



**Original Research Article**

## **Mercury Levels Monitoring in Selected Marine Biota in Vlora Bay, Albania**

***Alma Shehu<sup>1</sup>, Edlira Baraj<sup>2</sup>, Majlinda Vasjari<sup>1</sup>, Kledi Xhaxhiu<sup>1</sup>, Tomas Pluhacek<sup>3</sup>,  
Dhimiter Bello<sup>4</sup>, Petrit Kotori<sup>5</sup>, Nensi Isak<sup>1</sup>, Besnik Baraj<sup>1</sup>***

<sup>1</sup> Tirana University, Faculty of Natural Sciences, Albania

Email: barajbesnik@fshn.edu.al; majlinda.vasjari@fshn.edu.al; alma.shehu@fshn.edu.al;  
kledi.xhahiu@fshn.edu.al; nensi.isak@fshn.edu.al

<sup>2</sup> Polytechnic University, Faculty of Engineering, Physic and Mathematic, Albania

Email: e.baraj@fimif.edu.al

<sup>3</sup> Palacky Univ. Olomouc, Dep of Anal. Chem., Czechia

Email: tomas.pluhacek@upol.cz

<sup>4</sup> Zuckerberg College of Health Sciences, USA

Email: dhimiter\_bello@uml.edu

<sup>5</sup> Reald College, Vlora, Albania

Email: petrit.kotori@unireald.edu.al

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### **ABSTRACT**

Coastal environments affected by historical industrial activity may accumulate mercury in marine organisms and pose risks to ecosystems and human consumers. The study was motivated by the need to assess whether legacy contamination continues to influence marine biota in the coastal area of Vlora Bay. It was hypothesized that mercury concentrations in selected mollusks and commonly consumed fish species reflect spatial differences in environmental contamination within the bay. Samples of two mollusk species and twelve fish species were collected from several locations and analyzed for mercury concentration in tissue using standard laboratory procedures. The results showed low mercury levels in most organisms, with the lowest values recorded at the cleanest station and higher levels observed near the area influenced by past industrial activity, while fish concentrations remained below recommended limits for human consumption. These findings indicate limited current risk for moderate consumers but confirm the persistence of localized contamination and highlight the importance of regular environmental monitoring.

### **KEYWORDS**

*Mercury, Vlora Bay, Mytilus Galloprovincialis, Patella Caerulea, fishes.*

### **1. INTRODUCTION**

A United Nations Environment Programme (UNEP) investigation in Albania identified severe mercury (Hg) contamination at a former chemical complex near Vlora Bay, which

included a chlorine-alkali factory. The site and its surrounding environment were found to require urgent remediation due to the extent of pollution. Between 1976 and 1992 the total mercury released into the environment was estimated at approximately 65 tons [1]. Most of mercury pollution was caused by Chlorine-alkali unit, where mercury cathode was used for NaCl brine electrolyses and by PVC unit, where mercury dichloride ( $\text{HgCl}_2$ ) was used as a catalyst for the monomer synthesis of vinyl chloride ( $\text{C}_2\text{H}_3\text{Cl}$ ) [2]. During its operation (1976 – 1992), mercury liquid wastes of about  $500 \text{ m}^3/\text{hr}$  containing  $1.1 \text{ mg/L}$  were discharged directly into the sea without any treatment [3]. In addition to liquid waste, polluted sludge was deposited in an open, 25-hectare dump located near the shoreline, further contributing to environmental degradation. According to local reports, at least two workers died from Minamata disease, a severe neurological condition caused by mercury poisoning, and many others experienced premature deaths due to long-term exposure. The factory ceased operations in 1992, but the environmental and public health impacts of its activities remain a concern.

A soil sample found mercury levels  $> 10,000 \text{ mg/kg}$  in the area of the former plant [1]. The most contaminated territory was Electrolysis Plant reaching in soil the maximum level  $2472 \text{ mg/kg}$  [3]. Comprehensive mercury assessments of the contaminated area were conducted by Geotest (Brno, Czech Republic), which reported mercury (Hg) concentrations in soil of approximately  $75 \text{ mg/kg}$  in the soil [4]. These elevated levels were further confirmed by subsequent study conducted by Beqiraj *et. al.* [5]. Gworeck *et. al.* point out that environmental contamination by mercury is and will continue to be a serious risk for human health. Pollution of the terrestrial environment is particularly important as it is a place of human life and food production [6]. To address the contamination, a combination of containment measures and remediation strategies was implemented to limit the spread of pollutants and reduce existing environmental hazards. Materials with mercury concentrations exceeding  $10 \text{ mg/kg}$ , including contaminated soil, sludge, factory debris, underground cables, pipes and chemicals were encapsulated within a Confined Disposal Facility (CDF), totaling approximately  $50,000 \text{ m}^3$  of hazardous waste [5]. However, methods of remediation of heavy metals in the area around the hot spot for concentrations lower than  $10 \text{ mg/kg}$  might be effective [7].

