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Land-Based Pollution on the Black Sea along the Turkish Shoreline

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Abstract

Turkey's environmental pollution control strategies will contribute to the protection of the Black Sea water quality. Key pollution problems are eutrophication and non-point source (NPS) pollution. The Black Sea Trans boundary Analysis Project 2007 Report is the main source of this project in which the author of this paper was one of the contributors as expert. The aim is to analyze the current environmental situation in the provinces of Turkey that border the Black Sea and underline the most critical problems regarding pollution in the Black Sea. The results of this study show that the inadequate municipal discharge, lack of the treatment practices and poor wastewater infrastructure in Trabzon, Samsun, and Zonguldak provinces lead to eutrophication. NPS pollution is mostly due to agriculture and industry. The copper industry is the major industrial polluter in the region. Toxic chemical emission from industrial facilities is one of the leading environmental problems in the region.

Keywords: The black sea; Environmental; Eutrophication; Non-point source pollution; Turkey

Introduction

The Black Sea is an inner sea between southeast Europe and the Anatolian peninsula of Turkey. Over 90% of the deeper Black Sea volume is anoxic water; and the hydrogen sulfide layer begins about 150 m below the surface. The Black Sea is usually subjected to wastewater discharges originating mainly from municipalities, industry, rivers, and oil spills. Marine transportation of petroleum and routine maintenance of ships are reasons of the oil seeps. In Turkey, oil seeps are commonly seen in the Giresun Basin between Ordu and Trabzon [1].

This paper shows the level of pollution, and measurements taken against pollution on the Black Sea along Turkey's shoreline. The four major transboundary problems of the Black Sea are nutrient-enrichment/eutrophication, changes in marine living resources, non-point source (NPS) pollution, and biodiversity/habitat changes [2]. Pollution sources in the region are mostly nonpoint sources. NPS Pollution comprises true nonpoint source contamination and pollution arising from a multiplicity of dispersed, often individually minor, point sources [3]. Existing settlement practices are mainly distributed along the shoreline instead of steep shoulders or hills. Thus, pollution sources exist along the coast [4]. Infrastructure of the rapidly growing mass settlement is improper or not exists. Geographical formations of the Turkish Black Sea Coast make the installation of wastewater infrastructure difficult. Both municipal and industrial wastewaters are mixed and dumped into the Black Sea. Moreover, existing treatment practices in heavy industries are generally insufficient. About 450-500 tons of solid waste is disposed of each day in the Black Sea Region of Turkey [5]. Most of the municipal and industrial solid wastes, mixed with hospital and hazardous wastes, are dumped on the nearest lowlands and river valleys or into the sea in the Black Sea Region of Turkey [6]. Solid wastes should be categorized and dumped in accordance with their characteristics. Lack of separation causes the mixture of non-hazardous, hazardous, and inert waste from

municipalities and industry. Landfills intended for non-hazardous waste should not accept hazardous or inert waste. Nevertheless, the practice of illegal dumping along the coastline is common in the Black Sea region of Turkey [2].

Turkey has the third largest catchment area of the Black Sea. Investigated locations on the Turkish Black Sea Coast are shown on the map in Figure 1. The rivers flowing into the Black Sea is given in Figure 2. Turkey affects the pollution in the Black Sea mostly in terms of municipal nutrient pollution. Beyond nutrient pollution, there are other pressures on the Black Sea ecosystems, such as organic pesticides, heavy metals, and incidental and operational spills from oil vessels and ports.

Figure 1: Inspected areas from the Black Sea coast of Turkey (Trabzon, Samsun, Artvin, Giresun, Ordu, Zonguldak, Istanbul).
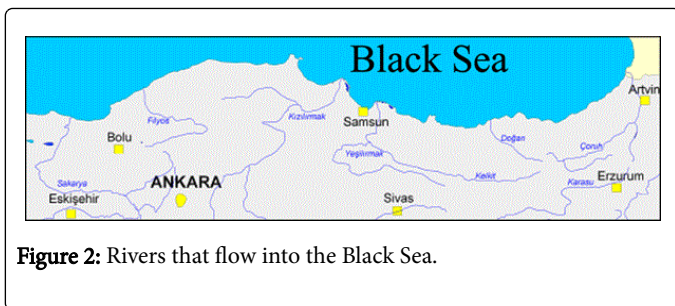
Figure 2: Rivers that flow into the Black Sea.

