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Evaluation of the Black Sea Land Based Sources of Pollution the Coastal Region of Turkey

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Abstract: The Black Sea receives large quantities of unregulated and uncontrolled fresh water with drawl for irrigation purposes, hydro and thermal power generation and the use of coastal areas for permanent human settlements; shipping; and untreated domestic, industrial and agricultural wastes drain into the sea *via* the rivers or directly. In spite of this, research on the heavy metal pollution in marine biota of the Black Sea is limited.

This review prepared to be informed of the urban sewage pollution loads and heavy metal concentrations of Turkish coasts of Black Sea. The urban sewages and heavy metals currently effective in Turkey coasts of the Black Sea so as to bring up the levels of land based sources of pollution with rivers and streams in the sea. The Black Sea has a special importance because of its being a sea that receives two large rivers, Kizilirmak and Yesilirmak and in this investigation we can show that Yesilirmak has higher amount of discharge then other rivers. This investigation was carried out with indicate to determine the aid of land-based sources and marine activities to the Black Sea, bringing up its present state.

Total chrome and cadmium concentrations are higher then other heavy metals streams and rivers because of high amount of industrial discharges. The data presented in investigation on the heavy metal contamination of marine organisms were different depending on pollution sources, element and species. According to the evaluation of inventories, the results are rising year by year.

Keywords: Black Sea, marine pollution, heavy metal, land based sources.

INTRODUCTION

Marine pollution may be defined as:

'… the introduction by man, directly or indirectly, of substances or energy to the marine environment resulting in such deleterious effect as harm to living resources; hazards to human health; hindrance of marine activities including fishing; impairment of the quality for use of seawater; and reduction of amenities' [1, 2].

Balkas *et al.* [3] pointed out that the oceanography of the Black Sea has been relatively well documented. The same, however, cannot be said for documentation of the levels of marine pollution and the regions that are affected by various human activities, especially in coastal areas [3]. Although, the Turkish coastal regions of the Black Sea are relatively poor in the metal releasing industrial activities, mining and agricultural activities on land may be an important source in the delivery of some metal pollutants. The Black Sea receives large quantities of unregulated and uncontrolled fresh water with drawl for irrigation purposes, hydro and thermal power generation and the use of coastal areas for permanent human settlements; shipping; and untreated domestic, industrial and agricultural wastes drain into the sea *via* the rivers or directly. In spite of this, research on the heavy metal pollution in marine biota of the Black Sea is very limited. Moreover, corresponding data on the pollution state of the Black Sea off Turkey are rare.

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THE STUDY AREA

The Black Sea is the world's largest inland sea and widely perceived to be polluted. Almost one-third of the entire land area of continental Europe drains into it and the Black Sea environment have suffered degradation from the waste from approximately 17 countries (Fig. **1**).

The Black Sea is located between the latitudes $40^0$55' and $46^0$42' N and the longitudes $27^0$27' and $41^0$42' E. The Black Sea has historically been one of the most biologically and ecologically productive marine ecosystem in the world.

Evaluation of Urban Sewage Effects to the Turkish Coasts of the Black Sea

In the Black Sea, some cities use the sewerage system directly but most of the small settlement areas used septic tanks. On the other hand, present sewerage systems show also variety such as combined or separate system (Fig **2**). Ordu, Giresun city centres have separate sewerage systems where Sinop, Trabzon and Zonguldak have combined systems but only Samsun city centre have both combined and separate sewerage system [4].

Many industrial untreated industrial and agricultural wastes drain into the sea. Table **1** shows that annual load of pollutants from Turkish Black Sea coast.

Domestic discharge is the greatest source of organic matter discharged into coasts. In Turkey, many towns and cities situated on the coast, however, sewage is discharged untreated. Organic matter is an important nutrient, as it is a source of food for many benthic invertebrates in the marine ecosystem.

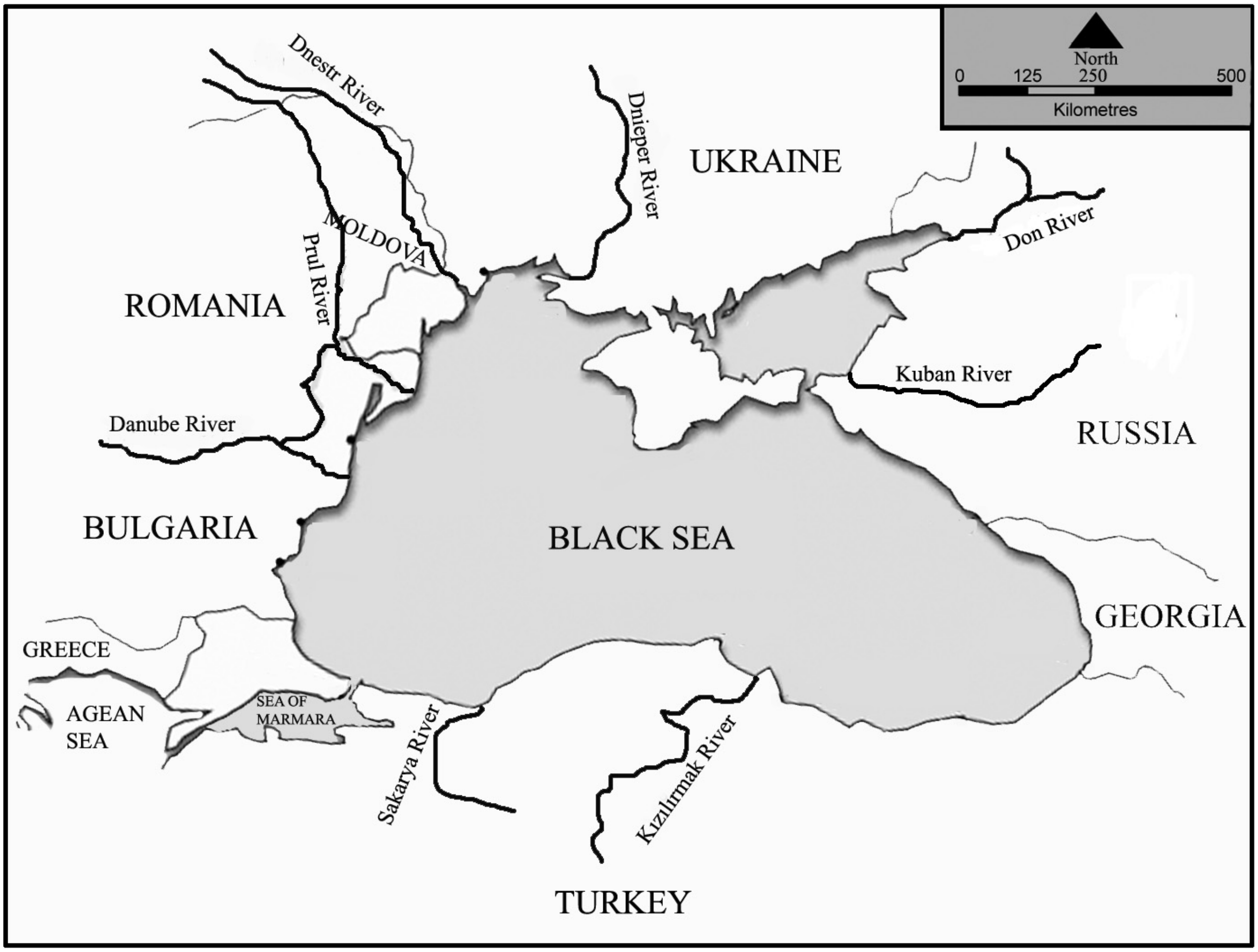

Fig. (1). The Black Sea and its discharge points.

