

Research Article / Araştırma Makalesi

Sustainable Management of Water Resources in the Context of Water Quality: Balıkesir City Center Case Study

*Su Kalitesi Bağlamında Su Kaynaklarının Sürdürülebilir Yönetimi:
Balıkesir Şehir Merkezi Örnek Olay İncelemesi*

Yasemin HAYTA^{1*} , Edip AVŞAR² , Sevgi AKKOY³

¹ Balıkesir University, Faculty of Economics and Administrative Sciences, Department of Political Science and Public Administration, Balıkesir, Türkiye

² Bilecik Şeyh Edebali University, Vocational School, Department of Environmental Protection Technologies, Bilecik, Türkiye

³ Bilecik Şeyh Edebali University, Graduate School Institute, Department of Emergency and Disaster Management, Bilecik, Türkiye

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ABSTRACT

Water is a vital resource for the planet and humanity, and it is indispensable for sustainable development. According to the Sustainable Development Goals, access to water of adequate quantity and quality is a fundamental right for all. However, clean water resources are diminishing day by day due to the climate crisis and increasing pollution. At the same time, pressure on existing water resources continues to intensify. This situation renders the sustainable management of urban water resources increasingly critical. In this context, the primary aim of the article is to assess the water quality and microplastic content of existing sources in the urban center of Balıkesir and to propose strategies for the sustainable management of these resources. Within the scope of the study, water quality was evaluated by measuring physicochemical parameters at seven representative points selected in the drinking water distribution network by Balıkesir Metropolitan Municipality and the Directorate General of Balıkesir Water and Sewerage Administration (BASKİ), and three types of microplastics were analyzed at six points using the pyrolysis–gas chromatography/mass spectrometry (Py GC/MS) method. Noncompliance was not observed in the samples with respect to the measured physicochemical parameters. Based on similar studies in the literature, the microplastic levels measured in Balıkesir waters were found to be low; however, in order to prevent an increase in concentrations, necessary measures should be taken to reduce plastic use, prevent plastics from reaching water resources, and ensure recycling of existing plastic waste.

Keywords: Balıkesir, Microplastics, Sustainability, Water resources management

ÖZ

Su, dünya ve insanlık adına hayati öneme sahip bir kaynak olup sürdürülebilir kalkınma için elzemdir. Sürdürülebilir kalkınma hedeflerine göre ihtiyaç duyulan miktarda ve kalitede suya ulaşım herkesin en temel hakkıdır. Ancak günümüzde iklim krizi ve yoğun kirlilik nedeniyle temiz su kaynakları her geçen gün daha da azalmaktadır. Su kaynakları üzerindeki kullanım baskısı ise gün geçtikçe artmaktadır. Bu durum kentlerde sürdürülebilir su kaynakları

yönetimini daha da önemli hale getirmektedir. Bu bağlamda makalenin ana hedefi Balıkesir kent merkezinde mevcut kaynakların su kalitesinin ve mikroplastik içeriğinin gözden geçirilmesi ve mevcut su kaynaklarının sürdürülebilir yönetimine dair stratejilerin ortaya konmasıdır. Çalışma kapsamında Balıkesir Büyükşehir Belediyesi, Balıkesir Su ve Kanalizasyon İdaresi Genel Müdürlüğü (BASKİ) tarafından içme suyu şebekesinde seçilen temsil edici 7 noktada fizikokimyasal parametreler ölçülerek su kalitesi ve 6 noktada Piroliz-Gaz Kromatografisi/Kütle Spektrometrisi yöntemiyle 3 tür mikroplastik analiz edilmiştir. Fizikokimyasal parametreler yönünden ölçülen numunelerde herhangi bir uygunsuzluğa rastlanmamıştır. Literatürdeki benzer çalışmalardan hareketle Balıkesir sularında ölçülen düzeyin düşük olduğu ancak konsantrasyon artışının önlenmesi yönünde plastik kullanımının azaltılması, plastiklerin su kaynaklarına ulaşımının önlenmesi, mevcut plastik atıkların geridönüşümünün sağlanması üzerine gerekli önlemlerin alınması sağlanmalıdır.

