

## Long-term monitoring and bioaccumulation of heavy metals in European anchovy (*Engraulis encrasicolus*, Linnaeus, 1758) from the Romanian Black Sea area: A risk assessment perspective

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Abstract. This study examines the ecological and consumer safety implications of heavy contamination in anchovy (Engraulis encrasicolus, Linnaeus 1758), one of the most widely consumed small pelagic fish in the Romanian Black Sea. Long-term data (1994-2019) were analyzed to assess the accumulation of copper (Cu), cadmium (Cd), lead (Pb), nickel (Ni), and chromium (Cr) in dorsal muscle tissues, focusing on contamination trends and bioaccumulation patterns. While concentrations generally align with established European Commission's safety thresholds, occasional exceedances, particularly for Cd and Pb, highlight episodic contamination events, especially during the 1990s and early 2000s. To evaluate potential health concerns, key risk assessment metrics: estimated daily intake (EDI), target hazard quotient (THQ), total target hazard quotient (TTHQ), and carcinogenic risk index (CRI) were applied. Cadmium consistently emerged as the most critical contaminant, with THQ and TTHQ values exceeding 1 in specific years, particularly among children due to higher intake per body weight. Although CRI values for Pb remained within the acceptable range, the cumulative non-carcinogenic risk during peak contamination periods warrants concern. The declining contamination trend observed in recent years reflects the effectiveness of environmental regulations. However, prolonged exposure to these metals may impact marine ecosystem stability and trophic interactions. Given the potential for cumulative pollutant effects and the possibility of re-emergence due to episodic contamination events, continuous surveillance and periodic risk assessments are recommended. This study highlights the significance of sustainable environmental monitoring and targeted mitigation efforts to protect marine ecosystems, sustain fisheries, and ensure seafood safety in the Black Sea region.

Keywords: anchovy; bioaccumulation; Black Sea; heavy metals; risk assessment.

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