Vlora Bay is one of the most significant coastal regions along the eastern shore of the southeastern Adriatic Sea. The bay is bordered by two protected areas: the Narta Lagoon to the north and the Karaburun Peninsula to the south. The Vjosa River, originating in Greece and flowing through much of southern Albania, empties into the northern part of the Narta Lagoon [8]. Recognized as the last wild river in Europe, the Vjosa was recently designated as a national park due to its unique ecological value. The coastline of Vlora Bay exhibits two distinct morphological features. The northern section consists of a shallow, sandy, and accumulative coastline, where the former chemical plant was located. In contrast, the southwestern section is characterized by a high, rocky shoreline that supports diverse marine life, including mussels and clams [9].

Despite its rich biodiversity and abundance of flora and fauna, Vlora Bay has experienced significant ecological degradation due to human activities, notably, the Soda-PVC Plant and other industrial facilities, situated approximately  $5 \text{ km}$  from Vlora City and  $4 \text{ km}$  from the Narta Lagoon [10].

Fishing is an important economic activity for the local population in Vlora Bay, which also hosts Albania's second-largest port. Vlora City has a resident population of around  $190,000$  people, but this number nearly doubles during the summer months due to tourism. This seasonal population increase leads to a substantial rise in pollution levels. Vlora is considered one of Albania's most attractive destinations for both its natural beauty and historical significance.

The total concentration of heavy metals cannot provide useful information about the risk of bioavailability, toxicity, and the capacity for immobilization in the environment [11]. However, mercury present in contaminated sediments can be transformed into bioavailable forms, making it accessible to aquatic life [12]. There is a tendency, that elements introduced with

solid waste material are less stably bound than those in natural systems [13]. Elevated mercury levels in sediments do not always correlate with increased concentrations in marine organisms, as the toxicity and bioaccumulation of mercury depend on its chemical form and environmental conditions [14]. Various physicochemical factors influence mercury's toxicity [15]. Highest concentration of methylmercury is associated with organic-rich soils in riparian zones (stream banks) [16]. Frohne et al. assessed the effect of various factors on mobility of mercury (Hg) [17]. A comprehensive analysis of factors controlling mercury methylation in aquatic ecosystem is reported by Ullrich et al. [18]. Luo et al. review advances in microbial mercury methylation [19]. Methylmercury is particularly concerning due to its strong tendency to accumulate in fish muscle [20], where it often constitutes more than 95% of the total mercury content [21].

Due to decades of pollution from the chlorine-alkali complex, Vlora Bay has become a critical environmental concern. The Minamata disaster in Japan during the 1950s illustrated the severe consequences of mercury emissions on ecosystems and human health [22]. Environmental contamination by mercury is clearly a growing problem even today [23]. Despite this, Vlora Bay lacks a comprehensive and ongoing mercury monitoring program. The first assessments of heavy metals, including mercury, in sediments, biota, and macroalgae were conducted under the Programme for the Assessment and Control of Marine Pollution in the Mediterranean [24]. Çoçoli et al. reported mercury concentrations of 0.712 mg/kg in Vlora Bay sediments, the highest levels recorded along the Albanian Adriatic coast, compared to the background mercury level of 0.0167 mg/kg, [25]. However, the highest concentration found in the Northern Adriatic is reported in sediments from 0.02 to 8.63  $\mu\text{g g}^{-1}$  dry wt [26]. The Biomercury project (2005-2006) investigated using bacteria to remove mercury from a heavily contaminated PVC plant site in Vlora, Albania. [27]. However, the dumped sludge remained a long time near the shore with no precautions taken to prevent further contamination of the Bay or nearby residents [28]. While a study reports the Hg concentration in water and sediment in Adriatic Sea Coast [29], limited research has focused on mercury accumulation in algae, fish and mollusks [30]. In 2011, Corsi et al. conducted an integrated ecotoxicological study in Vlora Bay, evaluating bioaccumulation and biomarker responses in sea urchins, mussels, and fish [31].