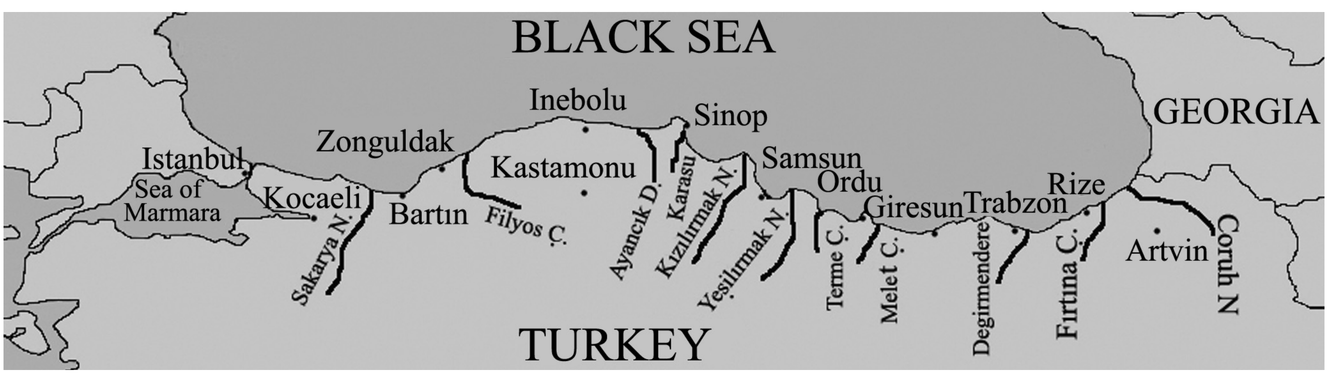

Fig. (2). Black Sea coastal towns and major rivers location points.

For example, Sinop is the smallest city and located on the Southern coasts of the Black Sea. Gökkurt [7] showed that some pollutant loads from Sinop city domestic discharge point to the Black Sea coast (Fig. **3**) and Table **2** shows participation of pollutants load from Turkish coast of the Black Sea and especially in Samsun, total load of pollution higher than other cities of Turkish coast of Black Sea (Table **2**). The calculations were done according to the flow of the discharge 52 litres per second [8]. Some of the parameters are exceeded the "Turkish Environmental Regulations" criteria. In the last decade, the local population in Sinop is about 30000; however the population increases up to 80000 in summer. Thus, untreated domestic wastes and human activity along the coastal zone increase in summer and probably give rise to high pollution.

In Fig. (**3**), in Sinop coasts suspended solid matter concentrations is very high respect to Turkish Environmental Regulation, 2004 -General Quality Criteria of Marine. The reason of this situation is estimated that untreated domestic discharges and erosion problem in coastal zone of Sinop peninsula.

Table 1. Annual Load of Pollutants from Rivers, Streams and Cities (Located in the Coast of Turkey) to Black Sea Coast of Turkey (TSS: Total Suspended Solid, BOD: Biologic Oxygen Demand, COD: Chemical Oxygen Demand, o-P: Ortho Phosphate, Total P: Total Phosphate) [5]

Rivers and Streams	Discharge ($km^3.yr^{-1}$)	TSS ($t.yr^{-1}$)	BOD ($t.yr^{-1}$)	COD ($t.yr^{-1}$)	o-P ($t.yr^{-1}$)	Total P ($t.yr^{-1}$)	NH_3±N ($t.yr^{-1}$)	NO_3±N ($t.yr^{-1}$)	NO_2±N ($t.yr^{-1}$)	TKN ($t.yr^{-1}$)	Surfactants ($t.yr^{-1}$)
Sakarya	6.02	217695	99805	192439	1214.4	1201.5	3449	11354	121	26703	693.1
Melen	1.57	61818	21366	68304	149.6	170.7	565	2006	55	9339	253.7
Cark	0.31	32102	7774	11524	174.3	247.8	329	690	10	1289	209.3
Alapli	0.27	9328	4460	14539	44.4	60.7	67	550	4.8	647	88.6
Gülüc	1.19	17413	32214	77277	43.6	77.5	1459	5530	24	3296	180.4
Kozlu	0.02	1438	291	864	10.9	12.4	96	71	1.7	76	4.4
Zonguldak	0.13	13258	17792	29178	47.9	48.4	214	452	2.9	912	27.7
Catalagzi	0.13	85825	5805	39072	4.8	19.9	298	315	2.6	557	23.0
Filyos	3.22	478764	46779	180102	566.9	574.6	554	2152	93	4777	614.8
Bartin	0.36	38636	7367	19812	28.7	36.5	102	81	8.9	394	57.1
Kizilirmak	7.39	296815	124241	307263	78.8	147.2	6139	7765	141	16368	1613.9
Mert	1.06	44848	20996	64010	371.7	473.7	1178	1694	384	441	970.5
Kurtun	0.16	108245	14772	56106	157.8	45.8	55	231	10	654	524.8
Yesilirmak	10.26	71563	164153	175230	3277.7	1126.7	2894	5813	211	16959	1758.9
Milic	0.43	2666	378	1601	153.9	65.6	6.3	57	4.3	500	524.6
Melet	0.83	30059	6515	23834	97.2	64.6	196	1774	13	997	170.8
Civil	0.16	274	2509	3134	27.9	44.6	9.4	22	6.1	246	257.2
Aksu	0.97	5233	9073	27115	84.3	41.2	98	1282	12	640	220.1
Fol	0.20	3469	1471	10091	67.8	67.4	100	483	8.1	158	138.3
Sögütlü	0.12	4270	1478	7137	28.7	9.4	98	480	2.8	158	73.4
Degirmen	0.87	15427	11147	30560	989.3	1406.7	279	459	17.8	1133	132.0
Cities											
Sinop (in 2000)	0.004	596	827	1635	32.7	37.3	85.9	7.3	0.13	114.6	4.7
Sinop (in 2006-2007)*		1748.8						39.58	0.25		
Samsun	0.008	1600	2054	3037	46.9	62.4	25.6	12.3	1.04	132.0	48.1
Ordu	0.010	886	1946	820	54.9	68.1	19.3	17.1	0.14	44.8	51.8
Giresun	0.004	473	2063	2249	27.9	50.8	16.5	9.5	0.13	128.5	36.2
Trabzon	0.010	1489	2099	2221	69.3	49.8	9.6	30.2	0.13	208.5	118.5
Rize	0.009	276	1477	1282	32.7	43.9	41.8	14.2	0.15	285.5	30.5

*Data from [6].

Sewage discharges are being dumped in many in coastal areas. Changes in the benthic community structure can be largely correlated with the extent of organic enrichment at sewage sludge dumping grounds. Table **3** shows that Turkish coast of Black Sea's data changes.

