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Temporal Variation of Organic and Inorganic Carbon Transport from the Southeastern Black Sea (Trabzon Province) Rivers

Sinan Nacar[1*], Uğur Satilmis[1]

[1]*Karadeniz Technical University, Faculty of Engineering, Department of CivilEngineering, 61080, Trabzon,Turkey.*

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Abstract

The input of organic carbon being an indicator of organic pollution as well to the oceans provides crucial sources in food web of estuarine ecosystems. The Black Sea surrounded by six countries is the world's largest land-locked inland sea and its total length of the coastal zone is 4,340 km, of which 1,400 km is shared by Turkey. The Black Sea receives annually a considerable freshwater input from the rivers carrying substantial loads of organic matter, nutrients and anthropogenic pollutants and the coastal parts are highly affected by eutrophication. The aim of this study is to determine the temporal variability of total carbon (TC), total organic carbon (TOC) and total inorganic carbon (TIC) carried from the eight Turkish streams to the Black Sea. The streams included in this study are Ağasar, Fol, Galanima, Değirmendere, Yomra, Karadere, Manahoz and Solaklı, within the boundaries of Trabzon Province, the most densely populated city located in the coast of Southeastern Black Sea. The water sampling studies have been monthly conducted in one station, which was selected at the point where the stream is discharged into the Black Sea, for each stream during a period of twelve months between March 2015 and February 2016.Considering the mean values for each stream, TOC concentration fluctuated from 1.59 to 25.90 mg/L and the Stream Yomra being under immense pressure due to various kinds of anthropogenic activities among which sand and gravel mining is the most disastrous one was the most critical one. The streams showed high TC and TIC yields during the summer and autumn months, corresponding to the seasonal trend of stream discharge. It was also found that TIC comprised the majority of the total carbon concentration, with mean percentages ranging from 68.9% to 84.06% in all of the streams.

Keywords

Black Sea, Total OrganicCarbon, Trabzon streams

1. INTRODUCTION

Water plays a vital role in all aspects of human and ecosystem survival. Unconsciously pollution of water of the rivers, lakes, seas and drinking water supplies are endangering life on earth day by day. Human activities like improper disposal of municipal and industrial effluents and indiscriminate applications of agrochemicals in agriculture are the main factors contributing to the deterioration of water quality [1]. An estimated 2 million tons of sewage and other effluents are discharged into the world's waters every day. In developing countries where over 90% of raw sewage and 70% of untreated industrial wastes are dumped into surface water sources the situation is worse [2].

The Black Sea has been increasingly threatened by nutrients carried by rivers over the past decades as a result of discharge of domestic wastes from coastal settlements and industrial areas [7]. The major rivers following into the Black Sea and their discharges are: Danube (203 km^3/yr), Dniper (54 km^3/yr), Dniesta (9.3 km^3/yr), Don (28 km^3/yr) and Kuban (13 km^3/yr). In addition to these rivers, a large number of smaller rivers along the Turkish and Bulgarian coasts contribute another 28 km^3/yr to the water budget of the sea [4]. There are several studies were made by researchers on the effect of different domestic and industrial discharges on the water quality of the Black Sea Coast of Turkey [3], [5], [6], [8], [9], [11], [13], [16], [17]. Also variation in the quality and quantity of river water has been studied worldwide in recent years [10], [14], [15].

The TC, TIC and TOC in surface waters and wastewaters are important analytical parameters describing the total content of all substances containing carbon. In practice, the TOC originated from natural and anthropogenic sources, and even if it is not directly responsible for dangers on human health, its determination is important for any kind of water that is used by public [19]. Researchers must consider that TOC depends on the kind of the measured water, but it is also affected by several parameters such as temperature, salinity, pH, microbial activity and surrounding vegetation [21].

The aim of this study is to determine the TC, TIC and TOC carried by streams located within the boundaries of Trabzon, the biggest province of the Eastern Black Sea Basin (EBSB), into the Black Sea.

