Unraveling the Cocktail Effect: Integrated Multi-Biomarker Response and Histopathological Alterations in Endemic Fish Exposed to Nanoplastics, Pesticides, and Heavy Metals

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Abstract:

Integrated pollution from nanoplastics, pesticides, and heavy metals in the coastal waters of East Java poses a significant threat to fish health by inducing oxidative stress and disrupting metabolic and endocrine functions. This study evaluates the biochemical and histopathological responses of fish exposed to these contaminants. Sampling was conducted at five stations, with three replicates per station, and 10 fish collected per station. Nanoplastics were quantified using Dynamic Light Scattering (DLS), pesticides by LC-MS/MS (Shimadzu LCMS-8060NX), and heavy metals by ICP-AES (Shimadzu ICPE-9820). Histological damage in gills and liver was assessed using a scoring method. Antioxidant enzymes (SOD, CAT, GPx) were measured with commercial kits, while biomarkers (MT, ROS, HSP-70, HSP-90) and cortisol were quantified via ELISA. Nanoplastics were most abundant in sediment at Station 3 (12.4 particles/g) and gill tissue at Station 4 (9.8 particles/g), indicating bioaccumulation. Heavy metals, particularly Pb and Cd, were highest in liver at Station 5 (5.3 and 3.1 µg/g, respectively).