This study aims to assess mercury concentrations in the mussel *Mytilus galloprovincialis*, the limpet *Patella caerulea*, and twelve fish species commonly consumed by the population of Vlora. The generated data contribute to understanding mercury bioaccumulation patterns in coastal marine food webs and provide essential information for environmental monitoring and the assessment of potential human exposure through seafood consumption. In addition to the analysis of marine organisms, two soil samples were collected and analyzed from the area of the former chlor-alkali plant in Vlora following the remediation of the contaminated site. The inclusion of soil samples is important in order to evaluate the current status of residual mercury contamination in the terrestrial component of the former industrial area and to provide a reference for the effectiveness of the remediation measures implemented in recent years. Former chlor-alkali facilities are widely recognized as long-term sources of mercury contamination due to the historical use of mercury-cell technology, which often resulted in substantial releases to surrounding soils and sediments. Even after remediation actions, localized hotspots of contamination may persist and may represent potential secondary sources of mercury to the adjacent coastal environment through surface runoff, groundwater transport, or sediment resuspension processes. Therefore, the analysis of soil samples from the remediated area provides an important complementary line of evidence for interpreting mercury levels observed in nearby marine organisms and contributes to a more comprehensive assessment of the environmental legacy of the former industrial activity in Vlora Bay.

## 2. MATERIAL AND METHODS

This section describes the study area, sampling procedures, analytical methods, and statistical analysis used in this study.

### 2.1 Study Area and Sampling Stations

The study was carried out in Vlora Bay, Albania, a coastal area historically affected by mercury releases from a former chlor-alkali and PVC industrial complex. Seven stations were selected to represent locations with different expected contamination levels. Stations S1-S5 were located within Vlora Bay, whereas S6 (Porto Palermo) and S7 (Butrint Lagoon, Saranda) were used as reference stations. Figure 1 shows the location of the sampling stations.

Sampling stations were defined as follows: S1, Petrolifera, directly in front of the former chlor-alkali plant; S2, Military Marine Academy, where only *Patella* specimens were collected; S3, Kristera Hotel, near the main drinking-water intake area of Vlora; S4, Bova, a buoy station close to S3; S5, Karaburun Peninsula, a comparatively undisturbed military-restricted area; S6, Porto Palermo; and S7, Butrint Lagoon, where mussels were farmed under natural conditions.

