

Heavy metal pollution in Inebolu and Bartın Ports, Black Sea, Turkey

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The study was conducted in Inebolu and Bartın ports located in Black Sea region of Turkey between August 2013 and July 2014. Sea water, sediment, and *Mytilus galloprovincialis* samples were collected from both ports and the amounts of 11 heavy metals (Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) in each sample were determined. When the results for sediment samples were compared with the limit values of US EPA, it was found that the port of Bartın was very polluted in terms of Ni, and moderately polluted in terms of Cr and Cu, while the port of Inebolu was very polluted in terms of Cu and moderately polluted in terms of Cr and Ni. Pollution was found in sea water in both ports. When the data of *Mytilus galloprovincialis* was compared with the meat quality standards of European Commission (EU), it was determined that As, Cd, Cu, and Zn values were high in Inebolu port and As, Cd, and Zn values were high in Bartın port. It was observed that the load diversity, ships, shipyard, submarine maintenance and repair facility, runoffs and rivers and port activities were responsible for the pollution.

[Keywords: Heavy metals; Sediment; Sea water; *Mytilus galloprovincialis*; Inebolu port; Bartın port]

Introduction

Ships are used to transport 80% of the world's burden due to the high load-bearing capacities¹. For this reason, human and industrial activities and population have increased significantly in the areas where ship traffic is intense, resulting in environmental pollution in port areas. It was pointed out that the biodiversity was quite diminished in Sydney harbor, the largest harbor in the world, as a result of dense population and intensified human activities².

Heavy metals, one of the major pollutants affecting the ports, are non-biodegradable and damage the metabolism by the way of their accumulation in organisms³. For instance, accumulation of Cd changes gill structure, deteriorates neural activities, and inhibits growth and nephrotoxicity⁴. As a result, ports are subjected to many studies focused on determining heavy metal pollution⁵⁻¹¹.

There are many factors that can lead to heavy metal pollution in ports. For example, the loads are significant heavy metal sources and the accidents during the handling of loads lead to heavy metal pollution. Additionally, river inputs to the port areas and human activities cause many different pollutants to enter the ports^{12,13}. As a matter of fact, both Inebolu

and Bartın ports have two river inputs and there are no treatment plants in both regions.

This study was aimed to determine the heavy metal pollution status of Inebolu and Bartın ports located in Black Sea. As a result of this study, the anthropogenic sources causing heavy metal pollution in the ports were identified and the precautions to be taken against metal pollution were suggested.

Material and Methods

The study was conducted at Inebolu and Bartın ports located in Black Sea Region of Turkey between August 2013 and July 2014. Sea water, sediment and *Mytilus galloprovincialis* samples were collected during the study period. The amounts of Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn were determined.

Study areas

Inebolu and Bartın ports are located in Black Sea region of Turkey (Fig. 1). Sea water and sediment samples were collected monthly from six different stations (Figs 2 and 3). *Mytilus galloprovincialis* samples were gathered only in August and November 2013 due to bad weather conditions.