Materials and Methods

Pollution problems

The Sakarya (Longitude: 29° 84′ 50″; Latitude: 45° 44′ 81″), Yesilirmak (Longitude: 30° 93′ 12″; Latitude: 45° 40′ 50″), and Kizilirmak (Longitude: 36° 41′ 50″; Latitude: 46° 77′ 00″) rivers are the most important rivers forming the watershed of the Black Sea in Turkey. The Coruh (Longitude: 41° 31′ 36″; Latitude: 40° 53′ 19″) and Filyos (Longitude: 32° 04′ 44″; Latitude: 41° 32′ 49″) rivers are other important rivers that discharge into the Black Sea (Figure 2). River pollution comes from five main pollution sources. According to Berkun and Aras [6], these are agricultural activities, domestic settlements within the catchment areas, the industrial sector, uncontrolled solid waste disposal, and the pollutants in the air due to heavy industry.

This paper basically relies on the aforementioned rivers' water quality data gathered through the project entitled The Black Sea Transboundary Diagnostic Analysis (GEF 2007) and experimental methods are explained in the report of this project (2007). Compounds, which contain nitrogen, phosphorus, and carbon in certain concentrations, can distort and disrupt aquatic ecosystems by overfeeding [7]. The contamination drained into the water bodies cause eutrophication or nutrient enrichment. Eutrophication can be defined as the process of changing the nutritional status of a given water body by increasing the nutrient resources [8]. Oxygen depletion events are related with increased eutrophication [9]. Eutrophication is one of the common problems due to an excess amount of phosphorus and nitrogen loads. Direct discharges from large municipal/industrial plants to the Black Sea account for only about 2% of the inorganic nitrogen, and 13% of the phosphate load discharged to the Sea via rivers [2]. This shows the importance of river pollution control; however, according to GEF (2007), there is no certain measurement of the river pollution in the Black Sea area of Turkey.

Eutrophication is a key factor in the decline of commercial fisheries through the loss of habitat to benthic feeding fish and macroalgal plant-dominated habitats. Phytoplankton blooms deplete dissolved oxygen with the result that conditions become lethal to the majority of organisms [10].

Results and Discussion

Statistical analysis was implemented in order to categorize river water quality in terms of Turkish Water Pollution Control Regulation (MEF, 2004). Turkish Water Pollution Control Regulation (2004) covers all aspects of water pollution control indicating river, lake, and groundwater quality, domestic and industrial wastewater discharge standards; discharge principles, setting of protection zones to water reservoirs etc. Inland waters are classified as: class I: high quality waters, class II: slightly contaminated waters, class III: contaminated waters, and class IV: severely polluted waters. Since the available data is continuous and also approximately normal, we can apply the One Sample T-Test (Table 1 for the One Sample T-Test results). It was preferred to think in theoretical rather than practical terms. Usually mean values of the observed pollution data are compared with the permitted values to decide on the pollution status. In this study, better assessment was conducted by applying statistical tests to decide on the real pollution status (Table 1).

One Sample T-Test about whether or not BOD5 is above the prescribed limits mentioned in Turkish Water Pollution Control Regulation (Concentrations are in mg/l)									
River Name	Mean Value of Concentration (Conc.)	Standard Deviation	Degree of Freedom	Test Value	Prescribed Limits in terms of Four Water Quality Classes (WQC).	p-value (level of significance)	Coefficient of Determination, R2 (observed value vs. Expected normal value)	Hypothesis check: (μ0>Test Value or μa<Test Value). 95% Confidence Interval (CI)	Decision
Sakarya	3.46	0.466	10	4	Conc. < 4: WQC-I. 4 < Conc. < 8: WQC-II. 8 < Conc. < 20: WQC-III. Conc. > 20: WQC-IV.	0.003	0.9	95% CI excludes null value, reject null hypothesis.	Water Quality Class Number 1
Yesilirmak	1.68	0.896	10	4	Same as above	0	0.82	Same as above	WQC Number 1
Kizilirmak	1.09	0.84	3	4	Same as above	0.006	0.99	Same as above	WQC Number 1
Filyos	3.68	1.588	5	6	Same as above	0.016	0.96	95% CI excludes null value, reject null hypothesis.	Water Quality Class Number 2
One Sample T-Test about whether or not NO2-N is above the prescribed limits mentioned in Turkish Water Pollution Control Regulation (Concentrations are in mg/l)									