Anahtar Kelimeler: Balıkesir, Mikroplastikler, Sürdürülebilirlik, Su kaynakları yönetimi

INTRODUCTION

Water, which is vital for the continuation of life on earth, is also an important resource for sustainable development. According to the UN Sustainable Development Goals, access to safe water is a universal right (UNEP, 2023). However, due to climate change, precipitation regimes are shifting. While some regions of the world struggle with drought, others face floods and inundations. Water scarcity is becoming increasingly evident (Karaman and Gökalp, 2010). Population growth, unplanned urbanization, and human activities increase the demand for water resources, while rising pollutant activities further degrade water quality. The scale of the water crisis is expanding every day, threatening both human and other forms of life (Körbalta, 2023). This situation makes it imperative to develop strategies that not only preserve the quality and quantity of water resources but also reduce the pressure on them to ensure sustainability. Since the Industrial Revolution, the world's population has tripled, yet water consumption has increased sixfold. Sustainable use of water resources is therefore a necessity to reduce this pressure; otherwise, a global water crisis will be inevitable. The water crisis can be defined as the inability of more than one billion people to access safe drinking water and the lack of adequate water and wastewater

infrastructure for half of the world's population (Orhon et al., 2002).

As of 2022, the per capita available water amount was 1,313 m³/year, and with population growth and drought, it is projected to fall below 1,000 m³/year after 2030, placing Türkiye among water-scarce countries (TOB, 2023). In this context, the importance of water resource management in cities and nationwide is increasing day by day.

Many scientific studies were conducted both in our country and around the world to develop and enhance sustainable water resource management strategies in urban areas, and as the water crisis deepens, the number of these studies continues to increase. Büyükerşen and Efelerli (2008) emphasized the necessity to implement a management approach based on sustainable environmental and development principles in basin use to ensure the healthy recharge and balanced distribution of water resources. Rouillard et al. (2016) highlighted the importance of utilizing technological innovations when developing urban water management strategies. Teksoy et al. (2017) brought attention to the need to improve the efficiency of urban wastewater treatment plants to ensure the sustainability of water resources. Konyalı Dereli and Çay (2023) stated that increasing impervious

surfaces and decreasing vegetation cover in cities exacerbate the negative impacts of floods in urban areas, demonstrating the necessity to increase infiltration and reduce surface runoff in cities. Yoo (2007) found that real income growth increases water consumption. Praskievicz and Chang (2009) determined that weather conditions significantly influence water-use patterns. Lins et al. (2010) showed that factors such as housing size and type, income level, water-use habits, and water billing structures play important roles in explaining household water consumption. Fan et al. (2017) demonstrated that urban water consumption is shaped by meteorological factors, socio-economic conditions, water supply, and conservation measures.

The literature indicates that when developing water resource management strategies, it is essential to benefit from technological advancements and to consider global environmental issues alongside regional dynamics. In this context, this study investigates the presence of microplastics, an emerging global environmental concern, in addition to conducting water quality analyses that will form the basis for developing a water resource management strategy for the central district of Balıkesir.

This study includes assessments and practices aiming to establish a management plan in line with the UN Sustainable Development Goals, through situational analysis and good practice examples in Balıkesir (city center), within the process of ensuring water efficiency in cities, a major issue both globally and in Türkiye.

This study aims to assess the current physicochemical quality and microplastic pollution levels of water resources in Balıkesir city center and to identify sustainable management strategies under the pressures of climate change and population growth. Although drinking water

sources may meet conventional quality standards, they can still contain microplastics of various types and concentrations due to anthropogenic activities, which forms the core hypothesis of this research. The study's originality lies in providing the first analytical assessment of microplastic presence in the Balıkesir drinking water distribution network and directly linking these findings to local water management and governance strategies.

Lessons learned from previous studies about water efficiency, the challenges encountered in implementation, and the roadmap and perspectives of the water sector in the world and in Türkiye are evaluated. The current water quality of Balıkesir (city center) was determined, and a roadmap for water efficiency is proposed.

CURRENT SITUATION IN BALIKESİR

The province of Balıkesir is located within the boundaries of the Susurluk Basin. The water potential and characteristics of the Susurluk Basin are presented in Table 1.