Metal Toxicity Effects to the Black Sea Ecosystem

Metals are natural constituents of the biosphere. They occur at a wide range of concentrations and a broad array of chemical attributes. Organism absorb heavy metals, essential or not, from the surrounding environment with the potential to accumulate them within their bodies. Certain heavy metals, such as copper and zinc, are essential biological micronutrients. All heavy metals are potential toxins at some concentration, the non - essential metals e.g. mercury, lead and cadmium are particularly toxic at relatively low concentrations. Heavy metals exert toxic effects at some concentration that have metal remnant in their wastes and by non-point source surface runoff [12]. It is well known that

Table 2. Participation of Pollutants Load from Turkish Coast of the Black Sea [9]

No	Stations	Total Load ($t.yr^{-1}$) %
1	Samsun	20.6
2	Trabzon	39.1
3	Giresun	56.0
4	Zonguldak	68.4
5	Ordu	76.2
6	Bafay vegetable liquid oil plant. (Samsun)	81.8
7	Rize	86.1
8	Bul-Co fish plant (Giresun)	89.3
9	Sinop	91.3
10	Bartın	92.9
11	SEKA paper plant (Giresun)	94.0
12	Slaughterhouse of meat and fish Association (Sakarya)	95.1
13	Artvin	96.0
14	Kastamonu	96.8
15	Bolu	97.3
16	Dogan Biscuit and Chocolate (Sakarya)	97.8
17	SEKA Paper Plant (Zonguldak)	98.1
18	Caroglu Slaughterhouse (Sakarya)	98.3
19	Koy-Tur Chicken Plant (Sakarya)	98.5
20	Mankap Vegetable Liquid Oil Plant (Zonguldak)	98.7
21	Karsu fish bait Plant (Trabzon)	98.8
22	Bekar Textile Plant (Samsun)	98.9
23	Akova Flour Plant (Sakarya)	99.0
24	Dokap Flour Plant (Zonguldak)	99.1
25	Sinop Textile Plant	99.2
26	Acid Industry. - Ethyl Alcohol Plant (Sakarya)	99.2
27	İpek Flour Plant (Zonguldak)	99.3
28	Elif Flour Plant (Trabzon)	99.4
29	Cargill Flour Plant (Sakarya)	99.5
30	Ketas Food Make with Milk Plant (Trabzon)	99.5
31	Ak A. Textile Plant (Zonguldak)	99.6
32	Ahenk Turkish Delight and Sugaring Plant (Samsun)	99.7
33	Kebir Food Make with Milk Plant (Trabzon)	99.7
35	Ansan Beverages Plant (Trabzon)	99.3
34	Camadan Flour Plant (Samsun)	99.3
36	Ünsan Flour Plant (Ordu)	99.9
37	Entas Chicken Plant (Sakarya)	99.9
38	Terme Metal Industry Plant (Samsun)	99.9
39	Yıldız Resine Plant (Samsun)	99.9
40	Özkasapoglu Feed Plant (Zonguldak)	100.0
41	Bizon Lumber Plant (Sakarya)	100.0

non-essential metals are very toxic to animals, so that the metal concentrations are regulated for human health and drinking water [13].

The pollution levels of the aquatic environment by heavy metals can be estimated by analyzing water, sediments and marine organisms. The levels of heavy metals in marine

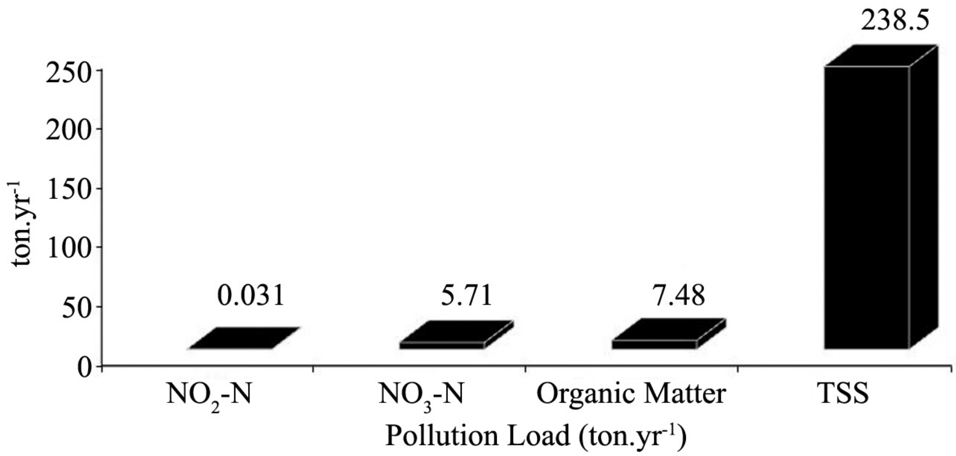

Fig. (3). Organic matter, suspended solid matter, nitrite nitrogen and nitrate nitrogen loads from Sinop city domestic discharge point [7].

organisms are often higher than in other constituents of marine environment because their ability to concentrate heavy metals from their habitat and it is important to know the changes in metal levels in marine ecosystem [13].

Metal concentrations are controlled by some solubility methods of their compounds with the ions ordinarily present in the sea. Some of the heavy metals naturally occurring in the marine environment are essential for normal growth. Thus, these organisms play a key role in the analytical schemes.

Most trace element pollution problems involve metals and rivers appear to be the most important transport mechanisms of heavy metals in the sea.

Table **4** shows that annual discharges of heavy metals in rivers and streams resulted from evaluation of inventories in the Black Sea region.

Table 3. Comparison of Data Related to Years in Black Sea Turkish Coasts (TSS: Total Suspended Solid, DO: Dissolved Oxygen)

Comparison of July Data	[10]	[11]	[5]	[7]
Salinity (‰)	17.5	13.8		15
pH	7.9	7.15		7.84
TSS ($mgr.l^{-1}$)	22		148.99	656
DO ($mgr.l^{-1}$)	6	5.17		2.8
Temperature (^0C)	26.2	22.81		25
Organic matter ($mgr.l^{-1}$)	9	7.22		9.12
Nitrate nitrogen ($mgr.l^{-1}$)	1.1		1.82	1.43
Nitrite nitrogen ($mgr.l^{-1}$)	0.019		0.032	0.04

The seasonal results of heavy metal concentrations sampling points through the Sinop, Samsun and Ordu cities in the Middle Black Sea Region of Turkey during May 2000-October 2001 (Table **5**).

Kizilirmak and Yesilirmak, the two most important rivers of Black Sea Region, and a lot of big and little industries (food, cement, fertilizer, pesticides, resin, plastic, textile, cigarette manufacturing) exist in the Middle Black Sea Region of Turkey. Most of these factories have no treatment plant and they have potential to create local pollution problem [14]. The two important iron and steel factories of Turkey exist in the western part of the Black Sea region. On the other hand, the eastern part of the Black Sea Region has no important industrial factories, but only hazelnut facilities, floor manufacturing and fish-oil factories. Besides small industrial activities, pulp and paper factory present in this region is one of the important industries. Heavy metals in marine environment causes by especially discharge of industrial pollutants.

The Black Sea has historically been one of the most biological productive regions in the world. According to investigations, these biological speciality losses year by year with the effects of pollution in Black Sea.

Most trace element pollution problems involve metals. Terms of trace elements identified a large group of metallic elements which are present in living organisms in limited amounts. Cadmium, mercury, chrome and lead are metals without any established biological function and include the more important contaminants in aquatic environment [15].

Anthropogenic activities such as agriculture, mining, industrial processing of ores and the use of metal components has resulted in increased inputs of heavy metals into the sea. Coastal urban centres are also sources large amounts of matter introduced into marine environment.

Marine organisms can be used as monitors to give information on concentrations of heavy metal. In this review these metal concentrations were reviewed in the Turkish coastal of the Black Sea. Table **6** shows the concentration of heavy metals in marine biota collected from Turkish Black Sea coast.

