunction. These findings underscore the severity of lead toxicity at concentrations typically prevailing in the environment and highlight zebrafish utility in assessing environmental contaminants. Nonetheless, further research coupled with molecular-level studies is warranted to elaborate the mechanisms of action of environmental pollutants, including heavy metals at ecologically relevant doses.

Keywords*: Developmental Toxicity, Hepatotoxicity, Immunotoxicity, Lead, Morphological Deformities, Nephrotoxicity, Oxidative Stress, Zebrafish Embryos*

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