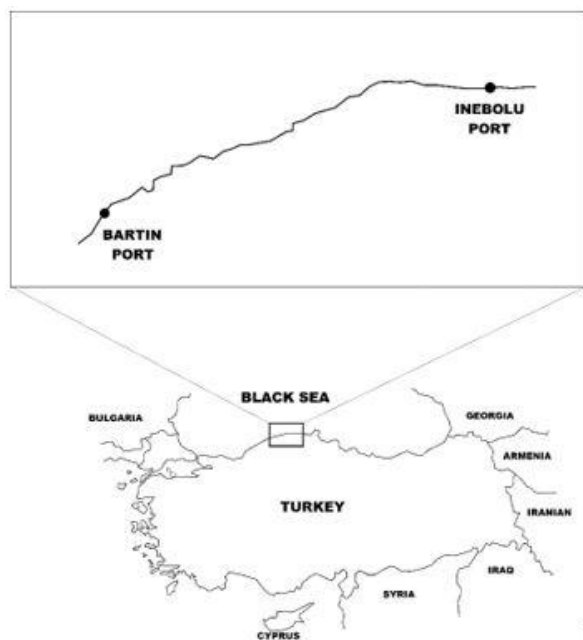


Fig. 1 — Location of Inebolu and Bartın ports



Fig. 2 — Stations in Inebolu port



Fig. 3 — Stations in Bartın port

In 2012, 453.688 tonnes of cargo were handled at Inebolu port and 60 vessels traded, while 1.317.819 tonnes of cargo were handled at Bartın port and 476 ships traded.

Sediment samples

During the study period, 1 kg sediment samples were collected monthly by using van Veen grab. At the same time, physico-chemical parameters were measured with a multimeter (Table 1).

Samples were put into plastic bottles sterilized with dilute acidic water and brought to the laboratory quickly. After the samples were dried at room temperature (approximately 25 °C) for 24 hr, they were passed through a 100 mesh (micron) sieve to prepare them for extraction.

The extraction process was done according to the standard methods of US EPA 3051a¹⁴. The heavy metal concentrations in the samples were determined with Spectro SpectroBlue ICP-OES instrument and CPI International Peak Performance Certified Reference Materials, Certified by ICP against NIST SRM3151 reference matter was used to calibrate ICP-OES (Table 2).

Sea water samples

Samples were gathered monthly from each station with Nansen bottle (from 4-5 m depth) and put into the 1 L plastic bottles sterilized with dilute acidic water. After the samples were taken, 3 ml of nitric acid was added and the samples were brought to the laboratory. After the samples were homogenized by using magnetic stirrer, they were put into 100 mL volume plastic bottles; and heavy metal amounts were measured directly with ICP-OES.

Mytilus galloprovincialis samples

Due to feeding by filtering the sea water and having high heavy metal accumulation capacity, *M. galloprovincialis* which is one of a mussel species was chosen as a bioindicator to assess the heavy metal pollution in the study. *M. galloprovincialis* samples were collected by scuba diving. The samples were brought to the laboratory with cold chains. After length, width and weight of the samples were measured (Table 3), their contents were removed using sterile dissection sets. The contents were then dried at 105 °C throughout 24 hr. The extraction process was carried out according to US EPA 3052 standard method¹⁵.

Statistical analysis

Kolmogorow Smirnov Test was applied to each data set to determine the normal distribution of amounts of the heavy metals obtained from sediment, sea water and *M. galloprovincialis* samples from both

Table 1 — Average amounts of physico-chemical parameters measured at the ports of Inebolu and Bartin during the study period

	Dissolved Oxygen (mg/L)		pH		Temperature (°C)	
	Inebolu	Bartın	Inebolu	Bartın	Inebolu	Bartın
August	7.85±0.37	8.18±0.15	8.41±0.04	8.44±0.02	26.2±0.21	25.07±0.36
September	8.05±0.22	8.13±0.18	8.47±0.02	8.25±0.38	20.62±0.19	21.53±0.26
October	9.33±0.07	-	8.38±0.04	-	17.37±0.41	-
November	-	9.73±0.13	-	8.42±0.09	-	13.65±0.18
December	10.28±0.21	10.19±0.12	8.49±0.02	8.59±0.03	11.87±0.33	11.27±0.20
January	10.53±0.08	10.46±0.09	8.51±0.01	8.55±0.02	9.51±0.28	9.7±0.06
February	10.89±0.14	11.03±0.07	8.48±0.03	8.56±0.01	8.2±0.19	8.1±0.15
March	11.09±0.06	11.46±0.06	8.47±0.02	8.53±0.02	10.73±0.85	7.82±0.12
April	10.25±0.06	10.34±0.14	8.52±0.04	8.57±0.00	15.43±0.26	13.37±0.29
May	9.37±0.17	9.6±0.16	8.57±0.02	8.46±0.08	22.07±0.47	21.2±0.44
July	8.54±0.23	9.02±0.11	8.46±0.02	8.43±0.01	23.98±0.28	22.75±0.5
June	8.37±0.09	8.57±0.18	8.41±0.03	8.4±0.02	24.1±0.42	24.81±0.47