Table 1. Basic characteristics of the Susurluk Basin (TOB, 2018)

Çizelge 1. Susurluk Havzası'nın temel özellikleri (TOB, 2018)

Data	Unit	Value
Total surface area	km ²	24,349
Drainage area	km ²	22,399
Average annual rainfall	Mm	712
Average annual flow	km ³ /year	5.43
Area within Türkiye	%	3.11

The Susurluk Basin, covering a large portion of Balıkesir province, is characterized by a heterogeneous lithological structure and diverse aquifer properties that developed in response

to this geological variability. Across the basin, a dynamic interaction exists between surface water and groundwater systems, and in addition to dam reservoirs, groundwater abstraction wells providing recharge play strategic roles in the supply of drinking and domestic water. An examination of the relationship between lithology and water chemistry indicates that geological control mechanisms throughout the basin largely determine the mineralization levels in water resources. However, intensive agricultural activities and industrial settlements exert significant pollution pressure on this natural geochemical framework. At the basin scale, the increase in impermeable surfaces accelerates surface runoff and restricts groundwater

recharge, particularly in urban areas, leading to morphological alterations that cause long-term decline in aquifer water levels (TOB, 2018; TOB, 2023).

In Balıkesir province, the sources of water for urban supply include dams, wells, springs, rivers, and lakes/ponds. The current distribution of drinking and utility water in the province is shown in Figure 1.

The most important water sources in the province are wells and dam reservoirs. Generally, groundwater resources are prioritized, while surface resources constitute 49% of the total. Dam reservoirs used for drinking water supply are listed in Table 2.

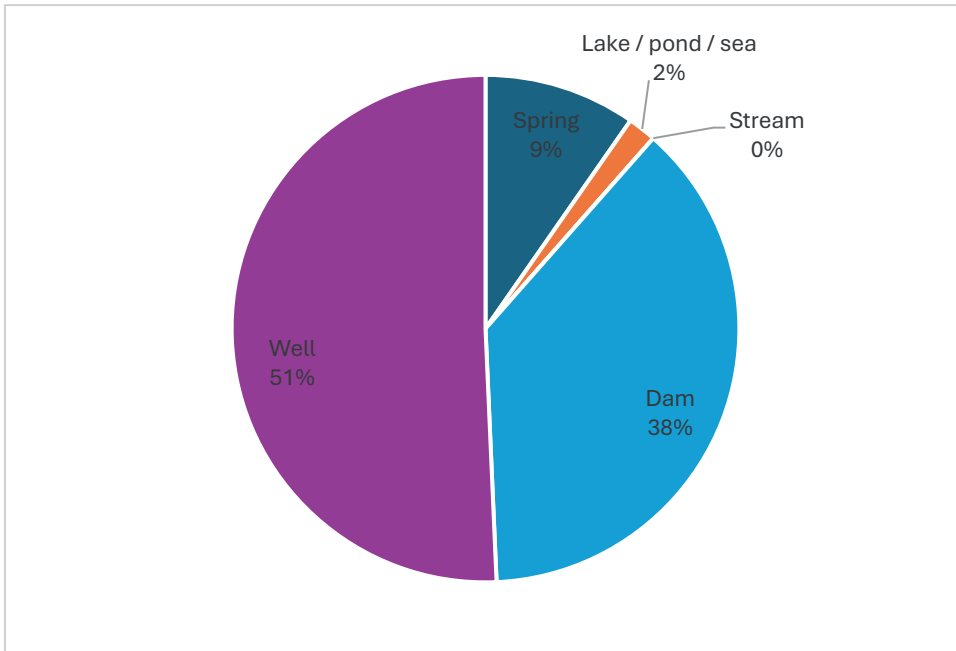


Figure 1. Distribution of water allocated by municipalities for drinking water networks in Balıkesir province in 2022 according to water source (TUİK, 2022).

Şekil 1. Balıkesir ilinde 2022 yılında belediyeler tarafında içme suyu şebekesi ile tahsis edilen su miktarının kaynaklara göre dağılımı (TUİK, 2022).

Table 2. Dams and reservoirs used for drinking water purposes in Balıkesir province (ÇŞB, 2024).

Çizelge 2. Balıkesir ili içme suyu amaçlı baraj ve göletleri (ÇŞB, 2024).