Sinop Peninsula is located on the Southern coasts of the Black Sea. Balkas *et al.* [3] pointed out that the oceanography of the Black Sea has been relatively well documented. The same, however, cannot be said for documentation of the levels of marine pollution and the regions that are affected by various human activities, especially in coastal areas [3]. According to the available data the heavy metal pollution increased in marine organisms of the Turkish Black Sea coast during the years. The Black

Table 4. Annual Load of Heavy Metals in Rivers and Streams Along the Black Sea Coast of Turkey [14]

Rivers and Streams	Discharge ($km^3.yr^{-1}$)	Total Chrome ($t.yr^{-1}$)	Cadmium ($t.yr^{-1}$)	Lead ($t.yr^{-1}$)
Sakarya River	6.02	128.595	781.144	-
Cark Stream	0.31	4.086	12.867	-
Melen Stream	1.57	95.96	28.726	-
Alapli Stream	0.27	-	11.520	13.927
Gülüc Stream	1.19	-	20.378	-
Catalagzi Stream	0.13	2.627	3.115	-
Kozlu Stream	0.02	-	0.053	-
Zonguldak Stream	0.13	0.791	0.885	-
Filyos Stream	3.22	-	262.824	-
Bartin Stream	0.36	16.230	0.773	18.196
Kizilirmak River	7.39	427.101	1234.239	722.303
Kurtun Stream	0.16	22.588	2.084	1.239
Mert River	1.06	19.214	98.761	-
Yesilirmak River	10.26	2549.228	1505.295	-
Milic Stream	0.43	-	3.067	0.459
Civil Stream	0.6	3.140	0.117	-
Melet River	0.83	128.298	124.780	5.045
Aksu Stream	0.97	3.608	8.326	-
Fol Stream	0.20	-	-	-
Sögütlüdere Stream	0.12	-	2.633	-
Stream of Degirmen	0.87	-	-	-

Table 5. The Seasonal Results of Heavy Metal Concentrations of Shore and Off-Shore Sampling Points through the Sinop, Samsun and Ordu Cities in the Middle Black Sea Region of Turkey During May 2000-October 2001 [14]

Sampling	Sampling Date and Pollutant Level ($\mu g.M^{+2}.l^{-1}$)																							
	May 2000						October 2000						April 2001						October 2001					
Point	Cd	Pb	Zn	Ni	Cu	Mn	Cd	Pb	Zn	Ni	Cu	Mn	Cd	Pb	Zn	Ni	Cu	Mn	Cd	Pb	Zn	Ni	Cu	Mn
Sinop Peninsula-A	13	-	42	-	-	152	-	-	-	-	200	160	34	30	-	-	-	-	x	x	x	x	x	x
B	x	x	x	x	x	x	4	-	-	-	180	-	50	-	538	-	-	-	x	x	x	x	x	x
Kizilirmak -A	13	-	44	-	-	127	-	-	-	-	110	-	-	25	-	12	-	-	-	307	-	81	23	99
B	x	x	x	x	x	x	6	-	-	-	180	-	-	-	-	60	-	-	-	-	-	94	15	142
Kurtun Stream-A	-	-	35	-	-	135	6	261	-	-	200	-	17	-	338	-	-	-	-	148	11	12	20	224
B	x	x	x	x	x	x	-	250	-	-	250	140	-	130	-	-	-	-	-	67	-	31	5	166
Samsun Harbour-A	-	-	26	-	-	127	6	-	-	-	200	-	39	20	-	-	6	-	-	34	135	-	26	163
B	x	x	x	x	x	x	-	-	-	-	210	-	35	-	549	133	36	18	-	-	21	56	-	163
Mert River-KBI, TÜGSAS-A	30	-	13	-	-	157	-	218	-	-	240	150	20	20	207	78	-	33	-	171	3	31	20	252
B	x	x	x	x	x	x	-	-	-	-	-	40	41	10	-	-	12	56	-	91	-	10	-	250
Yesilirmak-A	18	-	-	-	-	178	8	-	-	-	-	30	-	-	-	24	3	113	-	-	555	-	3	244
B	x	x	x	x	x	x	-	-	-	-	190	60	67	10	7	-	12	54	-	262	231	-	-	197
Melet river-A	25	-	11	-	-	191	-	164	-	-	310	-	-	-	-	-	26	98	x	x	x	x	x	x
B	x	x	x	x	x	x	-	-	-	-	140	-	26	163	-	30	-	69	x	x	x	x	x	x

A: Shore (500 m from edge); B: Off-shore (5555 m^{-3} mile from edge); x; not sampled; -: not detected.

Sea receives large quantities of unregulated and uncontrolled fresh water with drawl for irrigation purposes, hydro and thermal power generation and the use of coastal areas for permanent human settlements; shipping; and untreated domestic, industrial and agricultural wastes drain into the sea *via* the rivers or directly: In spite of this, research on the heavy metal pollution in marine biota of the Black Sea is very limited. Moreover, corresponding data on the pollution state of the Black Sea off Turkey are rare.

The data presented in Table **6** were compared with the guidelines [45, 46] for heavy metals in fish and shellfish.

Table 6. Heavy Metal Concentrations in Marine Biota from Sinop Coast of the Black Sea (Expressed in µg Metal g^{-1} Wet wt) (BS: Black Sea, EBS: Eastern Black Sea)