Sakarya	0.027	0.009	10	0.05	Conc. < 0.002: WQC-I. 0.002 < Conc. < 0.01: WQC-II. 0.01 < Conc. < 0.05: WQC-III. Conc. > 0.05: WQC-IV.	0	0.931	95% CI excludes null value, reject null hypothesis.	Water Quality Class Number 3
Yesilirmak	0.023	0.038	10	0.05	Same as above	0.043	0.831	Same as above	WQC Number 3
Coruh	0.067	0.053	8	0.05	Same as above	0.379	0.885	95% CI includes null value, accept null hypothesis.	WQC Number 4
Filyos	0.035	0.037	5	0.05	Same as above	0.373	0.829	Same as above	WQC Number 4
Kizilirmak	0.068	0.126	3	0.05	Same as above	0.791	0.844	Same as above	WQC Number 4
One Sample T-Test about whether or not NO3-N is above the prescribed limits mentioned in Turkish Water Pollution Control Regulation (Concentrations are in mg/l)									
Sakarya	1.447	0.273	10	5	Conc. < 5: WQC-I. 5 < Conc. < 10: WQC-II; 10 < Conc. < 20: WQC-III. Conc. > 20: WQC-IV.	0	0.924	95% CI excludes null value, reject null hypothesis.	Water Quality Class Number 1
Yesilirmak	1.274	0.526	10	5	Same as above	0	0.774	Same as above	WQC Number 1
Coruh	0.794	0.239	8	5	Same as above	0	0.963	Same as above	WQC Number 1
Filyos	1.093	0.78	3	5	Same as above	0.002	0.939	Same as above	WQC Number 1
Kizilirmak	1.143	0.312	3	5	Same as above	0	0.988	Same as above	WQC Number 1

Table 1: One Sample T-Test results for the observed river pollution data.

Ammonia Nitrogen data is available for this study and the average concentrations for all rivers except Filyos are above the 0.2 mg/L and below the 1 mg/L. This means that water quality of rivers other than Filyos can be classified as Water Quality Class (WQC) number 2 in terms of ammonia nitrogen (NH_3-N) concentration. Filyos River can be classified as WQC number 1 in terms of Ammonia Nitrogen concentration. Prescribed limits for Total Phosphorus mentioned in Turkish Water Pollution Control Regulation are 0.02 mg/L, 0.16 mg/L, 0.65 mg/L, and more than 0.65 mg/L, respectively for four WQC. The average PO_4^{-3} concentrations show that the water quality classes of rivers Sakarya, Yesilirmak, Coruh, Filyos, and Kizilirmak are WQC number 4, WQC number 2, WQC number 3, and WQC number 3 (was WQC number 4 in 2004), respectively in terms of PO_4^{-3} concentration. In terms of BOD_5 and orthophosphate loading, the Sakarya River needs to be protected foremost.

Human activities have an influence on the nitrogen (N) and phosphorus (P) content of many rivers [11]. Agriculture operations are also considered to be an important source of N and P [12,13]. Hence the best management technique could be to constrain the use of these pesticides and to support the success of organic agriculture in the Black Sea area. The Sakarya River is a source of pesticides, because it lies to the western part of the Black Sea and its drainage area includes fertile plains in northwest Turkey [14]. Rivers apart from Sakarya like Kizilirmak and Yesilirmak rivers are located on the eastern Black Sea coast and their drainage area includes regions in the Central Anatolia where agriculture is not as extensive as in the north-western part of Turkey where Sakarya River is present. The other streams do not contribute pesticides and PCBs into the Black Sea due to the lack of extensive agriculture and industrial activity in the region. Therefore because of the extensive agricultural activity in the Sakarya drainage area the pesticide use is high compared to the other river drainage areas. Natural NO_3 and PO_4^{-3} concentrations in rivers range from 0.05 to 0.2 mg/L and from 0.002 to 0.025 mg/L, respectively [15].