Dam/Pond Name	Location / Aim	Allocated Water Amount (hm ³)
İkizcetepeler Dam	Balıkesir / Drinking water	53.00
Gönen Dam	Bandırma / Drinking wate	31.50
Susurluk-Söve Dam	Göbel Town / Drinking water	0.32

Table 3. Capacity and characteristics of drinking water treatment plants in Balıkesir province (TOB, 2018)

Çizelge 3. Balıkesir ili içme suyu arıtma tesislerinin kapasitesi ve özellikleri (TOB, 2018).

No	DWTP Name	Location (district)	Capacity (people)	Capacity (m ³ /day)	Type	Status
1	Balıkesir Center	Karesi, Altıeylül	1,100,000	220,000	Conventional	Active
2	Bandırma	Bandırma	540,000	108,000	Conventional	Active
3	Erdek	Erdek	50,000	8,700	Conventional	Active
4	Gönen Sarıköy	Gönen-Sarıköy	20,000	3,000	Slow Sand Filter	Active
5	Susurluk	Susurluk	34,500	8,640	Packet System (Conventional)	Active
6	Marmara Avşa Island	Marmara, Avşa Island	30,000	6,000	Reverse Osmosis	Active
7	Ekinlik Island	Marmara-Ekinlik Island	600	600	Reverse Osmosis	Active
8	Susurluk Göbel	Susurluk- Göbel	5,000	1,000	Slow Sand Filter	Active
9	Susurluk Karapürçek	Susurluk- Karapürçek	10,000	1,000	Slow Sand Filter	Active
Total			1,790,100	356,940		

The drinking water supply for Balıkesir province is provided by nine drinking water treatment plants (DWTP) with a total capacity serving 1,790,100 people. The capacities and characteristics of these facilities are presented in Table 3 (BASKİ, 2025). The water supplied from the dams listed in Table 2 is treated at these facilities and subsequently delivered to the Balıkesir drinking water distribution network.

The existing drinking water network in Balıkesir is currently capable of serving 100% of the provincial population and the amount of water per capita in Balıkesir is 290 L/day (TUİK, 2022; 2025). In the cities of İstanbul, Ankara, and İzmir, the average amount of water withdrawn per capita was reported as 190, 242 and 210 L/

person·day, respectively. The national average is 229 L/capita·day (TUİK, 2022). In this context, the per capita water amount in Balıkesir is above both the national average and the average for these three major cities. However, in coming years, regular population growth is expected with the increase of industry in Balıkesir, and at the same time, the increase in agricultural production to meet this demand will put additional pressure on water resources. This raises the possibility that the city may face water supply problems in the near future. The annual population growth rate in Balıkesir is projected to be 0.4%. In this regard, Table 4 presents the population projections for Balıkesir in future years and the changes in per capita water withdrawal, assuming water resources remain constant (BKK, 2024).

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Table 4. Projected population of Balıkesir and changes in per capita water consumption.

Çizelge 4. Balıkesir'in tahmini nüfusu ve kişi başına su tüketimindeki değişimler.

Year	Estimated Population	Water Amount (L/capita·day)
2025	1,275,092	286
2030	1,322,975	276
2050	1,375,894	265

Based on the data, the amount of water used per capita in Balıkesir city center remains below the average amount used in metropolitan cities. Considering that regular population growth is expected in Balıkesir in the coming years due to industrial expansion, it is likely that the city will face problems with water supply in the near future. In this context, in line with the UN

Sustainable Development Goals, it is necessary to keep water resources in good condition and to urgently implement strategies based on urban water efficiency, while also considering recovery alternatives to address potential water scarcity problems in the near future.

MATERIALS AND METHODS

Fieldwork was conducted in the context of the study. During this phase, collaboration was established with Balıkesir Metropolitan Municipality and General Directorate of Balıkesir Water and Sewerage Administration (BASKİ). Water quality (7 points) and microplastic analyses (6 points) were carried out on samples from the drinking water network. The distribution of the sampling points is presented in Figure 2.