MACROALGAE	Heavy Metals								
Chlorophyta	**Area**	**Iron**	**Zinc**	**Nickel**	**Copper**	**Manganese**	**Lead**	**Cadmium**	**Cobalt**	**Ref.**
*Chaetomorpha linum**	Sinop	1044±15	7.7±0.3	12.3±1.6	3.4±0.47	17.2±1.9	2.1±0.1	0.03±0.1	0.37±0.06	[16]
*Enteromorpha intestinalis**	Rize	2747±240	12.4±1.1	3.16±0.21	9.08±0.51	48.1±3.2	101.10^{-3}±76	27.10^{-3}±2.1	6.10^{-3}±0.43	[17]
*Enteromorpha intestinalis**	Trabzon	343±21	9.50±0.65	4.62±0.32	7.14±0.46	60.6±5.2	59.10^{-3}±47	11.10^{-3}±1.1	1.10^{-3}±0.15	[17]
*Enteromorpha intestinalis**	Sinop	585±43	3.64±0.23	2.75±0.20	1.70±0.10	37.6±2.5	67.4±5.2	1.10^{-3}±0.10	6.10^{-3}±0.41	[17]
*Enteremorpha linza**	Sinop	-	13-78	16-198	6-89	-	17-182	0.11-0.90	-	[18,19]
*Enteremorpha linza**	Sinop	218-811	18.72-70	24.12-148	10.65-52.35	85-185	17.32-183	0.15-0.90	-	[20]
*Enteremorpha linza**	Sinop	2656±22	7.1±0.5	24.4±3.5	2.6±0.18	50.1±1.1	9.1±0.2	0.06±0.1	0.85±0.17	[16]
*Ulva lactuca**	Sinop	158-445	15-127	13-101	15-84	8-32	10-90	0.15-1.88	-	[20]
*Ulva lactuca** (unwashed samples)	Sinop	28.7±2.8	69.8±10.5	42.4±5.5	25.6±2.7	594±53	52±6.4	1.7±0.20	-	[21]
*Ulva lactuca** (washed samples)	Sinop	18.4±2.0	52.7±9.1	20.33±3.5	17.5±1.8	328±34	36.6±6.2	1.0±0.13	-	[21]
*Ulva lactuca**	Sinop	1127±6	72.75±0.2	8.97±0.42	9.93±0.10	82.18±0.57	<0.5	<0.02	<0.05	[22]
*Ulva lactuca**	Sile	550±2	9.6±0.1	<0.1	3.87±0.05	21.8±0.2	<0.1	<0.02	<0.05	[16]
*Ulva lactuca**	Sinop	357±1	394.4±1.6	<0.1	7.7±0.09	12.5±0.1	<0.1	<0.02	<0.05	[16]
*Ulva lactuca**	Rize	425±24	15.6±1.3	2.16±0.13	9.52±0.55	17.2±1.2	135.10^{-3}±50	5.10^{-3}±0.42	2.10^{-3}±0.16	[17]
*Ulva lactuca**	Trabzon	277±20	6.50±0.32	2.06±0.11	4.95±0.15	9.98±0.67	1.10^{-3}±0.10	4.10^{-3}±0.20	6.10^{-3}±0.47	[17]
*Ulva lactuca**	Sinop	306±25	19.1±1.6	2.72±0.14	6.78±0.42	11.7±1.1	22.10^{-3}±2.1	21.10^{-3}±1.9	3.10^{-3}±2.5	[17]
*Ulva rigida**	Sile	235±15	3.9±0.3	31±1.5	2.53±0.09	9.5±0.3	1.3±0.1	0.10±0.1	0.32±0.06	[16]
Phaeophyta										
*Cystoseira barbata**	Sinop	-	12-48	16-254	10-68	-	14-228	0.11-0.80	-	[18]
*Cystoseira barbata** (washed samples)	Sinop	33±3.5	44±6	25±3	10±1.5	547±78	19±2.4	1.2±0.11	-	[21]
*Cystoseira barbata** (unwashed samples)	Sinop	49±4.9	55±6	35±3.5	16±2	837±113	30±3.2	2.2±0.21	-	[21]
*Cystoseria barbata**	Sinop	427±3	111.4±0.1	10.35±0.05	8.62±0.08	79.95±0.32	<0.5	<0.02	<0.05	[22]
*Cystoseria barbata**	Sile	133±11	21.7±0.1	5.7±0.1	3.43±0.12	12.0±0.2	1.4±0.1	0.78±0.1	<0.05	[16]
*Cystoseria barbata**	Sinop	463±2	6.5±0.9	4.7±0.5	1.7±0.02	33.5±3	3.5±0.4	0.09±0.1	1.78±0.05	[16]
*Cystoseria barbata**	Sinop	242±15	6.62±0.26	2.05±0.14	2.47±0.18	14.9±1.3	4.6.10^{-3}±0.32	0.5.10^{-3}±0.04	9.10^{-3}±0.60	[17]
Rhodophyta										
*Antithamnion cruciatum**	Rize	1524±75	16.2±1.4	2.45±0.17	6.83±0.34	43.5±3.3	27.10^{-3}±100	17.10^{-3}±1.4	27.10^{-3}±2.2	[17]
*Antithamnion cruciatum**	Trabzon	2873±150	11.6±0.8	2.80±0.23	7.74±0.26	78.1±4.5	14.10^{-3}±10	4.10^{-3}±0.23	4.10^{-3}±0.32	[17]
*Antithamnion cruciatum**	Sinop	3949±200	48.9±2.8	10.3±0.9	17.1±0.9	285±10	39.10^{-3}±250	44.10^{-3}±3.5	81.10^{-3}±5.3	[17]
*Ceramium rubrum**	Sinop	4988±10	58±0.1	11.2±0.3	16.8±0.11	249.5±1	<0.1	1.62±0.1	4.36±0.12	[16]
*Ceramium rubrum**	Rize	1479±45	16.9±1.3	3.53±0.17	7.17±0.45	31.2±2.4	9.2x10^{-3}±0.52	9.10^{-3}±0.50	7.10^{-3}±0.50	[17]
*Ceramium rubrum**	Trabzon	1953±65	12.5±0.9	3.10±0.24	7.28±0.32	74.3±4.6	534.10^{-3}±42	0.6x10^{-3}±0.05	5.10^{-3}±0.45	[17]
*Ceramium rubrum**	Sinop	996±50	41.6±2.3	2.72±0.22	6.55±0.45	92.5±6.7	83.8x10^{-3}±5.5	0.5x10^{-3}±0.04	1.10^{-3}±0.8	[17]
*Corallina elongate**	Sinop	99±6	26.4±2.4	8.29±0.55	3.84±0.17	27.7±2.2	1065.10^{-3}±68	4.10^{-3}±0.32	7.10^{-3}±0.55	[17]
*Corallina granifera**	Sile	231±21	8.9±0.3	4.1±0.2	0.77±0.01	17.9±2.4	2.2±0.1	0.08±0.1	1.92±0.19	[16]
*Corallina mediterranea**	Sile	595±3	43.3±0.7	<0.1	3.1±0.09	64.7±0.2	<0.1	<0.02	<0.05	[16]
*Corallina mediterranea**	Sinop	1508±2	19.1±0.1	<0.1	3.9±0.07	56.7±0.2	<0.1	<0.02	<0.05	[16]
*Gelidium latifolium**	Sinop	618±26	64.8±5.2	1.73±0.13	6.84±0.44	77.6±4.7	14.10^{-3}±90	12.10^{-3}±1.1	16.10^{-3}±1.3	[17]

(Table 6) contd…..

