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SEDIMENT MICROPOLLUTANTS AND ENVIRONMENTAL INSIGHTS IN ECOLOGICAL MONITORING OF LAKE LIEPAJA

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Introduction

Lake Liepāja, a shallow lagoon-type lake in southwestern Latvia (surface area 37 km², average depth ~1.5 m), is affected by nutrient enrichment, sediment contamination, and climate variability. As part of the EU Water Framework Directive (*WFD*) and the *Natura 2000* network, the lake is monitored to assess its ecological condition. This study analyzes sediment data from 2017–2025, focusing on toxic trace metals - *As, Cd, Hg, Pb, Cu, Zn* and three persistent organic pollutants (*POP*) - *Aldrin, PCB138, PCB153* originating mainly from historical pesticide use and industrial discharges. Possible sources of metal contamination include urban runoff, port and industrial activities, and inflows from surrounding agricultural areas..

Methods

Monitoring data were obtained from the Latvian Environment, Geology and Meteorology Centre (*LVĢMC*), which provides long-term environmental observations for Lake Liepaja. Sediment samples were collected from 3 monitoring stacions – *Liepājas ezers (LE), pie Bārtas grīvas; LE, Vidusdaļa; LE, Tirdzniecības kanāls* – representing different parts of the lake. Spatial distribution of the sampling stations is shown in Figure 1.

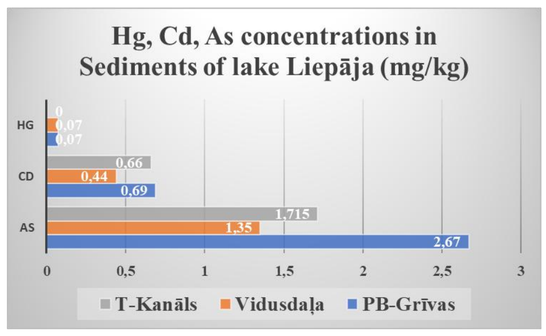
Figure1. **PB-Grīvas - 1**; **Vidusdaļa -2**; **T-Kanāls - 3**)

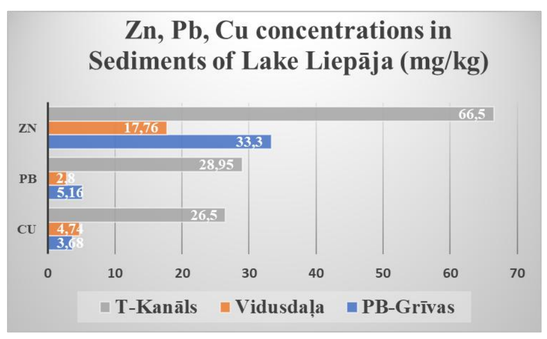
The available dataset included measurements of trace metals - *As, Cd, Hg, Zn, Pb, Cu* and organic pollutants - *Aldrin, PCB138, PCB153*. Data coverage varied between sampling points. For *T-Kanāls* (*No.3*) data were available for 2017 and 2020, except for Hg which covered 2017-2025. For stations *Vidusdaļa* (*No.2*) and *PB-Grīvas* (*No.1*), only limited data were available, covering the period 2017–2024. Surface sediments (0–10 cm) were collected from mentioned station points in Lake. Samples were dried, homogenized, acid-digested, and analyzed for metals using *AAS* (*Atomic Absorption Spectroscopy*) and *ICP-MS* (*Inductively Coupled Plasma Mass Spectrometry*) and for organic pollutants using *GC-MS* (*Gas Chromatography–Mass Spectrometry*). Concentrations are expressed in mg/kg for metals and in µg/kg for organic pollutants. Data were compiled and visualized in Microsoft Excel.

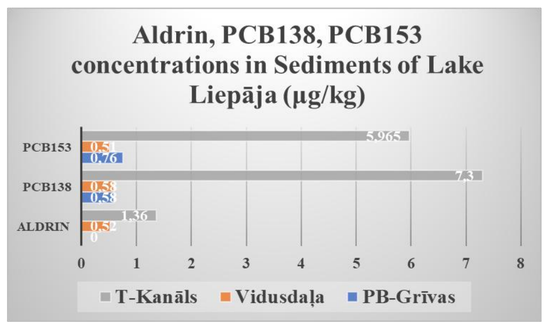
Note: Due to limited publicly available monitoring data, the presented results are indicative and serve as an initial overview of sediment contamination in Lake Liepāja. Further sampling and analysis are needed for comprehensive assessment..

Results

Metal concentrations varied spatially. *As* and *Cd* were highest at *PB-Grīvas*, moderate at *T-Kanāls*, and lowest in the mid-lake. *Hg* remained very low across all sites, for *T-Kanāls* ther were no *Hg* data in sediments. *Zn*, *Pb*, and *Cu* peaked in the *T-Kanāls* sediments, while *POPs* (*Aldrin*, *PCB138*, *PCB153*) also showed clear maxima there, indicating stronger port and marine influence. Overall, contamination was highest in the canal, moderate at the southern margin, and lowest in the lake center; results are indicative due to limited data.







These observations suggest that the margin/port-connected station *No.3* shows the highest contamination levels, followed by the canal *No.1* and lastly the mid-lake station *No.2*. The data indicate that contaminant input or accumulation is greater closer to lake-sea interaction and anthropogenic influence zones.

Discussion

Sediment data from Lake Liepāja show that all analyzed metals and *POPs* occur at low concentrations, mostly below the first soil quality threshold defined in *Cabinet Regulation No. 475* (*Procedures Regarding the Cleaning and Deepening of Surface Water Bodies and Port Aquatoria*), currently used by *LVĢMC* for sediment assessment.
Only *Cd* slightly exceeds this limit, while moderate *Zn* and *Pb* enrichment at T-Kanāls indicates local port and industrial influence. *POPs* were found only in trace amounts, consistent with national data showing no exceedances of *MK No. 475* or *EU Directives 2008/105/EC* and *2013/39/EU* on environmental quality standards and priority substances. The observed contamination pattern suggests impacts from urban runoff, historical industrial discharges, port operations, and agricultural inflows, typical for lagoon-type ecosystems such as Lake Liepāja.

Conclusion

Sediment contamination in Lake Liepāja is low overall, with only slight *Cd* enrichment and trace *POPs* detected. Metal and *POP* concentrations remain below Latvian reference thresholds (*MK No. 475*), indicating low ecological risk. As Latvia currently lacks explicit sediment quality standards, international guidelines — *CCME* (Canada, *ISQG/PEL*) and *NOAA* (USA, *ERL/ERM*) — can serve as useful interim benchmarks for ecological assessment and comparability. Continued long-term monitoring is essential for developing national sediment quality criteria suited to lagoon and coastal environments.