Table 1 — Continued

	Salinity (‰)		Conductivity (Ω·m)	
	Inebolu	Bartın	Inebolu	Bartın
August	17.23±0.08	17.16±0.44	27.73±0.17	27.87±0.75
September	17.62±0.04	17.37±0.12	28.52±0.09	28.18±0.16
October	17.15±0.05	-	28.29±0.4	-
November	-	17.45±0.1	-	28.23±0.42
December	17.48±0.03	17.56±0.09	28.13±0.1	28.38±0.15
January	17.43±0.02	17.59±0.05	28.29±0.23	28.37±0.09
February	17.0±0.09	16.95±0.07	27.83±0.17	27.59±0.45
March	16.87±0.1	16.29±0.38	27.3±0.13	26.4±0.61
April	16.85±0.6	17.67±0.09	27.35±0.3	28.52±0.15
May	16.85±0.4	17.29±0.29	27.42±0.61	27.92±0.17
July	17.46±0.05	17.15±0.21	28.35±0.1	28.11±0.37
June	17.33±0.07	17.21±0.1	28.01±0.8	27.96±0.5

Table 2 — Wavelength measured for each heavy metal by ICP-OES instrument and reference substance measurement values

	Wave Length (mm)	CPI International Peak Performance Certified Reference Materials, NIST SRM3151		
		Heavy metal amounts (ppb)	Measured average values (ppb)	Accuracy (%)
Al	167.078	500	511.91±4.37	102.4
As	189.042	500	498.5±2.9	99.7
Cd	226.502	500	509.974±3.99	102
Co	238.892	500	513.38±3.51	102.7
Cr	267.716	500	504.52±5.18	100.9
Cu	324.754	500	485.9±2.86	97.2
Fe	238.204	500	500.86±3.59	100.1
Mn	257.611	500	504.07±3.07	100.8
Ni	232.003	500	517.5±4.92	103.5
Pb	220.353	500	498.95±2.08	99.8
Zn	206.200	500	492.66±2.28	98.5

ports and as a result it was determined that the data are normally distributed¹⁶. Independent samples t-test was applied to the samples to show whether the

sediment, sea water and *M. galloprovincialis* samples differed between ports according to the means¹⁶. SPSS v22 software was used for statistical calculations.

Table 3 — Mean size of *Mytilus galloprovincialis* samples collected from Inebolu and Bartın ports

Liman Adı	Adet	Boy (cm)	En (cm)	Genişlik (cm)	Ağırlık (g)
İnebolu	79	6.61±1.24	3.67±0.79	2.88±0.72	16.57±9.63
Bartın	79	6.78±1.33	3.84±0.84	3.08±0.91	26.42±15.42

Table 4 — Comparison of sediment samples of Inebolu and Bartın ports, mg/kg dry weight

	Inebolu Port	Bartın Port	p values	t values	US EPA Guidelines			
					Unpolluted	Moderately polluted	Polluted	
Sediment (n=66)	Al	12782.61±3449	10604.12±286.7	0.000*	3.946			
	As	10.83±0.68	6.64±0.50	0.000*	4.016			
	Cd	0.72±0.07	0.86±0.08	0.333	-0.973	-	-	>6
	Co	34.32±1.87	8.25±1.92	0.000*	8.343	<25	25-75	>75
	Cr	53.36±13.58	32.56±6.59	0.361	-0.917			
	Cu	452.04±20.88	49.04±8.82	0.000*	9.778	<25	25-50	>50
	Fe	35608.71±112.16	28083.15±1031.9	0.000*	4.242			
	Mn	248.73±32.79	279.87±23.02	0.353	-0.933	<300	300-500	>500
	Ni	44.92±9.94	488.45±39.28	0.265	1.119	<20	20-50	>50
	Pb	0.0059±0.0005	0.0064±0.0006	0.962	0.048	<40	40-60	>60
Zn	0.104±0.006	0.063±0.004	0.001*	3.337				