2. MATERIAL AND METHOD

2.1. Study Area

The Black Sea is a semi-enclosed sea, whose only connection to the world's oceans is the narrow Bosphorus Channel. The area of Black Sea is $4.2*10^5$ km^2 with maximum and average depths of 2200 and 1240 m, respectively. Ninety per cent of its water mass is anoxic, thus it contains the world's largest anoxic water mass [18]. To the south, it is connected to the Mediterranean through the Bosphorus, which is the world's narrowest strait, with an average width of 1.6 km, depth of 36 m and a total length of 31 km. To the north, the Black Sea is connected with the Sea of Azov through the shallow Kerch Strait, which has a depth of less than 20 m. The Black Sea is surrounded by six countries located in Europe and Asia: Bulgaria, Georgia, Romania, Russia, Turkey and Ukraine (Figure.1). In fact, the Black Sea is influenced by 17 countries, 13 capital cities and some 160 million people [3].

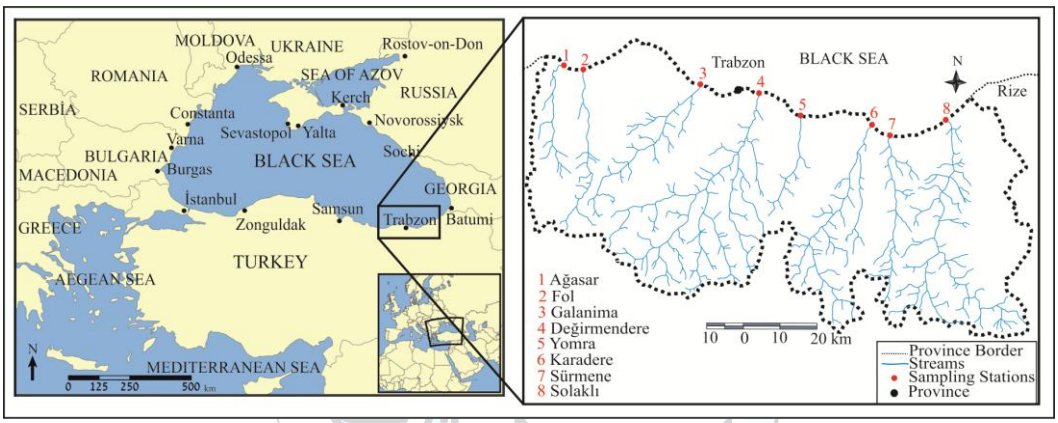

Fig.1. Study area and locations of the sampling stations

The ESBS is one of the most important hydrological basins in Turkey, and it is a major part of Caucasus Ecological Region together with Çoruh and Aras Basins [19]. Trabzon, the biggest province located in the ESBS of Turkey, lies between the 38° 30' and 40° 30' eastern longitudes and 40° 30' and 41° 30' northern latitudes. Trabzon with the area of 4,664 km^2 is a coastal city situated on the slope of the hills. The climate characteristic of the northeast coastal region of Turkey is rainy and humid. Trabzon has a typically moderate climate that is neither too warm in summers and nor too cold in winters [20].

There are many streams flowing in the boundaries of Trabzon into the Black Sea. A total of eight streams and one monitoring station for each stream were selected along the coast of Trabzon Province at the Eastern Black Sea Region of Turkey. The streams studied from the west to the east are Ağasar, Fol, Galanima, Değirmendere, Yomra, Karadere, Manahoz and Solaklı, respectively. These streams drain the major rural, agricultural, and urban of the Eastern Black Sea Region of Turkey and discharge into the Black Sea. The main nutrient loads include domestic wastewaters, agricultural runoff and industrial effluents. The Coordinates for each station are given in Table 1.

Table 1. Coordinates of stations

Station	N			E		
Ağasar	41˚	03'	26.14"	39˚	13'	07.51"
Fol	41˚	02'	48.69"	39˚	16'	40.22"
Galanima	41˚	01'	07.80"	39˚	35'	46.20"
Değirmendere	41˚	00'	06.00"	39˚	45'	25.80"
Yomra	40˚	57'	10.80"	39˚	52'	03.00"
Karadere	40˚	56'	05.40"	40˚	03'	38.40"
Sürmene	40˚	54'	52.80"	40˚	06'	41.40"
Solaklı	40˚	56'	35.40"	40˚	16'	01.80"

2.2. Water Sampling

Water samples were collected at all eight monitoring stations monthly from March 2015 to February 2016. The surface water samples were collected in 1.0 L polyethylene bottles. Plastic sample bottles, pre-cleaned with 1M HNO_3 and rinsed

with double-distilled water, were used to collect the water samples. At the point of collection, bottles were rinsed several times with water of streams and transferred to the laboratory in coolers containing icecap to reducing the degradation of samples before analysis. At the laboratory located in Karadeniz Technical University, Hydraulic Laboratory, the water samples were immediately analyzed within 12 h of sampling.