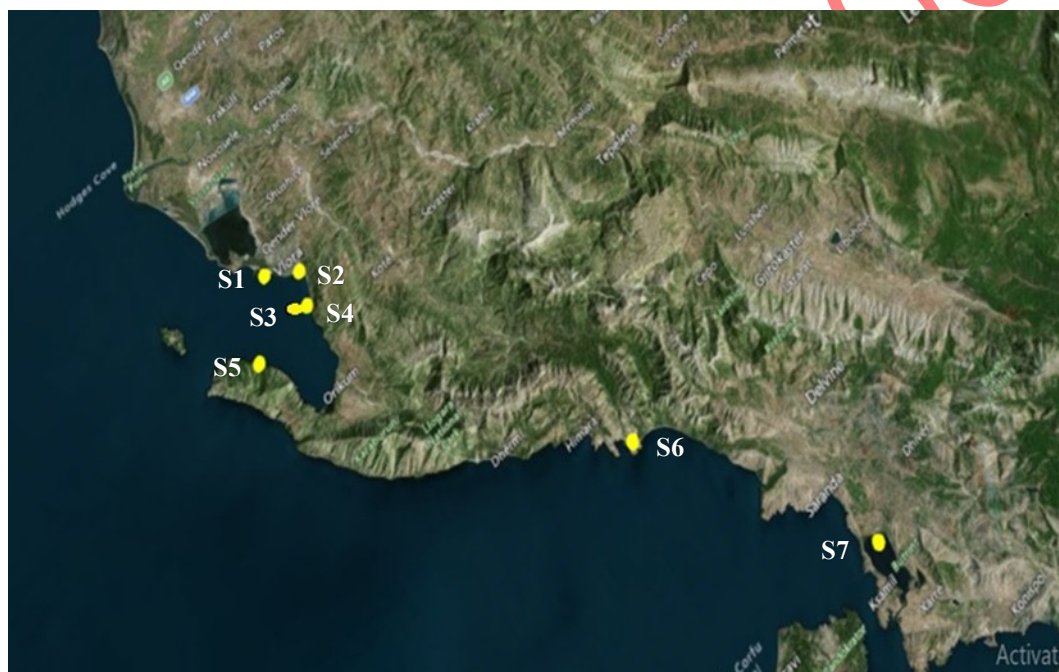


Figure 1. Sampling stations

### 2.2 Sampling Design and Sample Collection

The sampling campaign was conducted during 2023 and 2024. Specimens of *Patella caerulea* and *Mytilus galloprovincialis* were collected manually from rocky coastal sites and placed in plastic bags containing seawater for transport to the laboratory. The samples were collected randomly at each station to provide representative coverage of the local population. More than 50 individuals of *Patella caerulea* were analyzed from six stations (S1-S6). At station 7 has not been found *Patella caerulea*. Limpets from the genus *Patella* typically inhabit rocky coastal environments. In the Mediterranean Sea, this genus includes four species: *P. caerulea*, *P. ulyssiponensis*, *P. rustica*, and *P. ferruginea* [32]. *P. caerulea* (Linnaeus, 1758), endemic to the Mediterranean, is one of the most common species found on rocky shores [33]. In addition, intraspecific genetic variation has been reported to occur in Mediterranean *P. caerulea* in relation to changing hydrodynamic conditions [34]. Its presence extends to the rocky areas of Vlora Bay and the Ionian Sea coast.

A total of 33 individuals of *Mytilus galloprovincialis* were collected from six stations (S1 and S3-S7); mussels were not found at station S2. The collected *Mytilus galloprovincialis* specimens ranged from 2.9 to 4.7 cm in shell length, whereas *Patella caerulea* ranged from 1.3 to 4.3 cm. In the laboratory, samples were frozen at -20 C until analysis. Only the soft tissue of each individual was used for mercury determination; no pooled or composite samples were prepared.

Fish samples were obtained from local fishermen in Vlora, Durres, and Saranda during 2023-2024. Fifty-four individuals representing 12 species were analyzed. Each fish was identified before dissection, and muscle tissue was separated from the bone while keeping the skin attached to the muscle. Tissue samples were placed in polyethylene bags and immediately frozen. All biological samples were analyzed for total mercury on a wet-weight basis.

In addition, two series of soil-core samples were collected from the remediated industrial area: one from the former electrolysis plant and one from the former catalytic plant. These samples were used to evaluate residual mercury in the terrestrial component of the former industrial hotspot.

### **2.3 Reagents and Instrumentation**

All reagents used in this study were of high-purity grade (Suprapur, Merck, Germany), and Milli-Q water was used throughout the analytical procedure. Mercury concentrations were determined with a laboratory-constructed cold-vapor atomic absorption system coupled to an Analytik Jena Model 800 F instrument (Germany).

### **2.4 Sample Digestion and Mercury Determination**

Validated digestion procedures were applied for both biota and soil in accordance with the Marine Environment Studies Laboratory standard operating procedures [35]. Approximately 1.0-1.5 g of each biological sample was digested with concentrated nitric acid. To ensure complete oxidation of mercury species to the inorganic form, the oxidation step was strengthened by adding bromine monochloride or dichromate ions. Mercury was quantified using absorbance mode and the standard-addition method.

During digestion, nitrogen oxides produced spectral interference even when deuterium-background correction was used. This interference was minimized by bubbling air through the reducing cell for 1 min before addition of the reducing agent. Soil samples were digested and analyzed by the same analytical principle [35].

### **2.5 Quality Assurance and Quality Control**

Analytical accuracy was checked using the certified reference material IAEA-407 Fish. Recovery values for mercury ranged from 83% to 96%, confirming acceptable analytical performance. Procedural blanks showed no evidence of contamination. The use of individual samples, certified reference material, blanks, and matrix compensation through the standard-addition method supported the reliability and repeatability of the measurements.

### **2.6 Statistical Analysis**

Descriptive statistics were calculated for each species and station. Before analysis of variance, the assumptions of normality and homogeneity of variances were assessed using the Shapiro-Wilk and Levene tests, respectively. Differences among stations or species were evaluated by one-way analysis of variance, followed by Tukey's honestly significant difference

post hoc test when the overall test was significant. Statistical significance was defined at  $p < 0.05$ . Statistical analyses were performed using StatSoft Statistica 12.

### 3. RESULTS AND DISCUSSION

This section presents and discusses the main findings of the study with respect to mercury distribution in the investigated environmental compartments. The results are structured to address mercury concentrations in remediated soils, marine biota (molluscs and fish), and their spatial variability across the selected sampling stations. Statistical analyses are applied to evaluate differences among species and locations, providing insight into potential contamination patterns and sources. The findings are further interpreted in the context of existing literature to assess the persistence of historical pollution and its implications for environmental quality and food safety.