The p values marked with * indicate that the differences are significant

Results

The study was conducted at Inebolu and Bartın ports in the Central Black Sea region of Turkey between August 2013 and July 2014. Sea water and sediment samples were collected monthly during the study. *Mytilus galloprovincialis* samples were gathered only two times due to bad weather conditions and lack of a diver who can dive in the port area. In the samples, Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, and Zn ratios were determined to evaluate the pollution status of the ports.

The heavy metal concentrations in the sediment samples obtained monthly from Inebolu and Bartın ports is given (Table 4). The pollution level in Inebolu port was significantly higher than in Bartın port in terms of Al, As, Co, Cu, Fe, and Zn (12782.61±3449, 10.83±0.68, 34.32±1.87, 452.04±20.88, 35608.71±112.16 and 0.104±0.006 mg/kg dry weight, respectively) (p<0.05). For other metals, the differences between ports were not important (p>0.05). When the results were compared with the limit values of US EPA, it was found that Inebolu had high pollution in terms of Cu (452.04±20.88 mg/kg dry weight) and moderate pollution in terms of Cr and Ni (53.36±13.58 and 44.92±9.94 mg/kg dry weight, respectively) and Bartın port had high pollution in terms of Ni (488.45±39.28 mg/kg dry weight) and moderate pollution in terms of Cr and Cu (32.56±6.59 and 49.04±8.82 mg/kg dry weight, respectively). There was no pollution in terms of other metals.

The comparison of sea water samples of Inebolu and Bartın ports is given in Table 5. It was determined that heavy metal pollution in Bartın port was significantly higher than Inebolu port in terms of Al, Fe and Mn (0.116±0.016, 0.214±0.029 and 0.0065±0.0008 ppm, respectively) (p<0.05). There were no differences between the ports for As and Zn (p>0.05). On the other hand, the amounts of heavy metals did not exceed the limit values of US EPA.

When the *Mytilus galloprovincialis* samples were compared between the ports (Table 6), it was found that of amounts As (9.89 mg/kg, dry weight) and Pb (0.88 mg/kg, dry weight) obtained from Bartın port were significantly higher than Inebolu port (6.38 and 0.83 mg/kg, dry weight, respectively). The Co concentration (0.64 mg/kg, dry weight), Cu concentration (39.50 mg/kg, dry weight) and Fe concentration (458.66 mg/kg, dry weight) were importantly higher than the Bartın port (0.16, 7.05, and 409.84 mg/kg, dry weight, respectively) (p<0.05). The differences between the ports for other heavy metals were not significant (p>0.05). When the heavy metal concentrations were compared with the limit values of the meat quality values determined by EU Commission¹⁷, As, Cd, Cu and Zn in Inebolu port and As, Cd and Zn concentrations of *M. galloprovincialis* in Bartın port exceeded the limit values, clearly suggesting pollution in terms of these heavy metals.

Table 5 — Comparison of sea water samples of Inebolu and Bartın ports, ppm

	Inebolu Port	Bartın Port	p values	t values	US EPA Guidelines		
					Acute	Chronic	
Sea water (n=66)	Al	0.0324±0.0002	0.116±0.016	0.000*	-4.225		
	As	0.0042±0.0004	0.0051±0.0004	0.246	-1.166		
	Cd	Nd	Nd	Nd	Nd	40	8.8
	Co	Nd	Nd	Nd	Nd		
	Cr	Nd	Nd	Nd	Nd	1100	50
	Cu	Nd	Nd	Nd	Nd	4.8	3.1
	Fe	0.067±0.005	0.214±0.029	0.000*	-3.988		
	Mn	0.0024±0.0002	0.0065±0.0008	0.000*	-4.093		
	Ni	Nd	Nd	Nd	Nd	74	8.2
	Pb	Nd	Nd	Nd	Nd	210	8.1
	Zn	0.0051±0.0006	0.0044±0.0007	0.669	0.429	90	81