MACROALGAE	**Heavy Metals**									
Rhodophyta	**Area**	**Iron**	**Zinc**	**Nickel**	**Copper**	**Manganese**	**Lead**	**Cadmium**	**Cobalt**	**Ref.**
*Phyllophora nervosa**	Sile	359±37	24±1.2	70±0.3	5.46±0.13	75.8±1.1	1.9±0.1	0.12±0.1	3.12±0.26	[16]
*Porphyra umbilicalis**	Rize	784±24	22.4±1.1	4.04±0.15	3.93±0.10	19.1±1.2	648.10^{-3}±30	$23.6x10^{-3}$±1.5	42.10^{-3}±3.4	[17]
*Porphyra umbilicalis**	Trabzon	330±16	22.8±1.2	0.27±0.01	4.92±0.23	22.3±2.1	$6.1x10^{-3}$±0.25	$11.4x10^{-3}$±0.6	$6. 10^{-3}$±0.43	[17]
*Porphyra umbilicalis**	Sinop	114±10	19.4±1.5	2.24±0.20	4.19±0.15	13.3±0.8	282.10^{-3}±15	$3.4x10^{-3}$±0.24	$7. 10^{-3}$±0.64	[17]
*Phyllophora nervosa**	Sinop	1359±26	54.4±0.3	70.6±1.8	20.1±0.12	364.6±1.8	<0.1	<0.02	9.08±0.45	[16]
*Phyllophora nervosa**	Sinop	1559±65	48.6±1.8	36.2±2.2	14.1±0.7	261±17	22.10^{-3}±78	4.10^{-3}±0.33	49.10^{-3}±3.5	[17]
*Pterocladia capillacea**	Sile	288±1	86.2±0.5	<0.1	5.3±0.20	52.1±0.2	<0.1	1.36±0.1	<0.05	[16]
*Pterocladia capillacea**	Sinop	407±5	176.8±1.1	<0.1	<0.03	10.8±0.7	<0.1	<0.02	<0.05	[16]
PHANEROGAM										
Angiospermae										
*Cymodocea nodosa**	Sinop	191-1256	27.43-68.32	7.63-44.92	4.94-31.27	59-315	4.95-18.97	0.19-0.98	-	[20]
*Cymodocea nodosa** (washed samples)	Sinop	626±106	40.4±3.4	23.7±3.66	12.3±1.45	157±20	10.5±2.48	0.08±0.02	-	[23]
*Cymodocea nodosa** (unwashed samples)	Sinop	1230±148	56±3.9	40.3±5.2	18.8±2.10	219±21	21±5.1	0.16±0.03	-	[23]
CRUSTACEA										
Carcinus aestuarii	Sinop	1.32-4.72	3.66-7.19	0.15-1.55	0.17-4.40	0.03-0.43	0.25-0.96	0.03-0.07	-	[13]
Eriphia verrucosa	Sinop	2.54±0.78	10.1±1.55	1.42±0.43	2.61±0.38	0.17±0.022	0.44±0.08	0.18±0.041	-	[24]
Idotea baltica	Sinop	2.02-8.21	11.12-17.93	4.28-10.19	5.12-8.71	14.81-29.12	0.29-0.91	0.28-0.82	-	[20]
Idotea baltica	Sinop	4.1±1.12	14±1.38	7.7±0.71	6.7±0.68	21.9±3.26	0.61±0.09	0.60±0.09	-	[23]
Palaemon elegans	Sinop	2.13-4.71	7.24-15.41	1.19-3.84	2.44-3.48	0.19-1.42	0.38-1.78	0.17-0.73	-	[21]
MOLLUSC										
Mytilus galloprovincialis	Sinop	-	1.023-8.946	0.050-2.797	0.039-1.438	-	1.36-0.32	0.075-0.863	-	[18]
Mytilus galloprovincialis	Igneada	-	-	-	0.21-2.76	-	0.05-0.12	-	-	[25]
Mytilus galloprovincialis	Inebolu	-	-	-	1.96-13.7	-	0.12-1.3	-	-	[25]
Mytilus galloprovincialis	Sakarya	-	-	-	0.17-0.56	-	0.0-0.02	-	-	[25]
Mytilus galloprovincialis	Zonguldak	-	-	-	0.33-3.63	-	0.1-0.84	-	-	[25]
Mytilus galloprovincialis	Sinop	-	1.58-7.28	-	0.10-1.89	-	0.11-1.18	0.03-0.27	-	[26]
*Mytilus galloprovincialis**	Amasra	355±1	512.5±2.6	4.17±0.25	7.26±0.02	10.11±0.05	2.60±1.1	6.44±0.01	2.68±0.11	[22]
*Mytilus galloprovincialis**	Sinop	598±7	256.4±1.3	4.02±0.19	8.01±0.02	22.8±0.11	0.31±0.19	1.79±0.01	1.79±0.01	[22]
*Mytilus galloprovincialis**	Rize	511±3	78.12±0.15	24.07±0.26	11.52±0.02	5.66±0.07	<0.05	<0.02	5.36±0.33	[22]
*Mytilus galloprovincialis**	Samsun	-	-	-	-	-	1.085±0.065	0.41	-	[27]
*Mytilus galloprovincialis**	Sinop	-	-	-	-	-	0.26±0.03	0.47±0.01	-	[27]
*Mytilus galloprovincialis**	Sinop	-	24.862-519.701	-	4.301-10.96	-	-	0.305-4.878	-	[28]
*Mytilus galloprovincialis**	Samsun	-	317.25	43.8	23.35	46.9	0.95	<0.02	-	[12]
*Mytilus galloprovincialis**	Samsun	-	328.05	<0.05	13.1	66.35	<0.05	<0.02	-	[12]
*Mytilus galloprovincialis**	Samsun	-	396.5	0.6	12.85	73.05	108.6	<0.02	-	[12]
*Mytilus galloprovincialis**	Samsun	-	312.15	2.55	11.75	49.15	14.7	<0.02	-	[12]
*Mytilus galloprovincialis**	Camburnu	3340±165	630±32	6.0±0.3	190±6	59±3	21.0±1.0	4.0±0.2	-	[29]
*Mytilus galloprovincialis**	Rize	2390±72	600±30	1.0±0.1	260±8	54±3	5.0±0.3	3.0±0.2	-	[29]
*Mytilus galloprovincialis**	Rize	1400±42	340±10	3.0±0.2	90±3	41±2	9.0±0.5	3.0±0.2	-	[29]
*Mytilus galloprovincialis**	Cayeli	4030±121	230±7	3.0±0.2	130±4	46±2	5.0±0.2	2.0±0.1	-	[29]

(Table 6) contd…..

MOLLUSC	Heavy Metals								
	Area	**Iron**	**Zinc**	**Nickel**	**Copper**	**Manganese**	**Lead**	**Cadmium**	**Cobalt**	**Ref.**
*Mytilus galloprovincialis**	Hopa	1150±35	180±5	2.0±0.1	130±4	47±2	3.0±0.1	3.0±0.2	-	[29]
Patella caerula	Sinop	-	0.128-0.770	0.111-1.944	0.142-0.998	-	0.265-2.625	0.042-0.391	-	[19]
Patella caerula	Sinop	3.81-9.62	0.25-0.95	0.76-1.90	0.23-0.92	7.73-15.38	0.49-2.72	0.19-0.48	-	[20]
Patella caerula	Sinop	3.19-8.84	1.43-4.72	0.61-2.31	0.47-1.64	0.12-0.58	0.02-0.057	0.02-0.049	-	[30]
Patella caerula	Sinop	3.19-8.84	1.43-4.72	0.61-2.31	0.47-1.64	0.12-0.58	0.02-0.057	0.02-0.049	-	[31]
Rapana venosa	Sinop	-	0.215-0.84	0.259-0.604	0.214-1.603	-	0.260-0.979	0.156-0.550	-	[32]
Rapana venosa	Fatsa	199±37	49±6	2.17±0.6	57±8	1.9±0.8	3.2±1.2	1.0±0.5	-	[33]
Rapana venosa (muscle)*	Persembe	98±1	44.6±0.1	<0.01	35.02±0.14	3.48±0.03	<0.5	0.37±0.03	0.3±0.05	[22]
Rapana venosa (muscle)*	Rize	99±2	68.3±0.3	5.83±0.92	57.83±0.19	3.61±0.09	<0.5	<0.02	6.9±4.4	[22]
*Rapana venosa**	Sinop	-	-	-	-	-	0.1435±0.005	4.63±0.14	-	[27]
*Rapana venosa**	Sinop	-	2.678-104.025	-	10.458-79.167	-	-	0.273-11.535	-	[28]
FISHES										
Alosa bulgarica	Sinop	1.61-9.14	1.65-4.48	0.84-2.73	0.26-0.52	0.18-0.44	0.18-0.74	0.19-0.47	-	[34]
Alosa bulgarica (liver)	Sinop	9.14±1.307	4.48±4.16	2.73±0.34	0.52±0.072	0.44±0.052	0.74±0.125	0.47±0.080	-	[24]
Alosa bulgarica (muscle)	Sinop	1.61±0.307	1.65±0.17	0.84±0.202	0.26±0.056	0.18±0.032	0.18±0.028	0.19±0.056	-	[24]
*Alosa caspia**	Samsun	16.08±1.15	20.41±1.75	-	2.93±0.18	1.57±0.24	0.52±0.16	0.35±0.05	-	[35]
Belone belone (muscle)	Sinop	25±4.1	7.76±1.37	1.22±0.14	0.54±0.05	0.95±0.15	0.51±0.08	0.05±0.007	-	[13]
*Clupea sprattus**	Samsun	25.48±3.18	9.50±0.60	-	1.79±0.062	2.82±0.24	0.74±0.11	0.30±0.15	-	[35]
Engraulis encrasicolus	Inebolu	-	-	-	0.68-1.33	-	0.06-0.06	-	-	[25]
*Engraulis encrasicolus** (muscle)	BS	23.4±13.4	50.7±8.3	2.17±0.34	3.39±0.49	2.44±1.87	2.51±0.09	0.27±0.06	0.25±0.15	[36]
Engraulis encrasicolus (liver)	Sinop	9.89±1.73	7.30±1.12	3.90±0.62	1.76±0.08	1.93±0.05	1.87±0.08	0.112±0.009	-	[37]
Engraulis encrasicolus (muscle)	Sinop	4.87±1.15	3.55±0.68	1.51±0.22	0.69±0.06	0.58±0.02	0.78±0.04	0.025±0.005	-	[37]
*Engraulis encrasicolus**	Amasra	44±1	35.7±0.4	<0.01	2.21±0.11	2.23±0.03	<0.05	0.10±0.01	0.40±0.18	[22]
*Engraulis encrasicolus**	Samsun	10.45±1.63	17.38±2.01	-	1.94±0.10	1.96±0.12	0.38±0.02	0.20±0.03	-	[35]
*Engraulis encrasicolus**	BS	95.6 ± 8.1	40.2 ± 3.2	2.63 ± 0.15	0.95 ± 0.08	5.61 ± 0.40	0.33 ± 0.01	0.65 ± 0.04	-	[38]
Engraulis encrasicolus (muscle)	Trabzon	44.4±9.23	10.8±1.29	1.51±0.26	0.88±0.10	0.76±0.13	0.12±0.03	0.03±0.01	0.07±0.03	[40]
Engraulis encrasicolus (liver)	Trabzon	188±76.9	14.1±2.31	2.87±0.78	1.08±0.20	1.11±0.20	0.47±0.13	0.07±0.02	0.19±0.05	[40]
Engraulis encrasicolus (muscle)	Sinop	35.7±9.81	10.6±0.88	0.63±0.19	1.12±0.16	0.70±0.12	0.27±0.05	0.02±0.00	0.06±0.01	[40]
Engraulis encrasicolus (liver)	Sinop	78±11.5	12.5±0.96	5.10±0.59	1.27±0.20	1.53±0.36	0.74±0.19	0.06±0.01	0.11±0.02	[40]
Engraulis encrasicolus (muscle)	Bartın	35.9±12.1	45.6±22.1	0.51±0.12	8.58±2.15	2.82±1.12	0.87±0.40	0.06±0.02	0.08±0.01	[40]
Engraulis encrasicolus (liver)	Bartın	124±19.9	145±38	1.19±0.10	30.7±7.54	9.67±2.65	3.38±0.55	0.24±0.09	0.53±0.19	[40]
*Engraulis encrasicolus**	BS	18.0 ±2.697	25.416 ± 3.664	0.34 ±0.106	-	1.390 ± 0.326	0.329 ± 0.302	0.124 ± 0.018	-	[39]
Merlangius merlangus euxinus	Sinop	-	-	-	0.12-2.00	-	0.033-1.76	-	-	[41]
Merlangius merlangus euxinus (liver)	Sinop	18.68±2.98	9.18±1.98	5.12±0.61	1.87±0.11	2.29±0.38	1.81±0.07	0.110±0.009	-	[37]
Merlangius merlangus euxinus (muscle)	Sinop	9.04±1.52	4.36±0.71	2.61±0.51	0.88±0.08	1.20±0.14	0.74±0.06	0.025±0.004	-	[37]