#### 3.1 Mercury concentration in remediated area of Chlor – Alkali Plant

Two core soil samples were collected from the areas historically identified as the most contaminated zones of the former electrolysis plant (series 1, Figure 2) and the catalytic plant (series 2, Figure 2), both located within the former chlor-alkali industrial complex that has undergone remediation in recent years. These locations were selected because they were previously associated with intensive industrial activities and were therefore considered potential hotspots of mercury contamination. The measured mercury concentrations in the analyzed samples ranged from 0.023 to 0.076  $\mu\text{g g}^{-1}$ .

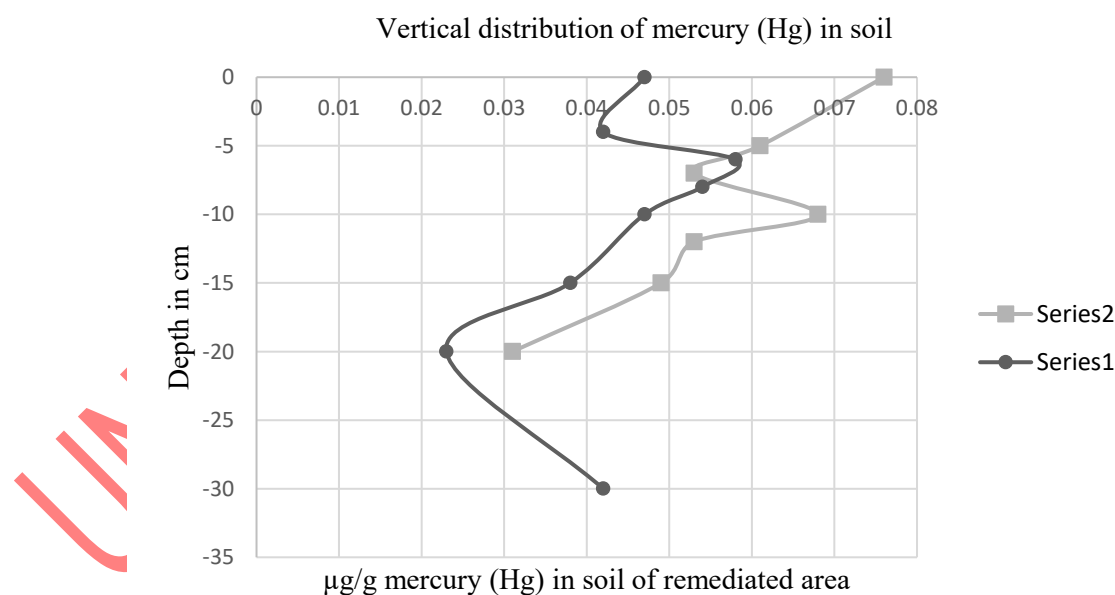


Figure 2. Mercury (Hg) concentration in soil of former Soda Chlor-Alkali Plant.

These values are relatively low and indicate that the remediation measures implemented at the site have been highly effective in reducing residual mercury contamination in surface soils [6]. Numerical sediment quality guidelines (SQGs) for freshwater ecosystems have previously been developed [36]. In our study, for better evaluation of the environmental significance of these concentrations, the results were compared with international sediment quality guidelines. In particular, the measured values were assessed against the Threshold Effects Level (TEL =

0.13  $\mu\text{g g}^{-1}$ ) established by the National Oceanic and Atmospheric Administration (NOAA). All measured concentrations were well below the TEL value, suggesting that the current levels of mercury in the remediated soils are unlikely to cause adverse ecological effects. This finding is particularly important for post-industrial coastal environments where historical mercury use in chlor-alkali processes has often resulted in persistent contamination of soils and sediments, [37].

Although only a limited number of soil cores were analyzed, the results provide valuable supporting evidence that the remediation efforts carried out at the former industrial site have significantly reduced the potential for mercury release to the surrounding environment. Moreover, these findings complement the analysis of mercury concentrations in marine organisms conducted in the present study, contributing to a more comprehensive assessment of the environmental legacy of the former industrial activity in the coastal area near Vlora.