The p values marked with * indicate that the differences are significant

Table 6 — Comparison of samples of *Mytilus galloprovincialis* in Inebolu and Bartın ports, mg/kg dry weight

	Inebolu Port	Bartın Port	p values	t values	European Commission		
<i>Mytilus galloprovincialis</i> (n=79)	Al	214.17±16.13	210.23±12.54	0.336	0.237		
	As	6.34±0.39	9.90±2.57	0.001*	-6.730		1
	Cd	1.03±0.08	1.04±0.09	0.297	-0.13		0,1
	Co	0.64±0.09	0.16±0.04	0.000*	4.085		
	Cr	20.81±7.83	14.15±3.99	0.232	0.680		
	Cu	39.83±4.73	7.08±0.36	0.000*	6.123		20
	Fe	457.23±44.54	410.72±25.45	0.036*	0.851		
	Mn	16.30±1.22	17.98±1.39	0.269	-0.737		
	Ni	11.11±3.85	8.44±2.33	0.222	0.532		
	Pb	0.83±0.11	0.88±0.07	0.002*	-0.365		1
	Zn	197.46±12.90	235.05±11.66	0.982	-1.90		50

The p values marked with * indicate that the differences are significant

Discussion

In both the ports, Cr, Cu and Ni pollution in terms of sediment and As, Cd, Cu and Zn pollution in terms of *M. galloprovincialis* were determined. It was suggested that the main factors in achieving these results were loads in the ports, shipyard and submarine maintenance and repair facility, ships, and river inputs. For instance, loads such as copper, pyrite, marble, stone charcoal, potato, chipboard, fertilizer, wood, coal, urea fertilizer and methanol were being handled in the port of Inebolu and mainly profile and ingot iron bars, citrus, diatomite mine, gypsum, cement, kaolin and kaolin clay, ingot iron, logs and coal in Bartın port. Copper mine is the main load in Inebolu port and this explained why Cu pollution was high in the sediment in Inebolu port. Similarly, the transport of the profile and ingot iron bars caused high Ni pollution in Bartın port. In addition, the dock is washed with pressurized water after each loading and unloading process at the port of Bartın. This meant that the waste left from every

loading and unloading process in the port is discharged directly into the sea. Other loads such as coal and fertilizer contained significant amounts of the heavy metals^{18,19,20,21,22,23,24}.

In addition to the loads, shipyard and submarine maintenance and repair facilities were also considered to have contributed significantly to the heavy metal pollution in both ports. Engine maintenance and other repairs were carried out at the submarine maintenance and repair facility. In Inebolu shipyard, all works except shipbuilding were done. Indeed, both facilities were significant heavy metal pollution sources^{25,26,27,28}. Especially in shipyards, wastes released after some processes such as bilge and ballast waters, protective dyes, blasting, dismantling and repair were among the most serious pollutant sources^{29,30,31,32}. The operations in Inebolu port were conducted in floating dry dock. Therefore, antifouling dyes containing high amounts of Cu and Zn were discharged directly into the sea. As a result, the findings reported high Cu pollution in Inebolu port.

In ships, another factor causing the heavy metal pollution in both ports, the antifouling dyes containing Cu and Zn components lose their function over time and thus their Cu and Zn are components spread in to the sea water³³. These components cause serious pollution especially in relatively small areas such as harbors, marinas, bay and gulfs^{34,35}. It is reported that 3.86 tonnes of Cu per year from a marina with 876 vessels consisting of sailing and motorboats and average 15 10⁶ kg Cu per year from around the world is spread in to the sea water³⁵. There is also an anchoring area at the port of Inebolu where 85 fishing boats are anchored all year round. Therefore, this effect became more important in the port of Inebolu.