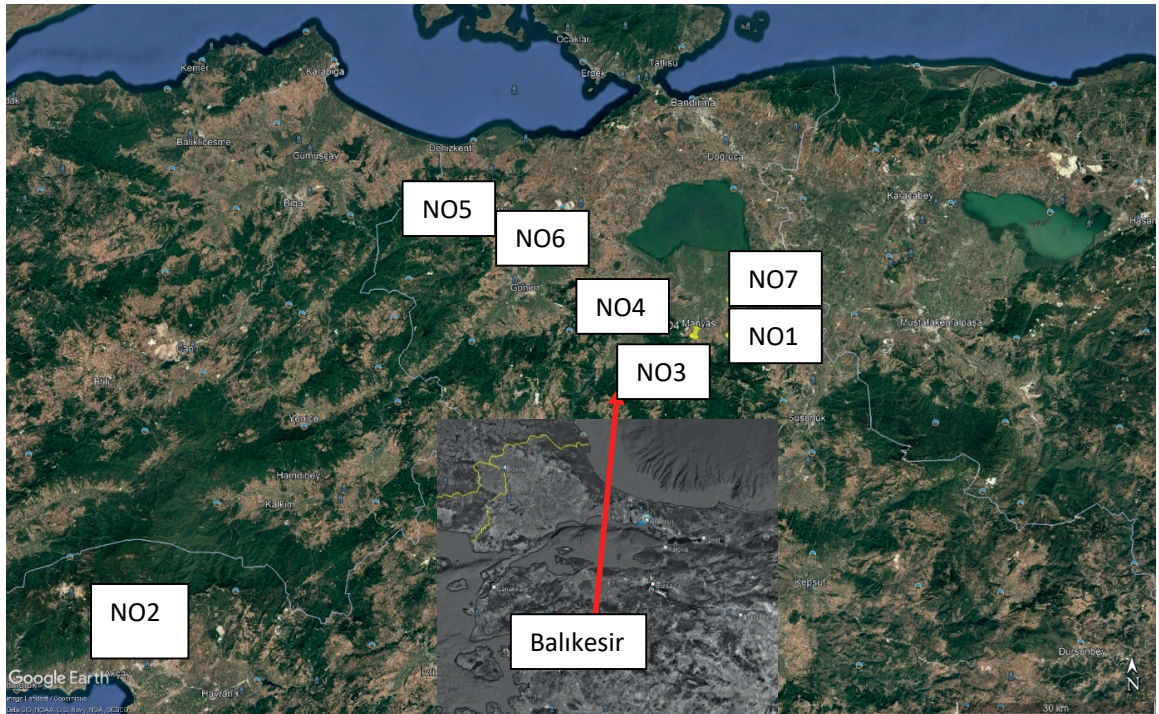


Figure 2. Sampling points for water quality and microplastic analyses

Şekil 2. Su kalitesi analizleri ve mikropplastik analizleri kapsamında numune alınan noktalar

Water quality analyses were carried out by collecting samples from seven points within the drinking water network (NO1-NO7), indicated in Figure 2 and Table 6. At six of these points (NO1-NO6), microplastic analysis were also conducted for microplastic types, which are significant pollutants and whose presence in water resources has increased considerably. Microplastic analyses were performed by the Central Laboratory of Bilecik Şeyh Edebali University (BARUM). In the final stage, problems related to water resource management were identified, and recommendations for a sustainable management model were made based on existing best practice examples. Within the scope of the study, microplastic analyses were conducted using the

pyrolysis gas chromatography/mass spectrometry (PY GC-MS) method with a Shimadzu QP2010-Ultra model device. The pyrolysis unit used in the device was the PY-2020 model. The analysis conditions are presented in Table 5.

For the analysis, 500 mL water samples collected from the sources were concentrated by evaporation to 1 mL. Subsequently, 0.2 µL of the concentrate was injected into the instrument, and microplastics were identified and quantified.

The indicator compounds used for the quantification of the microplastic types measured within the scope of the study, along with the MS scan range (m/z), R², and LOD values, are presented in Table 6.

Table 5. Specifications of the GC-MS analytical method for microplastic analysis.

Çizelge 5. Mikroplastik analizine yönelik GC-MS analiz yönteminin özellikleri.

Method Name	: PY GC MS METHOD
Device Type	: Gas Chromatography Mass Spectroscopy (GC-MS)
Device Brand	: SHIMADZU
Device Model	: QP2010-ULTRA MODEL
Pyrolyze Model	: PY-2020 IS
Analysis Condition	: Pyrolysis unit: Temperature: 550 °C, Time: 30 s GC unit: Carrier gas: high purity helium Column Flow: 1 mL/min Oven Program: 5 minutes at 40 °C, then heating at a rate of 20 °C/min up to 320 °C, held for 10 minutes MS unit Interface temperature: 300 °C Scan range: 30-500 m/z
Measured Microplastic Components	: PET (Polyethylene Terephthalate) PP (Polypropylene) PE (Polyethylene)

Table 6. Indicator compounds used in microplastic analysis and measurement-related parameters.