### 3.2 Mercury content in *Patella Caerulea*

Table 1 presents the descriptive statistics for mercury (Hg) concentrations in *Patella caerulea*. The results indicated that mercury concentrations in *P. caerulea* at all sampling stations were below the maximum allowable limit for food safety (0.5  $\mu\text{g/g}$  wet weight). This suggests that prolonged mercury release from sediments has not significantly increased mercury accumulation in local biota. Consequently they are safe for human consumption [38]. The relatively low mercury levels detected, even near previously contaminated sites, could be due to mercury converting into highly insoluble forms such as mercury sulfide (HgS), with a solubility product constant of approximately  $10^{-53}$  [39]. This transformation reduces mercury's bioavailability and its potential entry into the food chain [14].

Table 1. Descriptive statistic for *Patella caerulea* ( $\mu\text{g/g}$ , wet weight)

Stations	Mean. Conc. $\mu\text{g/g}$	Max. Conc. $\mu\text{g/g}$	Nr. of Individuals	St. Dev. $\mu\text{g/g}$
S1	0.053	0.084	13	0.0189
S2	0.035	0.048	7	0.0082
S3	0.020	0.035	11	0.0103
S4	0.023	0.036	7	0.0067
S5	0.028	0.037	5	0.0063
S6	0.026	0.033	7	0.0066
All Groups	0.033	0.084	50	0.0173

In all cases, prior to performing analyses of variance (ANOVA), the assumptions of normality and homogeneity of variances were evaluated using the Shapiro–Wilk and Levene tests, respectively. The results showed that the data did not significantly deviate from normality and that variances were homogeneous ( $p > 0.05$ ). Analysis of variance for *Patella caerulea* was applied to determine whether significant differences exist in the mean mercury concentrations among the selected sampling stations. The results are shown in Table 2. When the p-value is less than the 0.05 significance threshold, the null hypothesis is rejected, indicating that the observed differences in mean mercury concentrations are statistically significant. Although the mercury concentration at station S1 did not reach the critical significance level, it was notably higher compared to other stations. The mean mercury concentration at S1 was significantly different from those at stations S2, S3, S4, S5, and S6, with p-values of 0.0258, 0.0001, 0.0002, 0.0039, and 0.0003, respectively. These results suggest that historical mercury deposition at station S1 may still contribute to moderately elevated mercury levels in *Patella caerulea*.

collected from this site. The highest mercury concentration was recorded at station S1 (0.084  $\mu\text{g/g}$ ), followed by station S2 (0.048  $\mu\text{g/g}$ ), which is situated near the Naval Military Academy-an area still affected by illegal urban wastewater discharges.

Table 2. Analyse of Variance (ANOVA) results. Significant value 0.05.

Tukey HSD test; variable $\mu\text{g/g}$ Hg ( <i>Patella Caerulea</i> , 6 Stations) Approx. Probab. for Post Hoc Tests Error: Between MS = .00015, df = 44.000						
Stations	(1) .053	(2) .035	(3) .020	(4) .023	(5) .028	(6) .260
S1		0.0258	0.0001	0.0002	0.0039	0.0003
S2	0.0258		0.1516	0.4553	0.9360	0.687
S3	0.0001	0.1516		0.9974	0.8278	0.953
S4	0.0002	0.4553	0.9974		0.9754	0.999
S5	0.0039	0.9360	0.8278	0.975		0.998
S6	0.0003	0.6870	0.9533	0.999	0.998	

Interestingly, the lowest average mercury concentration (0.020  $\mu\text{g g}^{-1}$ ) was detected at station S3, rather than at reference sites such as Porto Palermo or the Karaburun Peninsula. It had been expected that the military base area would represent the cleanest site, due to its relatively greater distance from the former soda factory. However, this area may still be influenced by past and ongoing military-related activities, including mechanical operations and the construction or maintenance of small military vessels, which could contribute to local contamination. In addition, the sampling site near the Karaburun Peninsula is located close to a fish farming facility, which may represent an additional local source of organic matter and trace elements through aquaculture-related activities. In contrast, station S3 appears to be characterized by relatively cleaner seawater conditions, likely influenced by substantial inputs of freshwater from nearby mountainous catchments that may dilute contaminants before they reach the coastal zone. Moreover, this station is located close to the drinking water intake area supplying Vlora, which further supports the interpretation that this site is subject to comparatively lower levels of pollution.

### 3.3 Mercury content in *Mytilus galloprovincialis*

The mercury concentration results for *M. galloprovincialis* are presented in Table 3. The use of bivalve organisms as bioindicators for assessing chemical pollution in estuarine environments began in the early 1970s. Notably, Goldberg (1975) introduced the "Mussel Watch" program, describing it as a method to evaluate ocean health [40].