(Table 6) contd…..

	Heavy Metals								
FISHES	**Area**	**Iron**	**Zinc**	**Nickel**	**Copper**	**Manganese**	**Lead**	**Cadmium**	**Cobalt**	**Ref.**
*Merlangius merlangus euxinus**	EBS	14.137	15.322	-	2.71	-	1.078	0.601	-	[42]
*Merlangius merlangus euxinus**	Samsun	-	-	-	-	-	<0.05	<0.02	-	[27]
*Merlangius merlangus euxinus**	Sinop	-	-	-	-	-	<0.05	<0.02	-	[27]
*Merlangius merlangus euxinus** (muscle)	Sinop	57.2	38.47	0.312	18.54	0.675	2.184	0.355	-	[31]
*Merlangius merlangus euxinus**	Sinop	-	8.862-163.277	-	0.913-8.952	-	-	-	-	[28]
Merlangus merlangus	Kastamonu	-	-	-	0.62-3.25	-	0.02-0.11	-	-	[25]
Merlangus merlangus	Zonguldak	-	-	-	0.37-7.72	-	0.05-2.26	-	-	[25]
*Merlangus merlangus**	Perşembe	57±1	43.1±0.1	<0.01	1.86±0.04	3.56±0.09	<0.05	<0.02	<0.05	[22]
*Merlangus merlangus**	Rize	46±1	30.2±0.1	<0.01	4.54±0.11	2.22±0.04	<0.05	<0.02	<0.05	[22]
*Merlangus merlangus**	BS	2.5	3.3	-	1.3	-	0.088	0.0131	-	[43]
*Merlangus merlangus**	BS	104 ± 9.8	48.6 ± 3.9	1.92 ± 0.10	1.25 ± 0.10	1.96 ± 0.10	0.93 ± 0.07	0.55 ± 0.04	-	[38]
*Merlangus merlangus**	BS	4.48 ±0.441	6.029 ± 0.545	1.36 ±0.50	-	0.07 ± 0.024	0.502 ± 0.104	0.192 ±0.02	-	[39]
*Mugil cephalus**	BS	82.7 ± 5.6	40.2 ± 3.3	5.68 ± 0.40	1.26 ± 0.10	4.21 ± 0.24	0.61 ± 0.04	0.45 ± 0.03	-	[38]
Mugil spp. (muscle) *	Sinop	231.5	104.4	14.52	13.22	109.3	1.367	0.183	-	[31]
Mugil spp.* (liver)	Sinop	308.3	95.73	7.688	62.39	9.55	0.183	0.365	-	[31]
*Mullus barbatus**	Trabzon	39.0±1.0	11.5±3.5	-	9.10±5.9	0.40±0.13	6.86±0.26	<0.1	0.06±0.03	[44]
Mullus barbatus (liver)	Sinop	8.85±1.52	3.79±0.90	4.89±0.87	1.49±0.10	0.95±0.03	0.89±0.23	0.070±0.006	-	[37]
Mullus barbatus (muscle)	Sinop	4.18±0.81	2.42±0.27	2.26±0.59	0.76±0.07	0.33±0.02	0.28±0.06	0.023±0.002	-	[37]
*Mullus barbatus**	Samsun	-	-	-	-	-	0.0815±0.003	<0.02	-	[27]
*Mullus barbatus**	Sinop	-	-	-	-	-	0.051±0.0005	<0.02	-	[27]
*Mullus barbatus** (muscle)	Sinop	74.3	29.79	0.458	26.98	0.683	1.276	0.227	-	[31]
*Mullus barbatus** (viscera)	Sinop	103.6	33.88	1.015	4.03	2.354	2.769	0.678	-	[31]
*Mullus barbatus**	BS	4.5	4.3	-	0.01	-	0.077	0.017	-	[43]
*Mullus barbatus**	Sinop	--	1.424-63.290	-	0.380-2.714	-	-	-	-	[28]
*Mullus barbatus**	BS	163 ± 12	106 ± 9.1	4.34 ±0.35	0.98 ± 0.07	6.54 ± 0.50	0.84 ± 0.07	0.45 ± 0.04	-	[38]
*Mullus barbatus**	BS	21.2 ±1.476	7.573 ± 0.389	0.658 ±0.33	-	0.005 ± 0.018	0.727 ± 0.141	0.208 ± 0.017	-	[39]
*Mullus surmelutus**	Sinop	21.3±4.3	28.0±9.0	-	4.20±1.8	0.42±0.13	<0.5	0.42±0.09	0.32±0.08	[44]
Platichthys flesus		-	-	-	-	-	<0.05	0.88±0.01	-	[27]
Pomatomus saltator (muscle)	Sinop	21±3.7	9.40±1.48	1.20±0.09	0.58±0.08	0.96±0.16	0.55±0.08	0.05±0.004	-	[13]
*Pomatomus saltator** (meat)	Sinop	421.3	82.2	20.22	35.6	69.02	2.253	0.343	-	[31]
*Pomatomus saltator**	BS	68.6 ± 5.3	35.4 ± 3.2	3.89 ± 0.30	1.83 ± 0.10	1.28 ± 0.10	0.38 ± 0.02	0.60 ± 0.05	-	[38]
*Psetta maxima**	Trabzon	31.0±1.7	38.6±4.1	-	4.2±0.6	1.25±0.39	2.38±0.09	0.30±0.07	0.59±0.16	[44]
*Psetta maxima**	Igneada	46.7±26.3	19.7±2.5	-	6.8±4.2	0.48±0.15	1.47±0.05	0.57±0.13	1.31±0.36	[44]
*Psetta maxima** (liver)	Sinop	373.6	125.8	25.98	14.22	126.1	1.037	0.268	-	[31]
*Psetta maxima** (meat)	Sinop	113.3	170.5	23.32	26.14	125.4	2.72	0.272	-	[31]
*Raja clavata**	Sinop	-	6.601-35.873	-	0.496-9.356	-	-	-	-	[28]
*Sarda sarda**	Samsun	9.52±0.81	11.20±1.44	-	1.28±0.14	1.06±0.27	0.22±0.04	0.09±0.02	-	[35]
*Sarda sarda**	BS	73.5 ± 6.3	48.7 ± 3.7	-	0.84 ± 0.05	2.68 ± 0.22	0.76 ± 0.05	0.90 ± 0.07	-	[38]