Çizelge 6. Mikroplastik analizinde kullanılan indicator türleri ve ölçüme yönelik bilgiler.

Polymer	Characteristic pyrolysate (P1-P2)	m/z	R ²	LOD (µg)	REF
PE	P ₁ = 1,13-tetradecadiene	55	0.995	0.125	Fan et al. (2022)
	P ₂ =1-Heneicosene (1-tetradecene)	41	0.987	0.05	Morioka et al. (2024)
PP	P ₁ = 2,4-Dimethyl-1-heptene	70	0.998	2	Morioka et al. (2024)
	P ₂ = 2,4,6,8-tetramethyl-1-undecene	69	0.998	5	Fan et al. (2022)
PET	P ₁ = Benzophenone	182	0.999	0.025	Morioka et al. (2024)
	P ₂ = Ethan-1,2-diyilbenzoate	105	0.999	0.05	Kaal et al. (2023)

LIMITATIONS

This study is subject to several limitations that should be considered when interpreting the results. First, although the Susurluk Basin extends over a large geographical area, the analysis was restricted to seven sampling points. These locations were selected because they are representative sites that are consistently used by the Balıkesir Metropolitan Municipality and the General Directorate of Balıkesir Water and Sewerage Administration (BASKİ) for routine water quality monitoring. Second, the assessment was based on a single sampling campaign conducted to evaluate the instantaneous condition of the water resources during the study period. As a result, temporal and seasonal variations in water quality were not examined. This limitation may constrain generalization of the findings with respect to long-term hydrological and hydrochemical dynamics in the basin.

RESULTS AND DISCUSSION

In cooperation with the Balıkesir Water and Sewerage Administration, water quality analyses were conducted on drinking water samples collected from different points in Balıkesir. The results were compared with the limit values specified in the Regulation on Water Intended for Human Consumption (RWIHC) (RWIHC, 2005).

The drinking water analysis results conducted in the Manyas district of Balıkesir at the end of 2024 and beginning of 2025 generally complied with RWIHC standards. According to Table 7, measurements in all neighborhoods showed that trace elements (arsenic, cadmium, lead, nickel, etc.) remained well below the limit values, indicating that the water resources are free from industrial and agricultural pollution.

The low levels of ammonium and nitrate indicate that there is no significant fecal contamination in the water resources. Agricultural fertilizers and the nitrogen cycle in soils are also important sources of nitrate. Physical parameters (turbidity, pH, color, conductivity) also remained within the acceptable range across the neighborhoods. Water pH values were between 6.5–9.5, and electrical conductivity values were well below the limits. This demonstrates that the local population generally has access to healthy drinking water sources.

In addition, microplastic measurements were carried out and evaluated (Table 8). According to Table 8, the presence of at least one type of microplastic in each water sample clearly shows that, alongside conventional parameters, micropollutants are highly significant and that conventional treatment practices are insufficient in removing them.

Table 7. Sample location information and water quality analysis results for seven samples (NO1-NO7)
Çizelge 7. 7 adet numunenin (NO1-NO7) alındığı yer bilgileri ve su kalite analiz sonuçları