In addition, there were river inputs to the ports of Inebolu and Bartın, with no wastewater treatment plants in both regions. Therefore, wastewater discharged directly in to the rivers increased the pollution load of the rivers. As a matter of fact, it is stated that many kinds and amounts of pollutants from cities reached the sea by river inputs³⁶.

When the pollution was evaluated in terms of *M. galloprovincialis* samples, As, Cd, Cu and Zn pollution for Inebolu port and As, Cd and Zn pollution for Bartın port were determined. In many studies, the mussels were used as bioindicator organisms to evaluate the pollution due to their unique characteristics, including their civility to live on hard substances, exhibiting high resistance to variable environmental conditions (temperature, salinity, oxygen concentration, pollution, etc.), living for long, producing metal binding proteins, feeding by filtration of the sea water, and accumulating high amounts of pollutants^{37,38,39}. It is reported that there is a direct correlation between the heavy metal amounts and the human activities in *M. galloprovincialis* samples³⁸. Which is compatible with our study. It was observed that metals with high concentration in sediment and seawater were also high in *M. galloprovincialis* samples obtained from the ports of Inebolu and Bartın.

Enrichment factor (EF)

The aim of the study was to determine heavy metal pollution in Inebolu and Bartın ports. To achieve this aim, we examined our findings using different approaches such as EF and I-Geo index. We used EF to determine whether the metal concentrations found in sediment were geochemically usual or unusual. Aluminum and Fe metals, which are common in the

earth's crust, are used for the calculation of the EF. According to the EF, if the EF value is between 0.5 and 1.5, it is considered that the heavy metal accumulation in the region is caused by natural events (wind, rain, flood, erosion, etc.). When the EF value is higher than 1.5, it is understood that the metal accumulation in the region is from point or non-point sources⁴⁰. Sediments containing high organic matter, clay and fine grains are dominant especially in the river estuaries^{40,41,42}. In clay minerals, Fe element is abundant⁴⁰. Because of the river inputs to the Inebolu and Bartın ports, Fe was used to calculate the EF. Indeed, in other studies also, the Fe element was used successfully in EF calculations^{40,43,44,45}. The EF was calculated according to the formula:

$$EF = \frac{(Me/Fe)_{\text{Sample}}}{(Me/Fe)_{\text{Background}}}$$

Where (Me/Fe)_{sample} is the metal-to-Fe ratio in the samples of interest and (Me/Fe)_{background} is the natural background value of metal-to-Fe ratio. As no previous studies were carried out in the ports of Inebolu and Bartın, the natural quantities of the elements in the earth's crust were used as past data (80000, 13, 0.3, 19, 90, 45, 47200, 850, 68, 16 ve 95 mg/kg was used for Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn, respectively)⁴⁶.

The EF values obtained from the ports of Inebolu and Bartın for sediments are given in Table 7. According to the results, it is understood that Cd, Co, Cu and Ni derived from point and/or non-point sources due to the fact that the EF values of Cd, Co and Cu (3.18, 2.39 and 13.31, respectively) in Inebolu port and Cd, Cu and Ni (4.82, 1.83 and 12.07, respectively) in Bartın port were found more than 1.5. Similarly, As, Co, Cr and Mn derived from natural facts due to finding the EF values of As, Cr and Ni (1.10, 0.78 and 0.87, respectively) in Inebolu port and As, Co, Cr and Mn (0.86, 0.73, 0.61 and 0.55, respectively) in Bartın port were between 0.5 and 1.5. Accumulation of other metals were found insignificant. These results demonstrated that Cr, Cu and Ni pollution in the sediment samples in both ports was derived from loads, shipyard and submarine maintenance and repair facility, ships and river inputs.