(Table 6) contd…..

		Heavy Metals								
FISHES	**Area**	**Iron**	**Zinc**	**Nickel**	**Copper**	**Manganese**	**Lead**	**Cadmium**	**Cobalt**	**Ref.**
*Scomber scombrus** (liver)	Sinop	209.4	71.48	4.666	52.37	22.61	6.38	0.891	-	[31]
*Scomber scombrus** (meat)	Sinop	120.3	69.53	1.684	3.62	9.44	2.948	0.172	-	[31]
*Scopthalmus maeoticus**	Sinop	-	-	-	-	-	<0.05	<0.02	-	[27]
*Solea vulgaris** (meat)	Sinop	52.2	93.79	2.343	11.58	3.73	3.571	0.217	-	[31]
*Solea vulgaris** (viscera)	Sinop	127	67.97	2.553	29.72	4.621	2.006	0.504	-	[31]
*Spicara smaris**	Sinop	-	6.234-57.743	-	0.610-4.161	-	-	-	-	[28]
Spicara smaris (muscle)	Trabzon	32.2±8	12.2±2.63	0.25±0.07	0.83±0.10	0.39±0.05	0.15±0.04	0.02±0.00	0.04±0.01	[40]
Spicara smaris (liver)	Trabzon	75.7±14.8	18.5±2.38	5.71±1.04	1.86±0.22	0.72±0.09	1.01±0.19	0.23±0.07	0.08±0.03	[40]
Trachurus trachurus	Igneada	-	-	-	0.36-0.68	-	-	-	-	[25]
Trachurus trachurus	Inebolu	-	-	-	1.24-2.8	-	0.02-0.06	-	-	[25]
Trachurus trachurus	Sakarya	-	-	-	0.06-0.24	-	0.27-0.66	-	-	[25]
Trachurus trachurus (liver)	Sinop	14.71±1.86	4.16±1.09	3.92±0.65	1.38±0.09	-	1.36±0.38	0.050±0.007	-	[37]
Trachurus trachurus (muscle)	Sinop	4.28±0.95	3.28±0.66	1.57±0.26	0.79±0.06	0.47±0.06	0.74±0.21	0.028±0.002	-	[37]
*Trachurus trachurus**	Samsun	32.40±2.70	12.05±2.30	-	1.52±0.35	3.76±0.45	0.85±0.16	0.47±0.10	-	[35]
*Trachurus trachurus**	BS	74.3 ± 6.1	37.4 ± 2.9	3.93 ± 0.25	0.95 ± 0.04	7.40 ± 0.60	0.68 ± 0.05	0.50 ± 0.03	-	[38]
MAMMALS										
Dolphin* (muscle)	Trabzon	10.1±0.6	6.5±0.3	<0.35	0.72±0.10	0.06±0.02	1.50±0.05	<0.10	<0.10	[36]
Dolphin* (liver)	Trabzon	561±71	84.1±32.8	<0.35	8.35±0.49	3.87±1.22	2.13±0.08	0.99±0.22	<0.10	[36]

- : not measured, ***:** expressed in µg metal g^{-1} dry wt.

From the public health point of view, the levels of the metals found in these studies are generally lower than the permitted levels (Table **7**).

According to Marine General Quality Criteria given in Turkish Environmental Regulation (Table **7**), it was seen that Cd^{2+} and Cu^{2+} levels generally were exceeded the criterion. In case of Pb^{2+} and Zn^{2+} levels they were sometimes exceeded the criterion, while Ni^{2+} concentrations were at the desired levels (see Table **5**).

In the available data of land-based pollution comprising river, stream, shore and harbor were shown to be exposed the heavy metal pollution [14].

Table 7. Some Part of General Quality Criteria of Marine and Inland Water Sources According to the Classes (I: High Quality Water, II: Slightly/Moderately Polluted Water, III: Polluted Water, IV: Heavily Polluted Water) [47]

Water Quality Parameters	Inland Water Sources				Marine ($mg.l^{-1}$)
	I	II	III	IV	
pH	6.5-8.5	6.5-8.5	6.0-9.0	Above 6.0-9.0	6.0-9.0
DO	-	-	-	-	< 90% of saturation
SS	-	-	-	-	30
BOD ($mg.l^{-1}$)	4	8	20	>20	-
T. Phosphorus (µg $PO4^{-3}$-$P.l^{-1)}$	20	160	650	>650	-
Cadmium (µg $Cd^{+2}.l^{-1}$)	3	5	10	>10	0.01
Lead (µg $Pb^{+2}.l^{-1}$)	10	20	50	>50	0.1
Copper (µg $Cu^{+2}.l^{-1}$)	20	50	200	>200	0.01
T. Chromium (µg $Cr^{+2}.l^{-1}$)	20	50	200	>200	0.1
Nickel (µg $Ni^{+2}.l^{-1}$)	20	50	200	>200	0.1
Zinc (µg $Zn^{+2}.^{-1}$)	200	500	2000	>2000	0.1
Manganese (µg $Mn^{+2}.l^{-1}$)	100	500	3000	>3000	-

CONCLUSION

Sustainable development of the Black Sea requires continued international co-operation. Solutions to the Black Sea environmental problems demand that uniform strict rules be adopted by each country. It means that the regulations should also cover those countries which influence the Black Sea environment through the rivers, mainly Danube, Dnieper and Dniester and another land based pollution sources.

Different types of pollutants in domestic and/or industrial discharges have different effects on human health and ecosystems at the point of discharge and in the surrounding environment. This surrounding environment may be very large and may extend beyond international borders. The risks increase proportionally with the quantity of the wastewater and concentration of the pollutant. Turkey is developing countries where industrial and urban developments mostly occur in coastal areas through increased input of wastes impose a further stress on the Turkish coasts of Black Sea.

The application of the agreements requires that each country which has a coast to the Black Sea, concerned creates an environmental policy. Harmonization of legislation and standards, preparation of effluent discharge inventories and mapping of major pollution sources and establishment of water monitoring programmers. These components are stated in the activities of the Black Sea Environmental Programme but the legislative frame for their realization still does not exist in all countries in the region.

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