Parameter	Analysis Method	Unit	Analysis Results							RWIHC (RWIHC, 2005).
			HAYDAR VE BOĞAZPINAR Dist. MANYAS (NO7)	DEREKÖY Dist (Cave) GÖNEN (NO6)	MADRA MOUNTAIN EDREMIT (NO2)	BOĞAZPINAR Dist MANYAS (NO1)	DEREKÖY Dist GÖNEN (NO5)	KAPAKLI Dist MANYAS (NO3)	HACIYAKUP Dist MANYAS (NO4)	
Aluminum (Al)	EPA 200.8	µg/L	<5	5.18	19.89	<5	8.4	35.49	<5	200
Ammonium (NH ₄)	TS ISO EN 14911	mg/L	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	<0.125	0.5
Antimony (Sb)	EPA 200.8	µg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	5
Arsenic (As)	EPA 200.8	µg/L	<2	3.7	<2	<2	2.69	5.98	3.31	10
Copper (Cu)	EPA 200.8	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2
Boron (B)	EPA 200.8	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1
Turbidity	SM 2130B	NTU	0.4	0.81	1.03	1.07	1.48	1.02	0.66	5
Iron (Fe)	EPA 200.8	µg/L	<5	<5	7.72	<5	<5	7.78	<5	200
Fluoride (F)	SM 4110B	mg/L	0.1	0.08	0.01	<0.01	0.1	0.06	0.05	1.5
E. Conductivity (EC)	TS 9748 EN 27888	µS/cm	498	616	55.7	476	586	564	664	2500
Cadmium (Cd)	EPA 200.8	µg/L	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	5
Chloride (Cl)	SM 4110B	mg/L	1.06	15.48	3.7	6.49	14.26	11.2	11.5	250
Chromium (Cr)	EPA 200.8	µg/L	<2	<2	<2	<2	<2	<2	<2	50
Lead (Pb)	EPA 200.8	µg/L	<5	<5	<5	<5	<5	<5	<5	10
Manganese (Mn)	EPA 200.8	µg/L	<2	<2	<2	<2	<2	<2	<2	50
Nickel (Ni)	EPA 200.8	µg/L	<1	<1	<1	<1	<1	<1	<1	20
Nitrate (NO ₃)	SM 4110B	mg/L	5.19	10.2	0.14	7.87	6.71	8.27	6.36	50
Nitrite (NO ₂)	SM 4110B	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.5
pH	Electrometric Method SM 4500H+ B)		8.08	7.47	8.09	7.54	7.43	7.28	7.24	6.5-9.5
Color	Physical (Pt-Co)		SUITABLE	SUITABLE	SUITABLE	SUITABLE	SUITABLE	SUITABLE	SUITABLE	TKEDY*
Selenium (Se)	EPA 200.8	µg/L	<5	<5	<5	<5	<5	<5	<5	10
Sodium (Na)	TS ISO EN 14911	mg/L	-	9.87	3.67	4.02	9.88	7.01	7.51	200
Sulfate (SO ₄)	SM 4110B	mg/L	10.67	<1	3.46	8.96	70.3	9.47	12.9	250

*TKEDY: Acceptable to consumers and no abnormal changes observed

Table 8. Sampling points among the six locations where microplastics were detected, types of microplastics, and concentrations identified

Çizelge 8. Numune alınan 6 noktada arasından mikroplastik tespit edilen noktalar; mikroplastik türleri ve tespit edilen konsantrasyonları

NO	Location	Type Detected	Compound Name	Concentration (µg/L)	Total Concentration (µg/L)
2	Madra Mountain Edremit	PP	2,4,6,8 tetramethyl 1 undecene	5.3	5.3
3	Kapaklı Dist. Manyas	PP	2,4,6,8 tetramethyl 1 undecen	4.0	4.0
4	Hacıyakup Dist. Manyas	PE	1,1- heneicosene	8	12
		PP	2,4,6,8 tetramethyl 1 undecene	4	
5	Dereköy Dist. Gönen	PE	1,1- heneicosene	8	12.6
		PP	2,4,6,8 tetramethyl 1 undecene	4.6	
6	Dereköy Dist. (Cave)	PP	2,4,6,8 tetramethyl 1 undecene	3.9	3.9

Li et al. (2023) reported that microplastics are now found everywhere in the global environment. The potential health risks of this emerging pollutant are highly concerning. Literature reviews show that microplastics are frequently detected in environmental and human samples. Humans are potentially exposed to microplastics through ingestion, inhalation, or skin contact. Microplastics can cause oxidative stress, DNA damage, organ dysfunction, metabolic disorders, immune responses, neurotoxicity, and reproductive and developmental toxicity at the cellular level. Furthermore, studies suggest that exposure to microplastics may be associated with various chronic diseases. Major commercial plastics include polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET), polystyrene (PS), and polyvinyl chloride (PVC).