Some pollution parameters have been given for Ordu and Giresun municipal wastewater; and their loads have been presented. However, their wastewater treatment plants have to be constructed. Discharge of these untreated wastewaters lead to the diminishment of dissolved oxygen (DO) level in the Black Sea.

In Trabzon province, pretreatment is applied as a wastewater treatment process. The steps in this process are screening, primary sedimentation, and grid removal. These are followed by construction of a marine disposal system. In Samsun and Zonguldak provinces, more comprehensive biological treatment is applied, and then, a marine disposal system is constructed. In the Bafra district of Samsun province, biological treatment is applied. Afterward, wastewater is discharged into the Kızılırmak River. Sludge from plants is dewatered by belt filters, and is meant to be used as a fertilizer. In the Ereğli district of Zonguldak province, primary treatment is applied. This treatment includes screening and primary sedimentation, which are followed by a marine disposal. The sewer system is a combined system and serves the whole city. Referring to the information announced by the General Directorate of Provincial Bank of Turkey, treatment plants are important, and, in time, there would be extensions for them. Additionally, during EU membership accession period, the Environment and Forestry Ministry of Turkey [16] has issued many regulations, and some deal with wastewater.

Metals are still one of the most common sources of environmental contamination; they originate from both diffuse atmospheric depositions, as well as from several point sources such as mines and foundries [17]. Heavy metals are a confirmed carcinogen, in animals causing lung and nasal tumors. They are bio-accumulated by a variety of aquatic organisms [18]. At low concentrations, most heavy metals may act as micronutrients, but they are toxic at higher concentrations [19].

KBI (Black Sea Copper Works Incorporation) Samsun copper, TUGSAS (Turkish Fertilizer Industry Corporation) Samsun fertilizer, and KBI Murgul copper factories are located in the region and they do not have treatment facilities. Their treatment plants have yet to be planned. The inhabitants and industries in this region generally use coal and fuel oil products for heating purposes; this is the reason for the atmospheric discharge of many metals. Correspondingly, heavy metal concentration in the Black Sea increases due to the precipitation and wet climate of the region. Heavy metal pollution of the marine environment has long been recognized as a serious environmental concern. In the sea, pollutants are accumulated in marine organisms and sediments, and subsequently, transferred to people through the food chain. The determination of the contents of trace metals in wastewater is also extremely important for human health. Levels of mineral and trace metals in marine algae samples have been widely reported in the literature [20]. The Artvin (Murgul) and Samsun copper industries cause critical pollution concentrations and loads. Their values are above the permitted limits, and strict measures must be taken to remedy the situation.

Conclusion

The most frequent pollution problem, eutrophication is caused by the excess amount of nutrient loading caused mainly by municipal and river discharges. In addition, rivers are the most important ones among pollutant sources. The findings are as follows:

In terms of BOD5 and orthophosphate loading, the Sakarya River is the river that needs to be protected most against pollution. There is no significant measure regarding the improvement of rivers' water quality. Thus, introducing a proper waste management system around the rivers has to be a priority for the government.

The results show that Trabzon, Samsun, and Zonguldak provinces should control their municipal discharges better, and install the necessary infrastructure connected to the appropriate treatment facilities.

Non-point source (NPS) pollution is mostly due to agriculture and industry. Although assessing the scale of NPS pollution within the Black Sea is not simple, traditional agricultural practices and the frequent usage of pesticides give us an idea about the possible loading.

Apart from pesticides, the Black Sea receives toxic chemical loading also from industrial facilities. The copper industry is the major industrial polluter in the region. Heavy metal pollution of the marine environment is one of the leading environmental problems. The Artvin (Murgul) and Samsun copper industries cause critical pollution concentrations and loads. Oil spills and seeps are other frequently seen chemical pollution sources that cause NPS pollution. Further work is required for treatment plants.

Within this research also statistical analysis was applied in order to categorize river water quality in terms of class I: high quality waters, class II: slightly contaminated waters, class III: contaminated waters,

and class IV: severely polluted waters according to Turkish Water Pollution Control Regulation.

The habitat in the Black Sea is gradually being changed due to pollution, currents through straits, and the physical formation of the Black Sea.

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