Geo-accumulation index (I-Geo)

Another approach used in the assessment of heavy metal pollution in Inebolu and Bartın ports is the geological accumulation index⁴⁷. The aim of this approach is to compare the current amounts of metals

Table 7 — Enrichment factor values calculated for Inebolu and Bartin ports

	Inebolu Port	Bartın Port
	EF Values	EF Values
Al	0.21	0.22
As	1.10	0.86
Cd	3.18	4.82
Co	2.39	0.73
Cr	0.78	0.61
Cu	13.31	1.83
Mn	0.39	0.55
Ni	0.87	12.07
Pb	0.0005	0.0007
Zn	0.0014	0.0011

Bold face showed the anthropogenic inputs to the ports

Table 8 — Metal geoaccumulation index values in the sediments from Inebolu and Bartın ports

	Inebolu Port		Bartın Port	
	I-Geo Values	Class	I-Geo Values	Class
Al	-3.23	0	-3.50	0
As	-0.85	0	-1.55	0
Cd	0.68	1	0.93	1
Co	0.27	1	-1.79	0
Cr	-1.34	0	-2.05	0
Cu	2.74	3	-0.46	0
Fe	-0.99	0	-1.33	0
Mn	-2.36	0	-2.19	0
Ni	-1.18	0	2.26	3
Pb	-11.99	0	-11.87	0
Zn	-10.42	0	-11.14	0

Bold face exhibited the levels of pollution according to Müller's scale

obtained in sediments with pre-industrial amounts. To achieve this, the density of the elements found naturally in the earth's crust is utilized. In this way, pollution levels of metals in the sediment can be revealed⁴⁷. The following formula is used in calculation:

$$I_{geo} = \log_2 \left(\frac{C_n}{1.5 \cdot B_n} \right)$$

In the formula, C_n is the observed concentration of the interested metal (n) and B_n is the geochemical background concentration of the metal (n). Factor 1.5 is the background matrix correction factor to accommodate lithogenic effects.

The I-geo index results and their classification scale⁴⁷ are presented in Tables 8 and 9, respectively. According to the results, it is observed that while Inebolu port can be labeled from unpolluted to

Table 9 — Müller's classification scale for geoaccumulation index

Class	I-Geo Value	Quality of sediment
0	$I_{geo} \leq 0$	Unpolluted
1	$0 < I_{geo} < 1$	From unpolluted to moderately polluted
2	$1 < I_{geo} < 2$	Moderately polluted
3	$2 < I_{geo} < 3$	From moderately to strongly polluted
4	$3 < I_{geo} < 4$	Strongly polluted
5	$4 < I_{geo} < 5$	From strongly to extremely polluted
6	$5 < I_{geo}$	Extremely polluted

moderately polluted in terms of Cd and Co (0.68, 0.27, respectively) and from moderately to strongly polluted in terms of Cu (2.74) pollution, whereas Bartın port labeled from unpolluted to moderately polluted in terms of Cd (0.93) and from moderately to strongly polluted in terms of Ni (2.26). It was determined that point and/or non-point sources led to these results.

Conclusion

The study was conducted in Inebolu and Bartın ports located in Black Sea region of Turkey between August 2013 and July 2014. In both ports, Cr, Cu and Ni pollution in terms of sediment and As, Cd, Cu and Zn pollution in terms of *M. galloprovincialis* were determined. It was suggested that the main factors in achieving these results were: Loads in the ports, shipyard and submarine maintenance and repair facility, ships, and river inputs. Therefore, firstly, the handling of the loads should be so done more carefully. Secondly, submarine maintenance and repair facility and shipyard activities should be arranged to prevent the spread of pollution to the marine environment. Lastly, the pollution load from the river inputs to the ports should be reduced by constructing a wastewater treatment plant in both Inebolu and Bartın ports.

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