Using a similar measurement method, Dalmau-Soler et al. (2024) measured microplastic (MP) concentrations in four different water samples, reporting values ranging between 11.3–77.1 µg/L. Gomiero et al. (2021) reported MP concentrations in drinking water networks ranging between 6.1–93.1 µg/L. Based on similar

studies in the literature, the levels measured in Balıkesir waters are relatively low. However, measures must be taken to prevent concentration increases by reducing plastic use, preventing plastics from reaching water resources, and recycling existing plastic waste.

These findings indicate that sustainable water management practices at the local scale have yielded positive results. Although the results remain below the limit values, variability among neighborhoods highlights the need for regular quality monitoring.

For the efficient and effective use of water resources, it is crucial to utilize alternative sources rather than relying solely on natural water resources. Climate change-induced drought is one of the pressing environmental problems threatening water resources and, consequently, humanity's future.

Balıkesir province is developing not only in terms of agriculture and tourism but also in industry, with five organized industrial zones. Parallel to this development, necessary measures must be taken to protect water resources. More effective irrigation methods should be used in

agriculture. Instead of flood irrigation, efficient techniques such as drip irrigation and sprinkler irrigation should be adopted. Studies show that the State Hydraulic Works (DSİ) achieved up to two-thirds savings in irrigation water in different provinces. In terms of urban landscaping, native vegetation that requires minimal water and maintenance should be utilized (Yarın, 2024; Süzer, 2025). Natural ecosystems should not be destroyed during construction.

As industry in the province continues to grow and the number of organized industrial zones (OIZ) increases, the expansion of social facilities will also lead to population growth. When admitting firms to existing OIZ, priority should be given to companies that adopt a green industry approach—those that use fewer natural resources, produce high value-added products, and emphasize waste recycling practices.

In this context, considering the increasing agricultural and industrial activities, population growth, and climate impacts, it should be anticipated that pressure on Balıkesir's water resources will intensify in the coming years. Local governments are seeking new sources as a "Plan B" to reduce this pressure. However, Plan B should not be limited to searching for new sources. It must be remembered that resources are not infinite, and they must be used efficiently to ensure the best possible quality and quantity for future generations. Therefore, the most critical aspect of effective resource use is the implementation of recovery and reuse practices at the highest level. The existing water distribution infrastructure must be checked to identify and reduce leakage losses. In areas where leakage monitoring is not conducted, nearly 30% of clean water is lost before reaching the end user. Local governments should also employ digital twin applications to identify water use habits and raise public awareness about water-saving practices.

Based on usage characteristics detected by digital twins, water-saving equipment (e.g., aerators) should be installed to reduce household water consumption.

According to long-term meteorological data, Balıkesir receives rainfall on 95 days per year, with an annual average of 604 mm (MGM, 2025). Assuming 50% efficiency in rainwater harvesting after evaporation and losses, a building with a roof area of 100 m² could harvest approximately 30 m³ of rainwater annually. This water could be used for garden irrigation, toilet flushing, and car washing. Utilizing rainwater can help alleviate the demand on existing water resources.

Household water use data show that 26% of water is consumed in toilets and 22% in laundry. Rainwater harvesting should begin with public buildings and then be expanded (Kandır, 2024).

Due to climate change, extreme rainfall and related flooding events have been observed in the province. One of the reasons is the impermeability of urban surfaces, especially asphalt and concrete. It must be noted that stormwater runoff does not contribute to replenishing water resources. These waters should be stored, or where storage is not possible, infiltration should be facilitated to recharge groundwater. In this context, sponge city applications should also be implemented in Balıkesir. Otherwise, insufficient groundwater recharge will lead to a continuous decline in groundwater levels.

CONCLUSION AND RECOMMENDATIONS

Within the scope of the study, an assessment was conducted to determine water quality and microplastic levels in the Balıkesir drinking water distribution network. The results obtained

indicate that there are no water quality issues at the sampled locations. Except for sampling point 1, various types of microplastics were detected at the other sampling points (2–3–4–5–6). In this context, it is recommended to enhance recycling practices that prevent plastics from entering water resources and to review measures about reducing the use of single-use plastics in order to mitigate the increase in microplastic pollution in water sources. Additionally, considering the growing pressure on water resources due to drought, it is advised to promote practices such as rainwater harvesting and to evaluate alternatives for the treatment, recovery, and reuse of wastewater.

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