2.3. Water Analysis

TC, TIC and TOC content of the water samples were determined with a UV-vis spectrophotometer (DR 5000) by using its cuvette-test (LCK 380, TC), according to Standard Methods [22]. TOC is calculated as the difference between the TC and TIC values. These analyses were carried out in triplicate in room temperature (21 ± 2˚C) and their mean values were presented.

3. RESULTS AND DISCUSSION

The basic statistics of TC, TIC and TOC content (mg/L) for each studied stream are given in Table 2.

3.1. The Ağasar Stream

The TC levels of the Ağasar Stream show that the content varies between 19.10 mg/L in November and 41.90 mg/L in October. The TIC content changed between 14.20 mg/L in April and 34.60 mg/L in October. Also, the TOC content of the Ağasar Stream changed between 1.59 mg/L in November and 9.06 mg/L December. TC and TIC concentrations were highest during a three-month period from August to October.

3.2. The Fol Stream

For the Fol Stream, the content of TC varies between 22.60 mg/L in April and 41.60 mg/L August. The TIC levels of Fol Stream show that the content varies between 16.60 mg/L in April and 34.30 mg/L in October. The minimum TC and TIC content were determined in April. The TOC levels of the Fol Stream show that the content varies between 6.04 mg/L in May and 15.40 mg/L in February. TC and TIC content of the Fol Stream were highest during a three-month period from August to October. Also, the lowest content of TC, TIC and TOC were determined from March to May.

3.3. The Galanima Stream

Considering the yearly mean values for the Galanima Stream, the TC concentration was determined as 42.44 mg/L with a range of 27.40-61.60 mg/L, and TIC concentration 35.68 mg/L with a range of 24.40-55.50 mg/L. The lowest TC concentration was observed in April and the highest TC concentration was observed in August. The lowest TIC concentration was observed in April and the highest TIC concentration was observed in August. The TOC concentration of the Galanima stream was measured as 6.77 mg/L and, the lowest TOC concentration (1.60 mg/L) were observed in November and the highest TOC concentration (12.70 mg/L) were observed in December. TC, TIC and TOC concentrations were lowest during a three- month period from March to May. Considering the all streams, it was seen that the Galanima Stream had maximum TC and TIC concentrations.

3.4. The Değirmendere Stream

For the Değirmendere Stream, the yearly average TC content was determined as 38.76 mg/L with a range of 20.50 mg/L (June)-57.50 mg/L (January). Yearly average TIC concentration was 29.43 mg/L with a range of 17.20 mg/L (May-June) - 48.30 mg/L (September). The yearly average TOC content of the Değirmendere Stream was determined as 9.33 mg/L. The minimum TOC concentration (3.25 mg/L) was measured in June and, the maximum TOC (21.85 mg/L) concentration was measured in January. TC and TIC content of the Değirmendere Stream were highest during a three-month period from August to October. Also, the lowest content of TC, TIC and TOC were determined from April to Jun.

3.5. The Yomra Stream

The TC levels of the Yomra Stream show that the content varies between 16.20 mg/L in July and 73.10 mg/L in September. The TIC content changed between 10.50 mg/L in July and 52.60 mg/L in Jun. Also, the TOC content of the Yomra Stream changed between 4.06 mg/L January and 25.90 mg/L in March. TC and TIC content of the Değirmendere Stream were highest during a three-month period from August to October. Considering the all streams, it was seen that the Yomra Stream had maximum TOC concentration.

3.6. The Karadere Stream

For the Karadere Stream, the yearly average TC concentration was determined as 24.64 mg/L with a range of 15.10 mg/L (April)-35.70 mg/L (October), and yearly average TIC concentration 19.88 mg/L with a range of 12.50 mg/L (April)-30.80 mg/L (October). The yearly average TOC concentration value of the Karadere Stream was measured as 4.76 mg/L and, the lowest TOC concentration value (2.26 mg/L) were observed in May and the highest TOC concentration value (8.08 mg/L) were observed in December. TC, TIC concentrations were highest during a three month period from August to October. Also, TC, TIC and TOC concentration were lowest during a three-month period from April to Jun.