Table 3. Descriptive statistics for *Mytilus galloprovincialis*

Stations	Mean.Conc $\mu\text{g/g}$ .	Max. Conc. $\mu\text{g/g}$	Individuals	St.Dev.
S1	0.050	0.076	6	0.021
S3	0.019	0.057	6	0.019
S4	0.025	0.049	7	0.014
S5	0.041	0.054	4	0.011
S6	0.019	0.026	5	0.006
S7	0.018	0.028	5	0.008
All Groups	0.028	0.076	33	0.019

Farrington et al. reflects on 40 years of the "Mussel Watch". It reviews the program's evolution, effectiveness, and scientific impact in monitoring coastal water contamination using bivalves [41]. In Albania, mussels were first employed as bioindicators in the early 1990s. Upon comparison of our data on *Mytilus galloprovincialis* with previously obtained results for the same species collected in Durrës, Vlorë, and Sarandë, no statistically significant differences were observed [30].

Similarly to findings for *Patella caerulea*, Analysis of Variance, Table 4, revealed significant differences in mean Hg concentrations at station S1 compared to other stations.

Table 4. Analyze of Variance (ANOVA) results. Significant value 0.05.

Tukey HSD test; variable Hg µg/g ( <i>Mytilus galloprovincialis</i> results and stations)						
Approximate Probabilities for Post Hoc Tests Error: Between MS = .00022, df = 27.00						
Stations	(1) .050	(2) .018	(3) .0245	(4) .0410	(5) .0188	(6) .0177
S1		0.012	0.048	0.932	0.019	0.014
S3	0.012		0.978	0.215	1.00	0.999
S4	0.048	0.978		0.502	0.98	0.967
S5	0.932	0.216	0.501		0.256	0.213
S6	0.019	1.000	0.984	0.256		0.999
S7	0.015	0.999	0.967	0.213	0.999	

The highest mercury concentration was detected at station S1 (0.076 µg/g mercury), while the lowest concentration was observed at station S3 (0.010 µg/g mercury). In contrast, station S5 showed no statistically significant differences in mercury (Hg) levels when compared with the other stations.

Overall, the data on mercury accumulation in both *Patella caerulea* and *Mytilus galloprovincialis* suggest no evidence of seafood contamination by mercury from historical elemental mercury pollution in the area. This absence of significant contamination may be due to the mercury present in sediments existing primarily in elemental or inorganic forms, which are poorly bioavailable to marine organisms and thus unlikely to enter the food chain.

### 3.4 Mercury content in fishes from the Albanian Coast

The analyzed fish ranged in weight from 15 to 500 grams. No significant correlation was observed between fish weight and mercury concentration. Most species exhibited average mercury content below 0.06 µg/g. The mercury concentrations and descriptive statistics for fishes are shown in Table 5.

But, among the analyzed species, three predatory fish, *Trigla lyra*, *Sphyraena sphyraena*, and *Squalus acanthias* showed higher average mercury levels compared to other species, with mean content of 0.154, 0.175, and 0.172 µg/g mercury, respectively. Some individuals of these species exhibited even higher mercury levels, with maxima of 0.207, 0.394, and 0.210 µg/g mercury, respectively. Statistical analysis using analysis of variance confirmed a significant difference in Hg concentrations between the three predatory species—*Trigla lyra*, *Sphyraena sphyraena*, and *Squalus acanthias* and the other analyzed fish species, Table 6. According to FDA/EPA fish consumption guidelines, most fish species analyzed from the Albanian Coast fall under the “Best Choices” category (less than 0.15 µg/g mercury), which recommends consuming 2–3 servings per week [38].

However, *Trigla lyra*, *Sphyraena sphyraena*, and *Squalus acanthias* are classified in the “Good Choices” category, which limits consumption to one serving per week. Fish with average Hg concentrations exceeding 0.46 µg/g mercury are categorized as “Choices to Avoid”

by Food and Drug Administration / Environmental Protection Agency (FDA/EPA) guidelines [38].

Table 5. Descriptive statistics for fishes, sampling size N=54.

Descriptive Statistics (Spreadsheet fish)					
Level factor	N	Mean (µg/g)	St.Dev (µg/g)	-95.0% (µg/g)	+95.0% (µg/g)
	54	0.07	0.067	0.051	0.088
<i>Dicentrarchus labrax</i>	7	0.060	0.026	0.036	0.084
<i>Mugil cephalus</i>	3	0.024	0.001	0.022	0.026
<i>Merluccius merluccius</i>	5	0.036	0.014	0.019	0.054
<i>Sparus aurata</i>	5	0.046	0.011	0.033	0.059
<i>Engraulis encrasicolus</i>	4	0.019	0.004	0.012	0.026
<i>Mullus surmuletus</i>	7	0.04	0.034	0.009	0.071
<i>Lithognatus mormyrus</i>	4	0.046	0.016	0.022	0.071
<i>Squalus acanthias</i>	3	0.172	0.042	0.067	0.276
<i>Trigla lyra</i>	4	0.154	0.038	0.093	0.215
<i>Sphyræna sphyræna</i>	5	0.175	0.125	0.019	0.330
<i>Octopus vulgaris</i>	2	0.044	0.028	0.210	0.298
<i>Solea sp.</i>	5	0.046	0.022	0.018	0.074

In addition, It has been reported that frequent consumption of large predatory fish, such as swordfish, tuna, and halibut, may significantly increase methylmercury intake, potentially exceeding the tolerable weekly intake (TWI) [42].

Table 6. Analyze of Variance (ANOVA) results. Significant value 0.05.

Tukey HSD test; variable Hg µg/g (Spreadsheet fish) Approximate Probabilities for Post Hoc Tests Error: Between MS = .00206, df = 42.000												
Fish species	.060	.024	.036	.046	.019	.039	.046	.171	.154	.175	.044	.046
<i>Dicentrarchus labrax</i>		0.99	0.99	0.99	0.94	0.99	0.99	0.038	0.071	0.005	0.99	0.99
<i>Mugil cephalus</i>	0.99		1.0	0.99	1.0	0.99	0.99	0.01	0.02	0.002	0.99	0.99
<i>Merluccius merluccius</i>	0.99	1.0		1.0	0.99	1.0	1.0	0.01	0.06	0.001	1.0	1.0
<i>Sparus aurata</i>	0.99	0.99	1.0		0.99	1.0	1.0	0.02	0.04	0.003	1.0	1.0
<i>Engraulis encrasicolus</i>	0.94	1.0	0.99	0.99		0.99	0.99	0.003	0.01	0.001	0.99	0.99
<i>Mullus surmuletus</i>	0.99	0.99	1.0	1.0	0.99		1.0	0.01	0.01	0.001	1.0	1.0
<i>Lithognatus mormyrus</i>	0.99	0.99	1.0	1.0	0.99	1.0		0.03	0.06	0.006	1.0	1.0
<i>Squalus acanthias</i>	0.04	0.01	0.01	0.02	0.003	0.01	0.034		0.99	1.0	0.12	0.02
<i>Trigla lyra</i>	0.07	0.02	0.016	0.04	0.006	0.01	0.06	0.99		0.99	0.21	0.039
<i>Sphyræna sphyræna</i>	0.01	0.002	0.001	0.003	0.001	0.001	0.006	1.0	0.99		0.05	0.003
<i>Octopus vulgaris</i>	0.99	0.99	1.0	1.0	0.99	1.0	1.0	0.12	0.21	0.052		1.0
<i>Solea sp.</i>	0.99	0.99	1.0	1.0	0.99	1.0	1.0	0.02	0.04	0.003	1.0	

Based on the results and in reference to the new EU regulation, the average mercury concentrations in the analyzed fish samples were below the permissible recommended limits. However, one *Sphyræna sphyræna* individual exceeded the maximum mercury limit established by the latest EU regulation [43]. In Albania, there is a lack of public awareness about the risks associated with methylmercury in seafood. This is particularly concerning for vulnerable groups such as women and children, who are more sensitive to mercury exposure. It

is essential to provide information on the potential health risks of consuming seafood with elevated mercury levels.

## CONCLUSIONS

The contents of Hg in *Mytilus galloprovincialis*, *Patella caerulea* and fishes did not show critical values. However having in mind that over 16-year period, the total mercury released into the environment was estimated at approximately 65 tons, continuous monitoring is essential, especially during activities like port dredging, as they may mobilize mercury into more bioavailable and toxic forms. We recommend establishing a comprehensive monitoring program to track mercury levels in soil, water, and biota over multiple years. Climate change may influence also mercury cycling and mobility, particularly in wetlands or coastal areas, consequently the study of the biogeochemical cycling of mercury to understand its mobility and bioavailability in the remediated site is important. Encouraging interdisciplinary research that combines ecology, toxicology, social sciences, and environmental engineering to address the complex problems of mercury contamination is a serious challenge.

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