3.7. The Sürmene Stream

For the Sürmene Stream, the yearly average TC value was determined as 17.53 mg/L with a range of 14.50 mg/L (February)-24.30 mg/L (October). Yearly average TIC concentration value was 13.59 mg/L with a range of 10.50 mg/L (May) - 20.70 mg/L (October). The yearly average TOC content of the Sürmene Stream was determined as 3.96 mg/L. The minimum TOC concentration (2.20 mg/L) was measured in March and, the maximum TOC (5.44 mg/L) concentration was determined in December. TC, TIC concentrations were highest during a three month period from August to October. Considering the all streams, it was seen that the Sürmene Stream had minimum TC, TIC and TOC concentrations.

3.8. The Solaklı Stream

The TC levels of the Solaklı Stream show that the content varies between 14.20 mg/L (April) and 27.90 mg/L (October). The TIC content changed between 11.40 mg/L in April and 22.90 mg/L in October. Also, the TOC content of the Solaklı Stream changed between 2.75 mg/L April and 6.05 mg/L March. TC, TIC and TOC concentration were highest during a tree-month period from August to October and lowest during a three month period from April to Jun in the Solaklı Stream.

Table 2. Basic statistics of TC, TIC and TOC content monitored for the Southeastern Black Sea Streams

		Ağasar	Fol	Galanima	Değirmendere	Yomra	Karadere	Sürmene	Solaklı
TC (mg/L)	Mean	27.18	32.84	**42.44**	38.76	38.93	24.64	**17.53**	20.89
	Min	19.10	22.60	27.40	20.50	16.20	15.10	14.50	14.20
	Max	41.90	41.60	61.60	57.50	73.10	35.70	24.30	27.90
	SD	7.05	7.07	8.65	12.72	17.88	5.84	2.93	4.39
TIC (mg/L)	Mean	20.60	24.50	**35.68**	29.43	26.83	19.88	**13.59**	16.75
	Min	14.20	16.60	24.40	17.20	10.50	12.50	10.50	11.40
	Max	34.60	34.30	55.50	48.30	52.60	30.80	20.70	22.90
	SD	6.50	6.15	7.48	9.64	13.14	5.05	2.97	3.76
TOC (mg/L)	Mean	6.58	8.34	6.77	9.33	**12.14**	4.76	**3.96**	4.13
	Min	1.59	6.04	1.60	3.25	4.06	2.26	2.20	2.75
	Max	9.06	15.40	12.70	21.85	25.90	8.08	5.44	6.05
	SD	2.06	3.09	3.18	5.18	6.77	1.68	1.03	1.07

4. CONCLUSION

In this study the temporal variability of TC, TIC and TOC carried from the eight streams namely Ağasar, Fol, Galanima, Değirmendere, Yomra, Karadere, Manahoz and Solaklı, within the boundaries of Trabzon Province, to the Black Sea was investigated. The water sampling studies were monthly conducted in one station, which was selected at the near point where the stream is discharged into the Black Sea, for each stream during a period of 12 months between March 2015 and February 2016. The TC, TIC and TOC content of the water samples collected from eight stations along the coast of the Southeastern Black Sea were determined and evaluated. It was found that:

- The minimum TC concentration is determined in Solaklı Stream in April and the maximum concentration is determined in September in Yomra Stream. The minimum TIC concentration is determined in Yomra and Sürmene Streams and the maximum concentration is determined in August in Galanima Stream. Also the minimum TOC content was determined in November in Ağasar Stream and maximum content was determined in March in Yomra Stream.
- In all station, TC and TIC content show a similar trend throughout the year; start to decrease on spring, then rise during the summer and then it reached its peak in the autumn.
- TC and TIC content of stream water were highest during a three-month period from August to October for all streams while lowest from March to May for Ağasar, Fol and Galanima and from April to Jun for Değirmendere, Karadere and Sürmene streams.
- The maximum TC and TIC content are recorded in summer and autumn seasons, due to the low precipitation, where the lowest levels are determined in winter and spring because of the heavy rainfall causing dilution. But the maximum TOC content is recorded in spring.
- Considering the yearly mean values minimum TC, TIC and TOC concentration value are determined at Sürmene Stream and maximum TC and TIC value are determined in Galanima Stream, maximum TOC concentration is determined in Yomra Stream.
- Because of being under immense pressure due to various kinds of anthropogenic activities among which sand and gravel mining the TOC concentration of Yomra was recorded very high in all months.
- It is recognized that TIC generally constitutes the majority of the TC concentration with mean percentages ranging from 68.9% to 84.06% in all streams.

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